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Delivering Postgraduate Education to Construction Professionals in Tanzania via Distance Learning: Responding to a Rapidly Changing Global Education Market

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Abstract

This is a discussion paper which tells the story of the implementation of a postgraduate distance learning programme in Africa. Twenty full-fee Commonwealth Distance Learning Scholarships (CDLS) awarded to the University of Bath, has enabled a local partnership to be made with the National Construction Council (NCC) in Tanzania to deliver a distance learning Masters programme in International Construction Management (ICM). This paper highlights the fact that although the delivery of the programme itself has been largely successful, the broader local capacity development remit has been limited. It is clearly recognised that what is needed, to make a significant contribution to capacity building in the Tanzanian construction industry, is a holistic 'lifelong learning' diet of education and support to complement the postgraduate programme. A model is proposed which would provide a framework for this challenge. This paper is seen as an example of a case which offers a creative teaching and learning strategy in the delivery of education to a targeted overseas audience.

Keywords: distance learning, lifelong learning, scholarships, Tanzania

1. Introduction

'Globalisation is not only bringing diversity to countries' populations and especially to large cities, but also enhancing the number of potential students who 'shop' globally for the best higher education offerings. Just as marketisation has transformed entire sectors in the past three decades, so it is now transforming higher education, not just within countries, but globally' (Barber 2013). This swiftly changing global demand for higher education is driving Universities to rethink their business model and to start offering evermore creative teaching and learning strategies in the delivery of graduate and postgraduate programmes. Distance learning, as a mode of delivery, is an excellent pedagogy with which to take on this challenge.

Distance learning offers possibilities in terms of flexibility beyond that of on campus delivery. It has been around for many years. Moore and Kearsley (2012) categorise distance learning into five generations: correspondence, broadcast radio and television, open university, teleconference and internet. Clearly, for better or worse, we are operating in an environment where the rapid advancement in technology is transforming our thinking in how we learn and how we teach. Generally, what is accompanying this rapid technology advancement is an entrepreneurial approach to education as a service. Most forward looking academic institutions are encouraging and supporting such initiatives with the recognition that the quality of the students learning experience can be as successful as any other mode of delivery.

1.1 Case study introduction

This case study focuses on the delivery of an existing distance learning programme but packaged to suit a specific audience. Twenty full-fee Commonwealth Distance Learning Scholarships (CDLS) awarded to the University of Bath, has enabled a local partnership to be made with the National Construction Council (NCC) in Tanzania to deliver a distance learning Masters programme in International Construction Management (ICM).

The scholarship awarding body (the Commonwealth Scholarship Commission) set out clear criteria for the delivery of the programme. Namely:

- To provide a quality distance learning programme provided by a UK institution that has a track record for delivery of programmes through the medium of distance learning;
- To provide a learning experience for developing country students in association with an in-country partner;
- To show the development impact of the delivered programme both in terms of how the programme content can be applied to the Millennium Development Goals (MDGs) and the potential for capacity development.

These criteria shaped the approach taken by the ICM programme delivery team at the University of Bath. Experience from two previous similar arrangements in South Africa (2006-2010) and Zambia (2008-2012) had shown that the local partner plays a pivotal role in the delivery process. It is vital that a successful relationship is quickly established with the local partner and that lines of communication remain effective. In setting up the programme in Tanzania we took the following steps:

1. The local partner (NCC) was initially used for marketing. This proved very successful. We received 150 applications for 20 places.
2. With each scholarship co-hort which was selected a measured attempt was made to balance the group in terms of job role and type of organisation they worked for (Government, private consultants, contractors, academia) and area of first degree (Architecture, Civil Engineering, Construction/Project Management).
3. The once yearly residentials were arranged with the guidance of the NCC. They also acted as a source of reference to engage local academic and practice based residential presenters.
4. Discussions began with the NCC at the outset to develop ideas for capacity development through continuous professional development (CPD) events and how the ICM students could contribute to that experience. The NCC then became the conduit for local capacity development activities.
5. A mapping exercise was undertaken to demonstrate how particular content from each unit taught in the ICM programme applied to the MDGs for Tanzania.
6. The scholarship students embarked on the ICM programme and were taught as per the standard ICM programme structure (set out below) but with specific residentials taught in Dar es Salaam, Tanzania.

Our aim was to create what we term 'intelligent practitioners'. Scholarship students who not only up-skill their management knowledge by undertaking the ICM programme but also engender the ability to contribute to capacity development activities within the Tanzanian construction industry.

The ICM programme is a well-established and respected international distance learning programme. Since its launch in 1990 it has been continuously updated to ensure it remains relevant, contemporary and challenging. The latest update in 2007 has resulted in the programme being offered in a high quality blended format with materials taught through on-line e-tutoring using a virtual learning environment, supported by face-to-face residentials. The structure is set out below in figure 1.

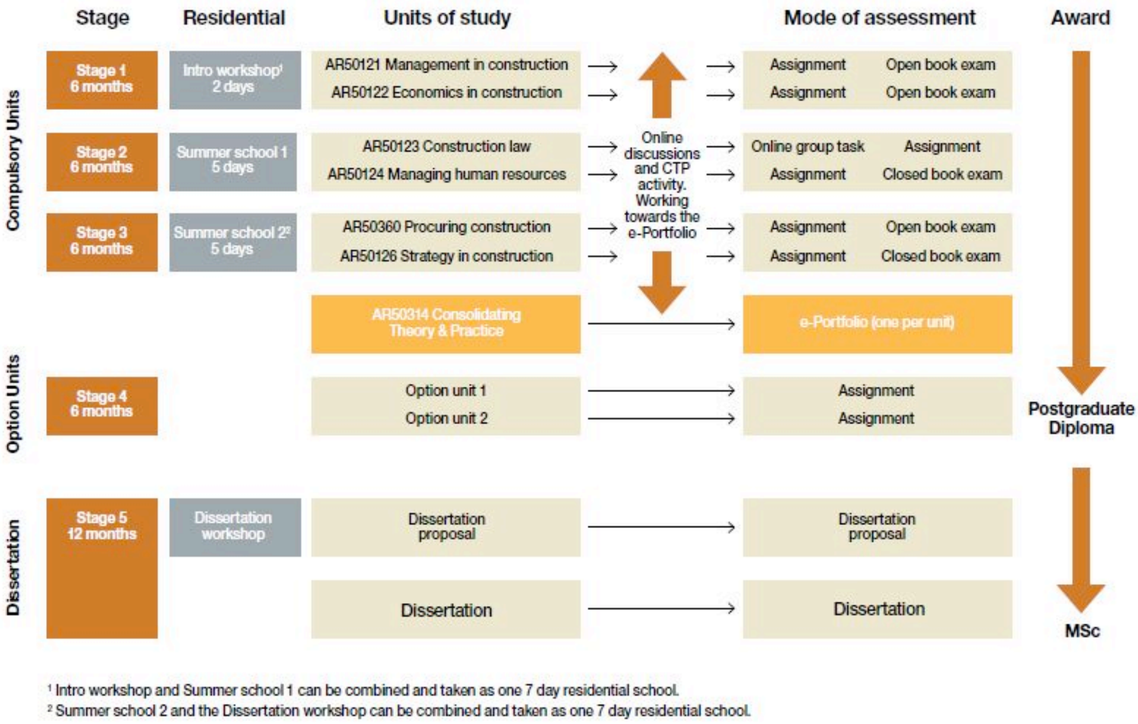

Figure 1: ICM programme structure

The pedagogical development of the programme has been structured on the ADDIE instructional design model (Morrison 2010), using the five phases of analysis, design, development, implementation and evaluation. This has resulted in what we term an 'integrated transition' curve model as illustrated in figure 2. The first third of the programme follows a reflective learning approach. (As all students continue to work full time during their studies it enables the immediate application of the newly learnt skills). This reflective learning is packaged in an integrated unit called 'consolidating theory and practice (CTP). The pedagogy then changes to a problem driven approach taught through two options units and which culminates in the completion of an academic dissertation.

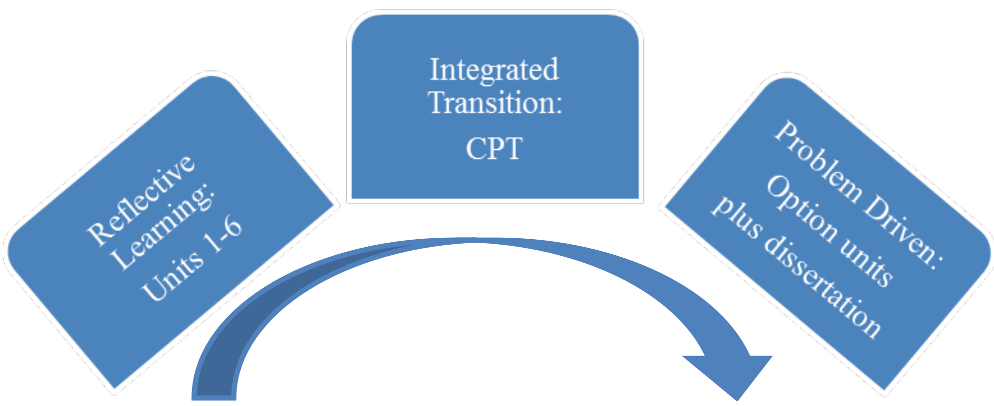

Figure 2: The ICM programme integrated transition curve mode

1.2 Observations of scholarship student engagement with the ICM programme

The first co-hort of scholarship students are now in the second year of their studies. All selected students started their studies with high motivation and excitement. After eighteen months this has changed somewhat as the reality of working and studying has sunk in. Balancing a life of work and the need to earn a living, with family and personal pressures along with their ICM studies is a challenging endeavour.

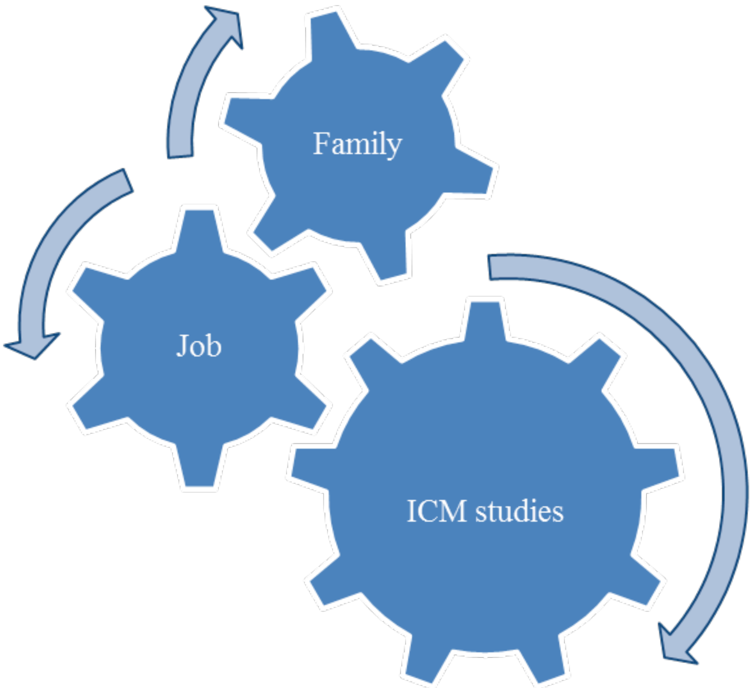

Figure 3: Scholarship student interconnectivity of life elements

Figure 3 illustrates the interconnected relationship between the three factors. For most students it is a complex picture. We can also add a multitude of constraints to this image. Time, study locations, technology limitations, personal motivation, intellectual ability to name but a few. They all influence the outcome of their learning experience. Simpson (2012) identifies the following qualities and skills distance leaners require to succeed in table 1.

Table 1: Qualities and skills required for success as a distance learner

Quality	***Skill***
Intelligence	*To deal with job pressure*
Numeracy	*Can handle demands of family*
Literacy	*Can manage the paperwork*
Motivation to learn	*Can organise own online environment*
Ability to ask for help	*Can prioritise*
Self-confidence	*Can accept constructive criticism*
Sense of humour	*Can handle assessment stress*

These illustrated qualities and skills paint a slightly simplistic picture but they do act as an effective framework against which we can record the key observations of our Tanzanian scholarship students. Against each of the skills common issues are presented in table 2.

Table 2: Observations on scholarship student engagement

Skill	***Comment***
To deal with job pressure	*A common job pressure is the requirement for students to spend periods of time working 'out of town' giving them limited internet access*
Can handle demands of family	*This has not been raised as a key issue amongst the students*
Can manage the paperwork	*Acquiring the appropriate study skills for distance learning has taken time for some students*
Can organise own online environment	*Forward planning amongst the students has been a recognised problem. While engaging in the online environment has not been a noticeable problem*
Can prioritise	*Job pressures can skew prioritise particularly around hand-in dates. Requests for extension are not uncommon*
Can accept constructive criticism	*Students have shown to be very keen to receive and respond to feedback and advise on their studies*
Can handle assessment stress	*We have recorded a continuous lower than average performance level amongst scholarship students in examinations specifically*

So after two years of study our scholarship students remain motivated, very hardworking and are managing the constraints, as best they can, to get through the ICM programme. But clearly, pressure of work particularly is preventing some students from fully engaging with their studies. This is resulting, in some cases, with students only submitting the bare minimum in some assessment activities. Invitations to engage in non-critical capacity developments activities are largely going unanswered. We still have some way to go before we can claim to have created the complete 'intelligent practitioner'.

This now brings us to the focus question in this paper – how can we better understand the landscape of capacity development in the Tanzania construction industry? How does the Masters programme we offer map to the broader picture? And what realistic role should the ICM students have in its delivery? To start to address this we embarked on eliciting the views of a sample of Tanzanian construction professionals.

2. Research methodology

Determining the demand for any good or service is normally the subject of a market research exercise and is commonly carried out by firms that specialize in collecting and analyzing specific data. However, along with getting a basic idea of market size, our study was also concerned with determining what may be the best approach to take in terms of delivery format. Given the high price and our perception that market research studies lack appropriate depth (at least within an acceptable budget), we decided against formal market research study at this stage, and instead sought the views of a type of focus group. A focus group is a marketing research tool in which data is generated through communication with and between a relatively small group of people. In our case the group consisted of some 17 people, which is rather larger than the norm (usually 8-10 people). 17 participants are not optimal as far as group discussion is concerned, so two sub-groups were formed, each being moderated. The up-side of the large total group was that the number of participants allowed us to collect a small amount of quantitative data which acted as a guide for the discussion phase in which the participants were encouraged to talk to one another: ask questions and comment on each other's points of view. According to Kitzinger (1995) this method enables us to find out not only what people think, but also how they think and why they think that way. At the same time Greenbaum (1993) points out that although focus groups can deliver high levels of useful product and market information, they are rather limited as far as being a research tool due to problems with objectively measuring results. Fortunately, the purpose of the exercise was not specifically concerned with academic research and the qualitative information provided by the group provided us with a richer understanding of the particulars of the market in a specifically Tanzanian context. Members of the focus group were all middle and senior management personnel currently employed in the Tanzanian construction industry and chosen on the basis of their ability to knowledgably discuss the questions raised.

Acting as moderators/facilitators for the two sub-groups we effectively served as discussion leaders aiming to stimulate rather than participate in the discussion(s). In doing so we worked from a set of questions raised during an initial question & answer session with the whole group.

The discussions effectively covered 4 key areas:

- A general assessment of the need for some CPD training &/or education in Tanzania,
- Identification of specific areas or topics
- Price and critical success factors
- Mode of delivery

Following the subgroup discussion phase, both groups were brought together in a plenary session during which a remarkably easy agreement was made on the key questions discussed. This suggests that the focus group members generally (if not entirely) held similar views about the need for, and problems associated with bringing CPD education/training to Tanzania.

3. Results

3.1 General assessment of need

The need for additional education and training for all construction professionals was unanimously agreed on, as was the feeling that the current provision is inadequate. In this latter respect, the lack of construction management courses, insufficient technical resources (teachers and reading materials) along with absence of professional accreditation in academic institutions were all cited. On the specific subject of provision for CPD courses, there was broad agreement that these would prove popular, but a high proportion of the group agreed that at present this area is something that only the Engineers Registration Board take seriously and that the whole idea is poorly supported by employers. Whilst the group generally thinks that CPD courses would be popular, not a single member of the focus group believed that the concept of 'lifelong learning' was well understood in the country. An understanding of the concept is a key element in developing a market for CPD and for overall improvements and capacity building within the Tanzanian construction industry. This issue thus represents the first barrier to marketing new courses. The subject of the main barriers to Construction Management education in Tanzania was then discussed. A key issue in this area concerns the role of political influence. On one hand, a burdensome level of bureaucratic regulations and procedures is seen as having a negative influence on both provision and take up of learning opportunities. Along with these respondents mentioned a lack of political will, inappropriate legal frameworks, undue political influence on the industry (for personal gain) and a general lack of institutional support for training and education for construction managers. A lack of coherence and fragmentation within industry-based institutions and organisations, coupled with too great a degree of separation between industry and academia are also viewed as hindering the development of up to date education and training. Closely related to these last points was a generally held view that there is little in the way of construction management research being undertaken and/or disseminated to practicing construction professionals.

3.2 Specific areas of need

Having recognized that there is a basic need for more training and education in the area of construction management, the discussion moved to two more focused items, namely what key Construction Management skills need improving in Tanzania? And what particular areas of study within construction management would be most popular? The groups began by brainstorming lists in each category. With no limit being placed on the number of ideas proposed, some 16 separate skills were identified, whilst areas likely to be popular subjects for courses generated 17 initial suggestions. Through a process of discussion and debate the two sub-groups initially reduced their lists to 8 key skills and 11 popular study areas before being tasked, in the plenary session with identifying the 3 most important areas.

The two questions are similar in some ways and for the most part the suggestions put forward applied to both questions. However, there were some differences. For example, conflict management, cost management and cultural awareness, were seen as areas in which there is need for more education and yet none of these appeared on the list of likely popular study areas. On the other hand some areas were considered to be likely popular subjects, but were not considered to be important skill development areas e.g. transport economics, arbitration, time management and quality management.

Working with subjects that appeared in both lists the plenary group quickly and easily reached agreement on 3 key areas of significance, Project Management, Facilities Management and Procurement. The importance of these areas was evident from the ease with which the group reached consensus.

Provision and availability of education and training courses is only of value if there is effective demand i.e. if someone is prepared and able to pay for it. According to the focus group, there is effective demand, but this is dependent on a number of factors. Firstly it is essential for most Tanzanians to continue working (and therefore receiving an income) in order to follow any kind of course/programme. This finding is no surprise and reflects the situation in many of the richer countries today e.g. the United States where the proportion of households earning a middle-class income fell from 50 percent in 1970 to 42 percent in 2010. (Barber et al, 2013).

Clearly price and income are vital considerations, but some of the issues identified by the group (lack of up to date research and out of date teaching materials) suggest that beyond basic demand, a question arises as to whether the simple selling of a course or programme of study/training provides the best value for money. All courses and programmes require regular updating as new research alters our understanding and practice of management, but as change occurs ever more rapidly, the price of keeping up to date may well become too much for those in poorer countries. One means of increasing the value of any course/programme is by replacing the simple one-off selling of the material, with the provision of an on-going service of updating over a long time period. The group felt that this would make any study programme more attractive and also suggested that such a service might also include being allowed to attend the annual residential schools associated with the University of Bath Masters programme.

Whilst the price of any programme is an important issue, it is interesting to see that when asked about the relative importance of a number of critical success factors (CSF), price was ranked in 4th place. The most critical success factor identified was that any programme should have a direct practical application. Close behind this factor was flexibility in terms of the study period and in third place was flexibility in terms of study location. The group also expressed the opinion that as part of introducing any new programmes into the country, the provider, should make formal links with Tanzanian universities, the NCC and even some of the larger Tanzanian contractors, so that the idea of lifelong learning may be spread across the industry and those responsible for its training and education.

3.3 Mode of delivery

The final area of interest concerned the manner in which any course/programme should be conducted. By far, the strongest preference was for a traditional classroom approach, conducted as evening classes. This result is interesting given that many of the focus group members are regularly away from the main cities in the country, working at remote locations. The second preference was for a distance learning approach mainly based on hard copy materials. The specification of hard copy materials is to overcome the unreliability of internet connections in the countryside. One interesting suggestion was that students should be able to use their phones for reading material as there is a much wider use of mobiles than computer based internet across the country. Intuitively this idea sounds good, but of all the suggested delivery modes this gained the weakest level of support.

4. Discussion

The situation that currently faces the indigenous Tanzanian construction firms is almost "Catch 22" in its nature. Without greater expertise firms cannot develop the capacity to compete against foreign firms for major projects and without the strong income revenue streams that accrue from winning major contracts, most firms within the industry are unlikely to be able to invest in the education and training necessary to develop the requisite levels of expertise.

Although we have no hard data, we are of the opinion (based on our experience of trying to establish working links in Tanzania and discussions with members of the focus group) that there is little, or no appetite on the part of the NCC or most of the various construction professionals registration boards (particularly for Architects, Quantity Surveyors and Contractors) for initiating or taking responsibility for driving forward CPD training for construction professionals. Indeed, the NCC has effectively farmed out provision of training to the respective professional registration boards, who appear to be, largely ignoring the matter. The overall picture is that little is currently being done by either the industry or the government to address the problem(s); although the government did set up the NCC and the Engineers Registration Board is attempting to develop an understanding of CPD among its members.

The award of the scholarships that enabled us to recruit twenty students to our MSc programme has inadvertently resulted in first hand observation of the need for other levels and forms of education and training within the Tanzanian construction industry. The focus group consisting of middle and senior managers currently working in the Tanzanian industry identified this need but also were unanimous in their belief that the concept of lifelong learning and therefore continual updating of knowledge and skills, was almost unknown to the country's professional bodies (with the possible exception of the previously mentioned Engineers' Registration Board). This situation means that it is virtually impossible for best practices to become embedded within the indigenous industry: a vital condition for effective capacity building and development.

As Barber et al (2013) point out, the global economy is changing as globalisation and technology transform supply chains and knowledge distribution. The issue is not about how much information/knowledge is available (most of it for free), but how one manages to select, synthesize and filter the relevant parts for specific purposes and how one then delivers the necessary support to ensure that learners get the most from their learning experience.

Given the ever increasing cost of gaining a degree of any kind from a European or American university; in real terms a rise of somewhere between 30-40% in the first decade of the 21st century (Barber et al., 2013), the chances of developing a market in poor countries for programmes that do not have direct relevance to the work environment seems likely to prove fruitless. Nevertheless, there is a genuine need for education & training designed to develop what we call 'intelligent practitioners' i.e. industry professionals who have up to date knowledge and skills related to the level at which they are employed. Provision of such educated-training is something that we can see as having a potentially good 'fit' with our Masters programme, which seeks to develop the intellectual toolkit necessary for industry professionals to become 'reflective practitioners'. Whilst the existing Masters programme continues to recruit a healthy and regular number of students each year, the programme is expensive and consequently the student base tends to come from those who are aiming for senior management posts. In terms of education & training, the Masters programme constitutes the tip of the construction education and training iceberg and without the solid mass of reliable and intelligent (up to date) professionals the industry will remain unable to capitalize on the valuable educational achievements of the few. The consequences of this might foreseeably include frustration on the part of the best educated Tanzanian construction managers leading to their relocation to other countries: in effect a brain drain.

The issue here then, is about identifying the appropriate conditions for developing the educational substructure that supports and complements Masters level programmes and inculcates an understanding of the concept of lifelong learning. The focus group were critical of the ability of Tanzanian universities to provide the necessary up to date teaching or to offer a variety of approaches to learning that will enable students to carry on working whilst learning. This situation is problematic because universities constitute the most respected learning institutions in most countries and are also the key qualification awarding bodies. If industry professionals do not have faith in the ability of these institutions to help develop capacity, then where can they turn for help? The problem is exacerbated by what is seen as a lack of integration within the industry, with universities, the NCC, government and major contractors all following their own agendas and not working together for the benefit of the industry. The focus group believe that what is required is some kind of external facilitator who can draw all the 'threads' of the industry together through formal links with Tanzanian universities, the NCC and some of the larger Tanzanian contractors. In this way, the group sees the possibility of all parties developing greater awareness, flexibility and closer interaction as central components of capacity building. As an example, it is felt that if construction firms interacted more closely with the universities (rather than simply headhunting the best students), they could help with designing programmes that actually lead to the acquisition of the skills required by the industry and programmes that are conducted with flexibility in terms of method of delivery and timeframes, so that learners can continue working, whilst studying or otherwise upgrading their skills. At the same time, the universities and the NCC should be collaborating on the identification and promotion of both educational and training opportunities and liaising with the various professional bodies/registration boards. The facilitator would then act as both a trigger and conduit for advancing the understanding of life-long learning as the idea becomes embedded in the key institutional bodies and is then passed on to their members (construction professionals) who ultimately must have the responsibility for their own learning.

5. Final thoughts

Capacity cannot be developed or potential fulfilled if we don't look at new approaches to education/training. On the contrary, strategy at the level of the Tanzanian industry, the country itself and the global university sector in general needs a thorough rethink. Formal and traditional degree programmes have their place, but the skills gap identified within the Tanzanian construction industry suggests that other models are required. Along with the issues of flexibility already mentioned, there are other potential challenges to the traditional model that might suit the construction industry very well e.g. programmes that require no formal qualification for entry and no grading of student work, but where the focus is on practical skills and where students are taught how to think in a proactive manner and to risk getting things wrong and then learning from their mistakes: such a programme already exists in the Philippines (developed by Ayala, one of the country's largest conglomerates) and is extremely popular because it increases students' employability.

Although the Masters programme will help to provide senior level management expertise within the Tanzanian construction industry, it is as we have pointed out only the tip of the iceberg. The development of significant capacity within indigenous contracting organisations requires more than an elite level because without appropriately skilled lower and middle management the elite will have no one to work with.

Figure 4 constitutes a potential model for the development of lifelong learning that includes all levels of skills within the industry. As a model it is of course hypothetical and open to challenge and change. However, it does address the issues raised by the focus group and acknowledges the need for radical change in the relationships between the major institutional players in the construction industry. It is our contention that the model represents a framework, which if adopted will make a significant contribution to the development of managerial skills and capacity at all levels within the industry.

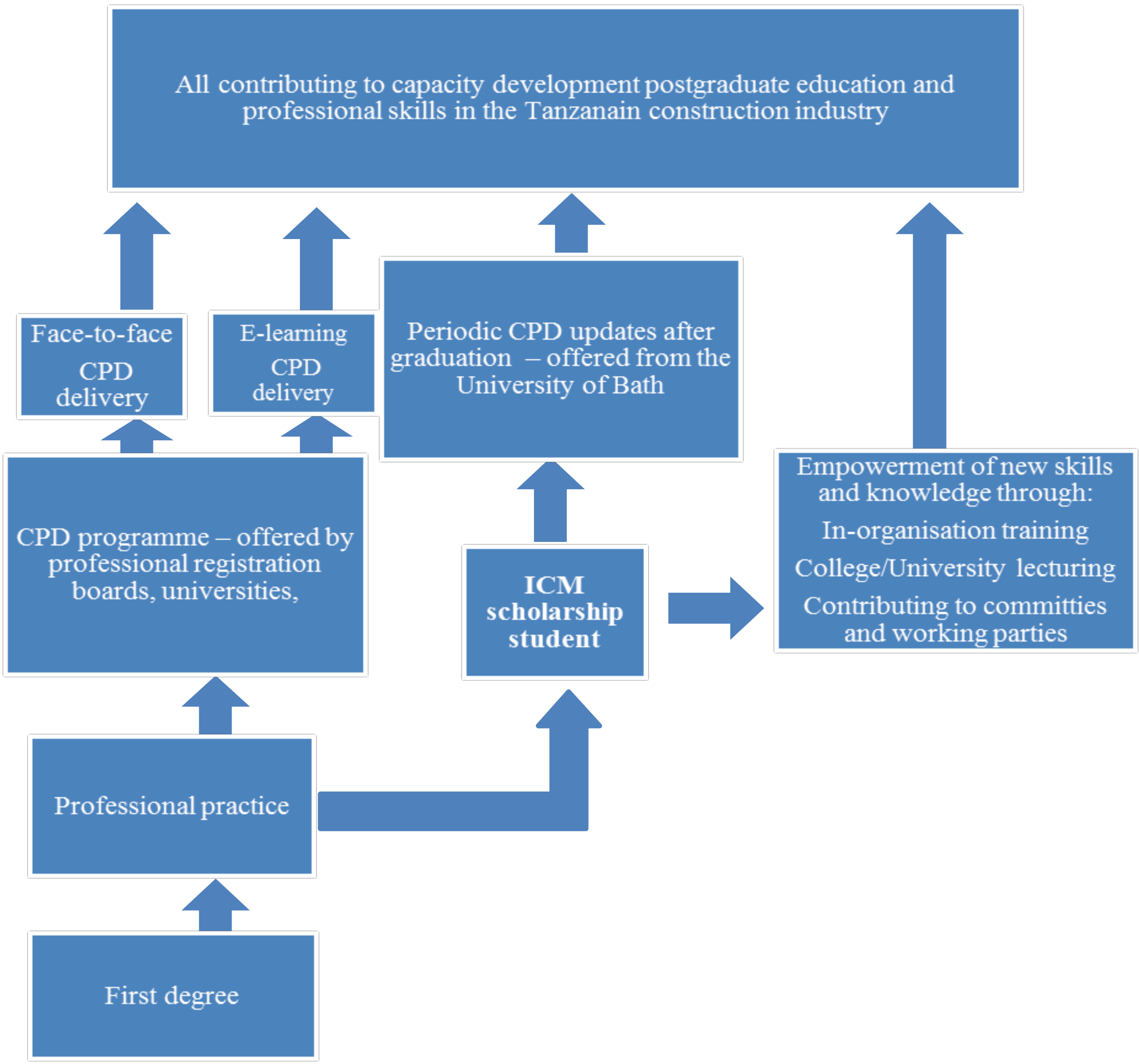

Figure 4: Life-long learning model

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Application of New Institutional Economics to construction management: literature analysis using keywords

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Abstract

The New Institutional Economics has been playing an increasingly important role in the construction management literature. This applies especially to the transaction cost theory and the principal-agent theory, both of which have been recurrently applied to the research in the field since the onset of the new millennium. This analysis of the construction management literature uses keywords containing the most important concepts of this theoretical framework. Keywords have become important parts of academic papers, and they are crucial in the literature search. However, this literature analysis shows a rather superficial understanding of the New Institutional Economics in the field. Although both the principal-agent theory and the transaction cost theory are parts of this theoretical framework, the analysis of literature presented here shows that the construction management community favours the latter to the former by a wide margin. More important, the interconnections between the two appear to be poorly understood.

Keywords: New Institutional Economics, transaction cost theory, principal-agent theory, literature analysis, construction management

1. Introduction

The New Institutional Economics has been receiving increasing attention in various fields of application, including construction management. This applies especially to two of its most important constituents, the transaction cost theory and the principal-agent theory (e.g. Lai et al., 2000 and 2008; Chang and Ive, 2002; Ive and Chang, 2007; Turner and Müller, 2003; and Müller and Turner, 2005). Both have been applied to a wide variety of problems in construction management. The purpose of this paper is to assess this development by analysing the literature in the field. Focusing on the leading journals in construction management, this literature analysis employs keywords used by the authors of papers in construction management. The keywords selected are the most important concepts of this theoretical framework.

Together with abstracts, keywords have long become important parts of academic papers. They are crucial in guiding the literature search, which has become essential to the academic community engaged in a wide variety of research activities. Authors have been advised by journal editors to carefully select the keywords so as to help identify their papers in terms of theoretical background, methodological approach, results of research, and so forth. As will be shown below, five leading keywords have been used in the keyword search presented in this paper. Together, these five keywords are central to the theoretical framework of the New Institutional economics (e.g., Jäger, 2008a,b).

Ceric (2013) investigated the application of the principal-agent theory to construction management by means of a literature review. The investigation focused on the seven leading journals in the field identified by Bröchner and Björk (2008). This paper extends the analysis to broader theoretical framework of the New Institutional Economics, which includes the transaction cost economics and the principal-agent theory. However, this study has focused exclusively on the keywords used by the authors.

In the sections that follow, the New Institutional Economics is introduced first. It offers a theoretical framework that encompases both the transaction cost theory and the principal-agent theory. Next, the methodology of literature analysis is presented. This section also presents the papers included in the analysis and the relevant keywords identified by the search. The main findings of the paper are then presented. The paper closes with conclusions comprising a recapitulation of the main findings, a discussion of limitations of the present investigation, and suggestions for further research.

2. The New Institutional Economics

Ronald Coase (1937) investigated why economic activities take place through different institutions, such as firms, and not only through markets. His contribution eventually led to a revolution in microeconomics and became the foundation of the New Institutional Economics (Williamson, 1985), which comprises the principal-agent theory and the transaction cost theory, as well as the property rights theory and the contract theory (Jäger, 2008a,b). The transaction cost theory and the principal agent theory are characterized by many similarities, but also by some differences (Williamson, 1988). Although modified by subsequent development, the Coase model remains central to the new framework (e.g., Lai et al., 2008).

The core subject in the principal-agent theory, occasionally referred to as the agency theory (Eisenhardt, 1989), is the relationship between the orderer as the principal and the contractor as the agent. Both parties are individuals who act out of their self-interest. Neither party is fully informed about the motivations of the other party, and both parties can therefore act opportunistically. According to the transaction cost theory, as well, every transaction involves a social relationship between individuals engaged in the exchange of goods or services. Each transaction takes place in an environment in which collective rules apply. Economic governance concerns these rules in firms and other institutions. Again, all parties engaged in the exchange of goods and services can act opportunistically.

Overseeing the exchange of goods and services so as to curb opportunistic behaviour entails a variety of costs, from screening and monitoring by the principal, to signalling and reputation by the agent. These are often referred to as agency costs. The problems that arise due to asymmetric information are those of adverse selection, moral hazard, and hold-up. Contracts that arise under threat of opportunism are called relational contracts. They revolve around trust between the parties involved because asymmetric information cannot be removed by contracts alone.

George Akerlof, Michael Spence, and Joseph Stiglitz shared a Nobel prize in economics in 2001 for their work on information asymmetry conducted in the 1970s. It provides one of the best known applications of information asymmetry in economics, which is the situation in which one of the two parties is better informed than the other, and in which they do not share the same interests (e.g., Jensen, 2000). Elinor Ostrom and Oliver Williamson shared a Nobel prize in 2009 for their work on economic governance performed in the 1970s and 1980s. Their contributions focus on hierarchical structures such as firms and other institutions that play a role outside markets proper.

3. Methodology

Again, this literature analysis started with the identification of the leading journals in the construction management field. For this purpose, the journals identified by Bröchner and Björk (2008) were used. Their research focused on the preferences of the authors contributing to the construction management field. They followed the most cited authors, whose preferences they investigated by an opinion survey. In the process, they identified 45 journals in the field, from which they identified the seven leading ones. Together with their publishers, the seven leading journals in construction management identified by Bröchner and Björk (2008: 742) are shown in Table 1.

Table 1: Top construction management journals by authors (Bröchner & Björk, 2008)

Journal	*Acronym*	*Publisher*
Automation in Construction	*AIC*	*Elsevier*
Building Research and Information	*BRI*	*Taylor & Francis*
Construction Innovation	*CI*	*Emerald*
Construction Management and Economics	*CME*	*Taylor & Francis*
Engineering, Construction and Architectural Management	*ECAM*	*Emerald*
International Journal of Project Management	*IJPM*	*Elsevier*
Journal of Construction Engineering and Management	*JCEM*	*ASCE*

For purposes of this literature analysis, the online archives of the journals listed above were searched for the following leading keywords: New Institutional Economics, transaction cost theory, principal-agent theory, economic governance, and asymmetric information. Again, these are the central concepts of the theoretical framework investigated in this analysis of the construction management literature, all of which have been introduced in the previous section. The main findings will be presented in the next section.

It should be noted that the archives of the journals go back to different years. In this case, JCEM archive goes back to 1930, BRI to 1973, CME and IJPM to 1983, AIC to 1992, ECAM to 1994, and CI to 2001. Therefore, the present review is slightly biased toward the journals with farther-reaching archives. As will be shown below, however, the bulk of the literature sited falls within the last decade. Therefore, the historical reach of the archives does not appear to be of great relevance in this case.

The analysis of construction management literature proceeded in three distinct steps. First, the papers in the leading journals containing the above keywords were identified by literature search. These keywords appeared anywhere in the papers. Second, the identified papers were analysed to identify the keywords listed by the authors. Only the papers with one or more of the above leading keywords were selected for further analysis. Third, the identified keywords were analysed for their interconnections, which suggest connections between the underlying concepts, as well. In addition to the five keywords above, thirteen additional keywords characteristic of the New Institutional Economics were searched for. Their interconnections were identified by literature search so as to establish the network of concepts guiding the research in the construction management field.

Table 2 summarises the search conducted in the seven leading journals. All together, 515 papers were identified in the search for keywords central to the theoretical framework of the New Institutional Economics. As noted above, there were five such keywords, of which the New Institutional Economics occurred 14 times, the transaction cost theory 324 times, the principal-agent theory 55 times, economic governance six times, and asymmetric information 126 times. As explained above, these keywords correspond to the main concepts of the theoretical framework in question. There are some overlaps in this count, as several of these concepts can sometimes be found in the keywords listed in the same paper. As will be shown below, however, these overlaps are not large.

Table 2: Incidence of leading concepts in papers in selected journals

Concept / Journal	*AIC*	*BRI*	*CI*	*CME*	*ECAM*	*IJPM*	*JCEM*
New institutional economics	*0*	*2*	*1*	*4*	*0*	*5*	*2*
Principal-agent theory	*0*	*2*	*2*	*10*	*5*	*30*	*6*
Transaction cost theory	*20*	*22*	*9*	*132*	*15*	*99*	*27*
Asymmetric information	*6*	*9*	*2*	*20*	*2*	*26*	*61*
Economic governance	*0*	*1*	*0*	*4*	*0*	*0*	*1*

Table 3 shows all the leading keywords found among the keywords listed in papers that appeared in the seven selected journals. All together, there are 45 such keywords that appear in 42 papers: two each in BRI and CI, 23 in CME, 11 in IJPM, and seven in JCEM. There are no such keywords in AIC and ECAM. As was noted above, this shows that there have been rather few overlaps in the results of the search.

Table 3: Incidence of leading concepts in keywords in selected journals

Keyword / Journal	*AIC*	*BRI*	*CI*	*CME*	*ECAM*	*IJPM*	*JCEM*
New institutional economics	*0*	*0*	*0*	*0*	*0*	*0*	*0*
Principal-agent theory	*0*	*1*	*0*	*1*	*0*	*3*	*0*
Transaction cost theory	*0*	*0*	*2*	*18*	*0*	*8*	*5*
Asymmetric information	*0*	*1*	*0*	*0*	*0*	*0*	*1*
Economic governance	*0*	*0*	*0*	*4*	*0*	*0*	*1*

The papers whose keywords contain one or more of the five leading keywords are presented in Table 4. Again, there are 42 of them. Like in tables above, they are organized by leading journal in the construction management field identified by Bröchner and Björk (2008).

Table 4: Papers cited

Acronym	*Papers cited*
AIC	*None*
BRI	*Lützkendorf & Speer (2005)*
CI	*Finne (2006), Ross (2011)*
CME	*Winch (1989), Lai (2000), Costantino et al. (2001), Chang & Ive (2002), Rahman & Kumaraswami (2002), Bridge & Tisdell (2004), Turner (2004), Chang (2007), Mccan (2006), Boukendour (2007), Chang & Ive (2007b), Ive & Chang (2007), Jin & Doloi (2008), Lai et al. (2008), Petrovic-Lazarevic (2008), Yung & Lai (2008), Ho et al. (2009), Roehricha & Lewis (2010), Sha (2011), Wu et al. (2011a), Chang (2013a)*
ECAM	*None*
IJPM	*Reve & Levitt (1984), De Witt (1986), Turner & Müller (2003), Zaglouhl & Hartman (2003), Müller & Turner (2005), Chang & Ive (2007a), Jin & Zhang (2011), Chang & Ive (2012), Li et al. (2012), Bond-Bernard et al. (2013), Chang (2013b)*
JCEM	*Lee et al. (2009), Jin (2010), Jin (2011), Wu et al. (2011b), Xiang et al. (2012), Li et al. (2013), Zerjav et al. (2013)*

As can be seen from Table 4, most of the papers identified by literature search come from the third millennium. The only exceptions here are Reve & Levitt (1984), De Witt (1986), and Winch (1989). There are the forerunners in the construction management field with respect to the New Institutional Economics. In particular, all three early papers refer to the transaction cost theory.

4. Main findings

Table 5 shows all interconnections between the leading keywords from the New Institutional Economics, as well as interconnections between them and a number of subsidiary keywords. As all connections are bidirectional, the table is triangular. The values on the diagonal show all cases in which a keyword appears by itself, where the keywords in question are connected only to themselves.

Table 5: Interconnections between leading and associate keywords from the New Institutional Economics

Keywords	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*	*16*	*17*	*18*	*Sum*
1. Adverse selection																			*0*
2. Agency costs																			*0*
3. Asymmetric information	*1*		*1*																*2*
4. Coase model																			*0*
5. Contract theory																			*0*
6. Economic governance						*2*													*2*
7. Hold-up																			*0*
8. Monitoring																			*0*
9. Moral hazard																			*0*
10. New Institutional Economics																			*0*
11. Opportunism																			*0*
12. Principal-agent theory	*1*		*1*	*1*								*2*							*5*
13. Property rights theory				*1*															*1*
14. Relational contracts																			*0*
15. Reputation																			*0*
16. Screening																			*0*
17. Signalling																			*0*
18. Transaction cost theory				*2*		*3*	*3*				*5*	*1*	*1*					*20*	*35*
Sum	*2*	*0*	*2*	*4*	*0*	*5*	*3*	*0*	*0*	*0*	*5*	*3*	*1*	*0*	*0*	*0*	*0*	*20*	*45*

Figure 1 offers a network representation of interconnections between keywords in Table 5. In other words, it is the graph equivalent to the matrix of keyword interconnections. The cases where keywords are connected only to themselves are represented by loops.

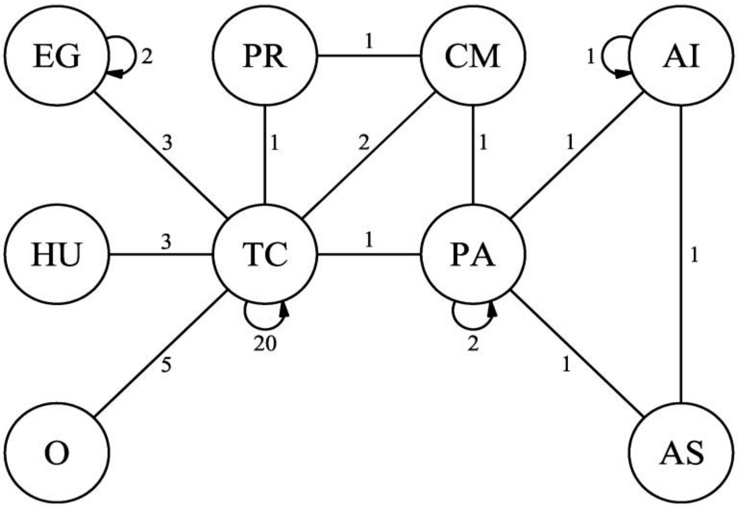

Figure 1: Network of interconnections between keywords in the New Institutional Economics (AI: Asymmetric Information; AS: Adverse Selection; CM: Coase Model; EG: Economic Governance; HU: Hold-Up; O: Opportunism; PA: Principal-Agent Theory; PR: Property Rights Theory; and TC: Transaction Cost Economics)

In accumulation, Table 5 and Figure 1 represent a mapping of the collective appreciation of the New Institutional Economics by the research community in construction management over some two decades. As can be seen from this mapping, the principal-agent theory and transaction cost theory are weekly connected in the network of keywords. The connection is provided by only one of the 42 papers identified. The same holds for the two theoretical frameworks and the Coase model, which is central to the New Institutional Economics, as well as the connections between the Coase model, the property rights theory, and the transaction cost theory. In each of these cases, the triangle connecting the three keywords appears in a single paper. The connections between the principal-agent theory, asymmetric information, and adverse selection are also weak. In fact, the triangle connecting the three keywords in the network appear in only one paper identified by the literature search conducted in this investigation.

The situation is markedly different in the case of the transaction cost theory and its connections to economic governance, hold-up, and opportunism. This part of the nework is interconnected more richly than the other. For example, opportunism and the transaction cost theory are connected five times. In addition, there is a large number of cases where the transaction cost theory is connected only to itself. The two parts of the network show clearly that the transaction cost theory is more central to the construction management researchers than is the principal-agent theory. Again, their interconnections between them are largely neglected.

It is interesting to briefly review the network shown in Figure 1 in terms of network connectivity as conceived in network analysis (Rodrigue et al., 2009: 31). The so-called Gamma index of network connectivity is a ratio between the actual number of links (e) and the potential number of links given the number of nodes (v) in a network. It varies between zero and one. In terms of the New Institutional Economics, all the concepts represented by the keywords in the network ought to be connected. The potential number of links is equal to 1/2 v(v-1). In our case, e = 11. The potential number of links is therefore 1/2 9(9-1) = 36. In other words, the Gamma index is equal to 11/36 = 0.31 or 31 percent. The mapping in Figure 1 thus shows relatively low connectivity by comparison with the potential connectivity of the network.

Returning to the treatment of the interconnections between the concepts of the New Institutional Economics in the literature, there are exceptions among the papers surveyed. The most notable among them is the paper by Lai et al. (2008), which carefully examines the Coase model and its role in the construction management field. This paper considers the entire theoretical framework in a systematic fashion. The literature surveyed in the paper is also exemplary. Most important, the paper offers a Coasian research agenda for the field. Although it also focuses on the transaction cost theory, other parts of the theoretical framework of the New Institutional Economics are also carefully considered. This is an exception worth following in the future.

5. Conclusions

The New Institutional Economics offers a wide range of concepts of great value to the construction management field. The key concepts from this theoretical framework point at the self-interest of all parties engaged in the exchange of goods and services related to construction. Every transaction is thus open to opportunistic behaviour, which cannot be eradicated by more or better contracts. It can only be mitigated through better understanding of construction activity on both the principal and the agent's behalf.

It is incumbent upon the researchers in the construction management field to master the New Institutional Economics as a theoretical framework underpinning a growing portion of their research. The literature analysis presented in this paper shows that the appreciation of the theoretical framework in question is cursory at best. In particular, the analysis shows a marked bias toward transaction cost theory at the expence of the principal-agent theory. However, both ought to have a place in the construction management field. In addition, they need to be properly interconnected.

The main limitation of the research presented in this paper is its relatively narrow scope. This refers both the the number of journals and the number of keywords investigated. In particular, there were only seven leading journals covered by the analysis, and only five leading keywords were employed in it. However, the objective of this paper was only to broach the subject and thus lead the way toward a broader literature analysis.

The analysis presented here can be extended in several different but related ways. First, a larger number of journals in the construction management field need to be investigated using the literature analysis introduced in this paper. Second, a greater range of keywords associated with the conceptual framework of the New Institutional Economics needs to be investigated to better understand the mapping of their interconnections in the literature. And third, the research community in the construction management field needs to be better appraised of the theoretical underpinnings of their research. In particular, the many connections between the principal-agent theory and transaction cost theory, as well as the property rights theory and contract theory, need to be brought into sharper focus in the future research activity. It is to be hoped that the findings presented in this paper will serve as a welcome departure for all the above.

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Lessons learned practices in the UAE construction industry

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Abstract

The failure of learning from our mistakes or those of others, has generated unnecessary waste of time and costs, in the construction industry, due to its project based, fragmented and unstable nature. Lessons Learned, as an important way of improving projects performance, is analyzed in this study, with the aim to explore the current practice of Lessons Learned in the UAE construction industry. A literature review has revealed what "Lessons Learned" is under different contexts, and focused on various factors influencing a Lessons Learned Programme. The research method of a series of structured interviews, followed by an on line questionnaire, is adopted in this study. It was found that although the concept of Lessons Learned is quite familiar by most of professionals in the project management in the UAE construction industry, Lessons Learned practice is mainly performed in an informal way (individually or ad hoc). As for barriers for Lessons Learned practice, Culture factors, such as "Afraid to be blamed for mistakes" and "lack of learning culture" (1^{st} and 2^{nd} rank) influence significantly in Lessons Learned practice. It is also found that a formal lessons learned programme does exist in some organizations. However, with the lack of a dedicated Lessons Learned repository and Lessons Learnt system, Lessons Learned has yet a long way to reach its potential.

Key words: Lessons Learned, Construction industry, knowledge management, project management, UAE

1. Introduction

Organizations in the construction industry always pursue “value for money” in essence. To achieve this, errors shall be avoided in a maximum way and controlled by all means. It is any organization’s desire not to make mistakes, especially repetitive mistakes. At the same time, the good practice shall be strengthened and implemented to continue the success across all projects.

Basically Lessons Learned serves the organizational function of capturing knowledge, transferring the individual tacit knowledge to organizational explicit knowledge and eventually aiming to retain the knowledge within an organization. So far “Lessons Learned” attracts much attention in the fields of Learning, Knowledge Management and Project Management (Jugdev, 2012; Disterer, 2002; Schindler and Eppler, 2003) as shown in Figure (1), Lessons Learned covers the crossed area of these three research fields.

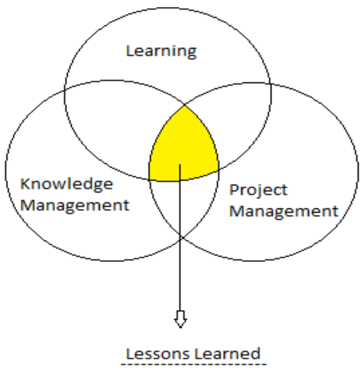

Figure: The Definition of Lessons Learned

The US Construction Industry Institute (CII, 2007c) provide Lessons Learned examples that include:

- a lesson learned that is incorporated into a work process;
- a tip to enhance future performance;
- a solution to a problem or a preventative action;
- a lesson that is incorporated into a policy or a guideline; and
- an adverse situation to avoid.

2. Lessons Learned Programme and the Success factors

Caldas et al. (2009) pointed that the purpose of Lessons Learned programme is to optimize the capture and dissemination of those hard-earned lessons, a Lessons Learned programme consists of the people, processes and technologies that support the collection, analysis, and implementation of validated lessons learned in organizations. Additionally CII (2007c) identified seven key areas which affect the success of a lessons learned programme - leadership, lesson collection, lesson analysis, lesson implementation, resources (human, monetary, material, technology), maintenance and improvement, and culture. Various factors are summarized in the below Figure

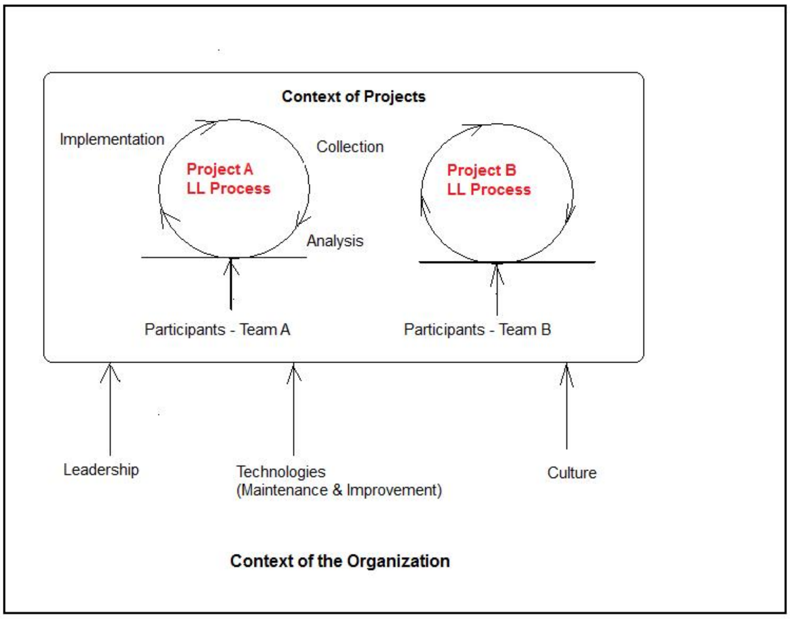

Figure 2: Various Factors influencing a Lessons Learned Programme

We can see under the context of the projects, there are two independent projects, named A and B. Both projects have separate Lessons Learned process (collection, analysis and implementation), involving with own team participants on the project level. Under the context of the organization, “leadership”, “technologies”, “culture” are the supporting and influential factors, as they are strategically related factors which impact on all current and future projects within an organization.

There is growing concerns on legal issues and some organizations have delayed launching a formal Lessons Learned programme in a fear of negative legal ramifications (Caldas et al., 2009). Lessons Learned may carry commercially sensitive information which companies do not like to disclose, or in a fear that if errors in construction openly discussed, the legal claims could rise (CII, 2007c).

3. Research methodology and justification

The objective of this study is to investigate the current Lessons Learned practice in the construction industry in the UAE, and assess the possible risks/resistance of introducing Lessons Learned practice to project related organization in the UAE.

Structured interviews and an on line questionnaire survey, were selected to gain maximum benefits of both qualitative and quantitative research approaches. Structured interviews were firstly conducted to obtain a more comprehensive perception from the senior industry professionals in order to add depth to the research data. The findings from the interviews will be used to establish and validate the following online questionnaire.

4. Analysis and research findings

The author conducted separate interviews with five individuals from three companies, ranging from owner (3 nos), consultant (1 no) and contractor (1 no). Those interviewees come from prominent local/international companies, most of them are at senior posts with a combined 76 years experience in the industry in which, combined 49 years experience is in UAE.

The interview result shows that although the concept of Lessons Learned is well known in the construction project management field, the deeper understanding as a process as well as the formation in other fields (such as organizational learning and knowledge management) needs to be spread and strengthen. Lessons Learned practice does happen in the project life cycle, by an individual's initiatives, an informal project practice or a formal company mandatory practice. Professionals often record good or bad lessons by the end of a project and lessons learned are normally collected in the final project review meetings. Verifying lessons are normally done by project manager who is in charge and distribution is limited within the project team. Lessons Learned database is not observed in any of companies with which 5 interviewees are currently working. The storage and retrieval are limited to the archived documentation level. All interviewees recommend the Lessons Learned practice in their companies, by citing the similar reasons and benefits, such as project improvement, reduction of risks, increasing company competitive edges etc. However the perceived barriers are various, due to the different perspectives. Legal risks are not referred or considered by all interviewees.

From the feedback of interviews, an on-line questionnaire was conducted in an aim to obtain more factual data from wider perspectives. The questionnaire was designed with the reference of peer suveys done by Fong and Yip (2005), Graham and Thomas (2007), Paranagamage et al (2012), Carrillo (2005). Around 110 email invitations were sent to professionals involved in the UAE construction industry. A total of 30 responses were obtained (response rate was 27%), among which 26 respondents completed the survey. So that 26 valid questionnaires were used in data analysis. Out of total 26 respondents, 5 respondents fall in the category of owner/developer (19%), 10 respondents fall in the category of consultant (42%) and 11respondents fall in the category of contractor. All of the main organization types are well represented and the survey equally covers all the aspects of respondents. Majority of survey respondents are from large organizations (58%) with more than 500 employees, while other respondents are from medium organizations (31%) with employees number from 101 to 500, there are around 11% respondents from small organizations with below 100 employees. 31% respondents come from the senior management level and 65% respondents come from middle management. They well represent the practitioners who are involved in the Lessons Learned practice. Total 65% respondents have worked in the construction industry for more than 10 years, with further breakdown of total 30% have worked for more than 10 years in the UAE construction industry. Around 62% respondents have worked in the UAE construction industry between 6 to 10 years. This reflects that the targeted respondents have adequate experience to answer and comment the Lessons Learned topic, which leads to a fair and objective survey result.

Table 1: Respondents familiarity with Lessons Learned

What is the level of Lessons Learned practiced in your company?		
Answer Options	*Response Percent*	*Response Count*
Unaware of value added / no personal interest	*7.7%*	*2*
Individual practice on one's own initiative	*26.9%*	*7*
Informal company practice ad hoc (not a mandatory company procedure)	*38.5%*	*10*
Formal company practice (mandatory)	*26.9%*	*7*

Table 2: Level of Lessons Learned in respondents companies

Have you ever heard of "Lessons Learned" in the construction industry?		
Answer Options	*Response Percent*	*Response Count*
Yes	*88.5%*	*23*
No	*11.5%*	*3*

88% of respondents have heard of "Lessons Learned" in the construction industry, which is good news and indicates the concept is popular among the UAE practitioners. However only 27% respondents consider their companies have the formal Lessons Learned incorporated in the company procedures. When divided by company categories, further analysis shows that 20% owners and 41.67% consultants state that their companies practice formal Lessons Learned, while only 9% contractors state the same. This certainly shows that although the concept is popular, the formal Lessons Learned practice is not pervasive among organizations in the UAE construction industry, with the least formal Lessons Learned practice, appears among contractors. Total 7 respondents say their companies have formal Lessons Learned. Among them 5 respondents (71.4%) are from the category of consultant, 1 respondent (14.3%) is from the owner side and 1 respondent (14.3%) is from the contractor side. This indicates that consulting companies are ahead of owner and contracting companies in terms of formal Lessons Learned practice. They are the main implementer in the UAE construction industry. The result is contrary to the survey done in the North American (CII, 2007c), where shows contractors are the leading force of Lessons Learned programme.

Table 3: Frequency of recording good practice during the running of projects

Do you often record good practice during the running of projects?						
Answer Options	*Often (4)*	*Sometimes (3)*	*Seldom (2)*	*Never (1)*	*Mean*	*Response Count*
For individual use	*15*	*10*	*1*	*0*	*3.54*	*26*
For team members' use	*12*	*10*	*4*	*0*	*3.31*	*26*
As a company asset	*10*	*11*	*3*	*2*	*3.12*	*26*

Table 4: Frequency of recording good practice upon completion of projects

Do you often record good practice upon completion of projects?						
Answer Options	*Often (4)*	*Sometimes (3)*	*Seldom (2)*	*Never (1)*	*Mean*	*Response Count*
For individual use	*14*	*10*	*1*	*0*	*3.52*	*25*
For team members' use	*14*	*7*	*5*	*0*	*3.35*	*26*
As a company asset	*14*	*7*	*3*	*2*	*3.27*	*26*

Overall, most respondents sometimes/often record good practices for individual use, for team use and as a company asset, during the running project and upon completion of projects. However professionals record lessons more often for individual use, than for team use and much more often than for company use.

Table 5: Frequency of recording bad practice during the running of projects

Do you often record bad practice during the running of projects?						
Answer Options	*Often (4)*	*Sometimes (3)*	*Seldom (2)*	*Never (1)*	*Mean*	*Response Count*
For individual use	*11*	*8*	*4*	*3*	*3.04*	*26*
For team members' use	*10*	*8*	*5*	*3*	*2.96*	*26*
As a company asset	*9*	*8*	*4*	*5*	*2.81*	*26*

Table 6: Frequency of recording bad practice upon completion of projects

Do you often record bad practice upon completion of projects?						
Answer Options	*Often (4)*	*Sometimes (3)*	*Seldom (2)*	*Never (1)*	*Mean*	*Response Count*
For individual use	15	5	3	3	3.23	26
For team members' use	13	6	4	2	3.20	25
As a company asset	12	5	5	4	2.96	26

The rate of recording bad practices is lower than that of recording good practices during the running of projects and upon completion of projects. It is understandable that professionals avoid recording bad practices, as it is unpleasant and it might affect their career, or they may not see any value in them.

Table 7: Rating the methods used for sources of lessons learned

What are the methods used for sources of lessons learned?							
Answer Options	*Strongly Agree (5)*	*Agree (4)*	*Neutral (3)*	*Disagree (2)*	*Strongly Disagree (1)*	*Mean*	*Response Count*
Formal discussions with team mates	6	17	3	0	0	4.12	26
Informal discussions with team mates	9	13	4	0	0	4.19	26
Intranet / company database	6	11	7	2	0	3.81	26
Weekly internal sharing meeting	5	16	3	2	0	3.92	26
Weekly external progress meeting	2	16	6	2	0	3.69	26
Failed practice in projects	11	11	4	0	0	4.27	26
Good practice in projects	13	10	3	0	0	4.38	26

Overall, most of respondents strongly agree or agree all above methods as good sources of lessons learned. Respondents rank that good practice and failed practice are the two highest ranks among all sources. The finding is in line with the literature review that both positive and negative experience can be the sources for the lessons learned.

Table 8: Rating the timing of acquiring lessons learned

When is the appropriate timing for acquiring lessons learned?							
Answer Options	*Strongly Agree (5)*	*Agree (4)*	*Neutral (3)*	*Disagree (2)*	*Strongly Disagree (1)*	*Mean*	*Response Count*
Milestone reviews	11	13	2	0	0	4.35	26

After key decision making	*5*	*16*	*5*	*0*	*0*	*4.00*	*26*
After completion of a project	*12*	*13*	*0*	*1*	*0*	*4.38*	*26*
After a good practice	*8*	*16*	*2*	*0*	*0*	*4.23*	*26*
After a bad practice	*10*	*14*	*2*	*0*	*0*	*4.31*	*26*

Most of respondents strongly agree or agree that all of the above timing is appropriate for acquiring lessons learned. With the highest rank for "after completion", followed by "milestone reviews" and "after a bad practice", in fact, there is no time limit for recording lessons. The professionals shall record lessons as soon as they are discovered.

Table 9: Rating the channels of distributing lessons learned

What are the suitable channels for distributing/sharing lessons learned?							
Answer Options	*Strongly Agree (5)*	*Agree (4)*	*Neutral (3)*	*Disagree (2)*	*Strongly Disagree (1)*	*Mean*	*Response Count*
Document distribution	*10*	*13*	*3*	*0*	*0*	*4.27*	*26*
Intranet (internal access)	*9*	*13*	*4*	*0*	*0*	*4.19*	*26*
Company website (public access)	*4*	*9*	*7*	*5*	*1*	*3.38*	*26*
Email distribution	*8*	*9*	*6*	*2*	*1*	*3.81*	*26*
Lessons Learned meetings	*14*	*10*	*1*	*0*	*0*	*4.52*	*25*

Overall, the respondents agree Lessons Learned meetings, Document distribution and Intranet, as suitable channels for distributing and sharing lessons learned (the 3 highest ranks). There are 3 respondents (11.5%) disagree/strongly disagree Email distribution and there are 6 respondents (23%) disagree/strongly disagree Company website (public access) distribution. Professionals do not seem to recommend these two methods as these methods may touch the sensitivities of confidentiality or due to the culture factors.

Table 10: Reasons and benefits for introducing lessons learned

If yes, what are your reasons and the benefits for introducing lessons learned?						
Answer Options	*Strongly Agree (5)*	*Agree (4)*	*Neutral (3)*	*Disagree (2)*	*Strongly Disagree (1)*	*Mean*
Project improvement in terms of Cost, Time and Quality	*18*	*8*	*0*	*0*	*0*	*4.69*
Minimize project risk	*16*	*10*	*0*	*0*	*0*	*4.62*
Reduce variation orders	*10*	*10*	*5*	*1*	*0*	*4.12*
Improve team coordination.	*15*	*10*	*1*	*0*	*0*	*4.54*
Encourage project learning	*15*	*10*	*1*	*0*	*0*	*4.54*
Increase company's competitive edge	*16*	*9*	*1*	*0*	*0*	*4.58*
Enhance company's reputation	*17*	*9*	*0*	*0*	*0*	*4.65*

All respondents (100%) agree to include or recommend Lessons Learned practice in their companies, which is expected. Most of the professionals agree all listed reasons, with project improvement in terms of cost, time and quality, enhance company reputation and minimize project risk, being the most 3 highest ranks. It seems some professionals show their doubts on the effect of "reducing variation orders". This is probably due to the fact that many variation orders are unpredictable at the beginning of the project and uncontrollable during the project execution, which definitely limits the applicability and effects of Lessons Learned.

Table 11: Barriers and risks for introducing lessons learned

What are the barriers and risks for introducing lessons learned?						
Answer Options	*Strongly Agree (5)*	*Agree (4)*	*Neutral (3)*	*Disagree (2)*	*Strongly Disagree (1)*	*Mean*
Project performance is good enough	2	10	6	7	1	3.19
Unware of value added	5	11	6	3	0	3.72
Lack of training in the topic	5	16	3	2	0	3.92
Lack of learning culture	5	17	2	2	0	3.96
Lack of time	7	11	3	5	0	3.77
Lack of technical infrastructure	3	12	6	4	0	3.56
Lack of top management support	7	12	4	3	0	3.88
Afraid to be blamed for mistakes	11	9	5	1	0	4.15
Insuficient distribution and difficult in retrieving lessons	3	11	6	5	1	3.38
Difficult to apply a lesson to another project	1	8	8	6	2	3.00
Legal risk	3	7	7	6	2	3.12

After analysis of the data, the most affective factors which respondents strongly agreed, are found, they are Afraid to be blamed (1st rank), Lack of learning culture (2nd rank) and Lack of training in the topic (3rd rank). It indicates that in the Middle East region, the tradition and culture greatly influence people's thoughts. Being afraid to be blame is professional's most concern, when Lessons Learned practice is to be adopted. The above survey indicated that legal is one of the least barriers for introducing Lessons Learned in UAE. However legal issues are the main barrier, preventing many companies in North America from the practice of Lessons Learned. This is probably due to the lack of company sponsored Lessons Learned programme in the region, most of practitioners conduct Lessons Learned in an informal way. In another words, we have not reached such maturity to consider the legal risks.

Table 12: Rating ways of improvement of lessons learned

Regarding the way of improvement, please rate and put in sequence order (1 is the most important, 7 is the least).								
Answer Options	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*Rating Average*
Strategically include lessons learned into corporate company policy and procedures	*13*	*3*	*5*	*1*	*1*	*2*	*1*	*2.38*
Team leaders and project managers should be required to search for Lessons Learned before the start of new projects and conclude Lessons Learned by the end of a project	*6*	*5*	*5*	*4*	*3*	*3*	*0*	*3.08*
Include Lessons Learned in the project programme/manuals, preferably linkng to project stage gates	*1*	*8*	*7*	*6*	*4*	*0*	*0*	*3.15*
Include Lessons Learned in the consultant's scope of work	*0*	*1*	*1*	*7*	*3*	*5*	*9*	*5.42*
build up a Lessons Learned data base, with regular maintenance	*2*	*4*	*2*	*3*	*11*	*3*	*1*	*4.15*
Appoint an external facilitator for training and conducting Lessons Learned	*0*	*0*	*1*	*3*	*1*	*13*	*8*	*5.92*
Promote learning culture and learning habit within an organization	*4*	*5*	*5*	*2*	*3*	*0*	*7*	*3.88*

After analyzing the data, “strategically included Lessons Learned into corporate company policy and procedures” occupy the 1st rank position. The result is in line with the literature review that leadership is the most important factor for Lessons Learned practice. “Team leaders and project managers should be required to search for Lessons Learned before the start of new projects and conclude Lessons Learned by the end of a project” (2nd rank) and “Include Lessons Learned in the project programme/manuals, preferable linking to project stage gates (3rd rank), imply that formal lessons learned programme is preferred by professionals, to enforce the implementation.

5. Conclusions and Recommendations

The survey shows that in the UAE construction industry, Lessons Learned practice is mainly performed in an informal way (individually or ad hoc) in spite that the concept of Lessons Learned is familiar by most of professionals in the project management. Thus the formal Lessons Learned programme is not pervasive either. Consulting companies are the leading force for practicing the formal Lessons Learned programme in the UAE construction industry and the contracting companies are the least practitioners in spite the fact that there are much more contracting companies, than consulting companies here in the UAE. The survey also shows that professionals record lessons more often for an individual use than for a team use, and much more often than for a company use. Lessons are normally recorded at the end of the project and good practices are referred more than bad practices. The verification of lessons, is commonly done by the project manager who is in charge. The distribution is within the team and sharing will take place via a Lessons Learned meeting, or company's intranet. The professions do not prefer channels for sharing lessons via email distributions or public websites. "Afraid to be blamed" is the number one barrier of Lessons Learned. It indicates that in the Middle East region, the tradition and culture greatly influence people's thoughts. Unlike their western counterparts, professionals in the UAE seem less concerned on legal risks.

With the consideration of the immature status of Lessons Learned practice in the UAE, it is evident that the current focus is to promote the usage of Lessons Learned, as well as enhancing the existing Lessons Learned programme. The authors proposed seven options as follows:

- Strategically include Lessons Learned into corporate company policy and procedures (1st rank)
- Team leaders and project managers should be required to search for Lessons Learned before the start of new projects and conclude Lessons Learned by the end of a project (2nd rank)
- Include Lessons Learned in the project programme/manuals, preferably linkng to project stage gates (3rd rank)
- Promote learning culture and learning habit within an organization (4th rank)
- build up a Lessons Learned data base, with regular maintenance (5th rank)
- Include Lessons Learned in the consultant's scope of work (6th rank)
- Appoint an external facilitator for training and conducting Lessons Learned (7th rank)

The authers also suggest a separate feasibility study on the applicable Lessons Learned system, to supplement the current research. The authors have realized that although few companies are ahead of the rest of the majority, by having formal Lessons Learned programme in place, the Lessons Learned process (collection, analysis and implementation) has been limited in a traditional way. Lessons Learned database does not exist, while lessons are stored randomly together with archived documents. It is necessary to find an applicable Lessons Learned system to support both online and offline Lessons Learned processes for better efficiency.

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Examining the Viability of Windows Impact/Update Method for Delay Analysis in Construction Disputes

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Abstract

Nowadays, construction delay disputes often end up on the arbitration route where the delay experts appointed by the parties advise the tribunal on the extension of times entitlements of the parties. For this purpose, the identification and quantification of concurrent and pacing delays are integral aspects of resolving these disputes using a proper delay analysis methodology. The aim of the study is therefore, threefold. Firstly, the available literature on the concurrent and pacing delays are analysed in detail to establish the principles for the evaluation of the concurrency and pacing delays. Secondly, a robust delay analysis methodology called 'windows impact/update method' is explained often used by the experts for the effective quantification of concurrent and pacing delays. This methodology is an improved version of time impact analysis and normal windows analysis. For better demonstration, the explanation of the methodology is facilitated with the help of a typical case study analysis. Finally, the principles of concurrency and pacing, as explained in the literature review, are promptly applied to the case study results to show the applicability of the analysis method on any types of delay disputes. The study shows the effectiveness of the windows impact/update method for the quantification of the concurent and pacing delays.

Keywords: Concurrency, Pacing, Windows Impact/Update Method, Arbitration, Expert Witness

1. Introduction

Historically, the evaluation of the extension of time and quantifying the various aspects of delays such as EOT, concurrent delays, pacing delays and and compensation for delay in construction is a disputed field of work (Gibson 2008). Once the dispute is excalated to the arbitration route, then the delay analysis would be carried out by 'expert witnesses'. The experts are appointed to give evidence on the aspects of either 'delay' or 'quantum' matters and their opinion may be in the form of a report called expert witness report and they will be cross examined in the court of Arbitration (Uff 2005).

To facilitate an independent report, the experts use the most appropriate delay analysis methodology. Even though there are many delay analysis methodologies available, a common-sense approach using an analysis method which uses contemporaneous progress is preferred. That is the reason the experts normally use windows impact/update method which is an 'actual' based method which can effectively quantify the concurrent and pacing delays.

The sections below review the principles of concurrency and pacing together with the procedure of conducting windows impact/update method. Further to this, these principles are tested with a sample case study which will illustrate the quantification of all aspects of delays.

2. Research Methodology

Even though there are many methods for conducting research, the case study analysis is one of the best qualitative research methods. Denzin and Lincoln (1994) defined qualitative research as the *"...studied use and collection of a variety of empirical methods – case study, personal experience, introspective, life story, interview, observational, historical, interactional, and visual texts…"*. Further Creswell (2007) explained that the case study research is the study of an issue or issues explained through one or more case studies. Therefore, the authors will use case study analysis as the research analysis method for this particular study.

Through research, the authors will collect all the information related to the case study from the lead expert witness related to a construction delay dispute and then discuss and interpret the results from the case study as explained in the relevant sections.

3. Concurrent Delays

Quite often in contraction contracts, the delays do not necessarily act alone but occur as a combination. When more than one delay event occur at the same time, then these delay events are said to be concurrent delays. In a first glance, there seems to be no agreement in analysing and calculating the concurrent delays due to differing legal principles. This is because of the fact that it requires the consideration of many factors affecting the contract such as the level of criticality of activities & technical integrity of the programme, float, the time of occurrence of the delays and their criticality, identification of the pacing delays, method of delay analysis, contractual provisions in the contract as well as legal provisions applicable to the contract. However, over the course of time, some approaches were developed for the identification and quantification of concurrent delays as discussed below.

3.1 Identification of concurrency

In order to verify that the delays in question are valid concurrent delays, first check would be to decide whether the delays are concurrent or consecutive as suggested by Gibson (2008). This can be done by reviewing the project critical path; delays will generally be consecutive unless there are two or more than two critical paths. For two delays to be concurrent, both of them should impact the critical path. Even if there are multiple critical paths in a project, it is quite un-common for the true concurrency to occur. Once it is established that there are concurrent delays present, then the delays have to be analysed further to identify and calculate two separate issues which are (A) calculate EOT entitlement in a concurrent delay situation and (B) calculate the total compensable period for which the employer should pay compensation and the period for which the employer can levy LDs.

3.2 Concurrent Delay Principles

This section reviews in brief the current literature available on the topic of quantification of concurrent delays.

3.2.1 The Devlin approach

As indicated by Williamson (2005), the Devlin approach is based on the judgement by Judge Devlin in a UK case[1] as explained in 'Keating on building contracts (para 8-25)'. Based on this approach, if there are two concurrent delay events one of which is an excusable compensable delay event and other is a contractor culpable delay event or even a neutral event, then the contractor would be able to recover time and cost. However, Pickavance (1997) indicated that the learned authors of Keating considers that this approach is not strictly applicable for contraction contracts because it would result in a scenario where both the Employer's claim for LDs and the Contractor's claim for loss and expense could succeed.

3.2.2 The Burden of Proof approach

Pickavance (1997) explained that if there are two causes and the claimant in in breach of contract, it is down to the claimant to show that the loss was caused otherwise than by his breach. Again, Pickavance (1997) indicated that the learned authors of Keating considers this method is very difficult to use in concurrent delay situations as both the claimant's claims for loss and expense and respondent's claim for LDs will fail as it has the opposite effect of Devlin position.

3.2.3 The Dominant Cause approach

This approach suggests that if there are two cause of delay, the effective or the dominant cause is to be considered as the deciding factor for the delay. Unlike the previous two approaches, this approach can be applied to alleged concurrent delays by seeking to establish which is the dominant cause of any particular period of delay; with the successful party being entitled to his loss and expense or liquidated damages as applicable. However, Pickavance (1997) stated that the dominant cause approach is a legal theory relevant to recovery of damages; not to provide relief from damages. There are many UK court cases[2] where the court rejected the dominant cause approach to calculate EOTs in concurrent delay situations. Further, Thomas & Wright (2011) pointed out based on 'Keating (para 8.021)' opinion that

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[1] *Heskell v Continental Limited [1950]* 1 All England 1033

[2] H. Fairweather and Co Ltd v London Borough of Wandsworth (1987) 39 B.L.R. 112

the dominant cause approch should not be used in extension of time situations, but can be applied to calculate compensation (or compensation periods) after the EOT has been identified and quantified.

3.2.4 The Malmaison approach

The famous Malmaison case[3] in UK in 1999 provided recommendations on the concurrent delay scenarios. The Judge Dyson in his judgement accepted that: *"……if there are two concurrent causes of delay, one of which is a relevant event, and the other is not, then the contractor is entitled to an extension of time for the period of delay caused by the relevant event notwithstanding the concurrent effect of the other event.* Obviously, the Society of Protocol (2002) supported this approach for the calculation of EOT. Core Principle 9, which deals with concurrent delay for computing EOT states that where concurrent delay occurs, the Contractor's concurrent delay should not reduce any EOT due to the Contractor. This approach was further supported in many UK cases[4]. Kheng (2003) suggests that the favourable method is the Malmaison approach on EOT even though there is a clash between the Malmaison approach and the dominant cause approach on concurrency. However, as explained by Thomas and Wright (2011) based on the views of 'Keating on Building Contracts' this approach is best suited to calculate EOT in concurrency.

3.2.5 Apportionment

Williamson (2005) commented about this approach based on the view of 'Keating on Building Contracts' that where there are two competing causes of delay of equal or relative causative potency, this approach suggests that the time overrun and its consequences should be 'apportioned' between the contractor and the employer on the basis to their relative causative potency. This approach is applicable in cases where the causes of the loss are truly concurrent in the sense that both causes operate together at the same time to provide a single consequence. Thomas and Wright (2011) also agreed to this apportioning of liability in case of concurrent delay events.

In a recent Scottish case[5], Lord Drummond Young made his judgement based on the dominant cause approach and apportionment approach for the quantification of concurrent delays related to EOT and compensation. However, as stated by Eyssell (2010), UK courts have not yet supported the apportionment approach for compensation in concurrent delay situations and they are still following 'all or nothing' on approach to liability. However, the authors consider that this is a good approach if it can be applied in a balanced way as it can satisfy the rule of 'natural justice' which is the basis of common law (Uff 2005).

3.2.6 First –past-the-post approach

As pointed out by Gibson (2008), this is based on the logic that the cause of delay, which occurs first in terms of time, will be used first to evaluate the impact on delay to completion. All the other causes of delay will be ignored unless they affect the completion date and continue after the first cause has

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[3] *Henry Boot Construction (UK) Ltd. V Malmaison Hotel (Manchester) Ltd (1999)* 70 ConLR 32

[4] Royal Brampton Hospital NHS Trust v Hammond & Ors(No 7) [2001] 76 Con LR 148

[5] City Inn Limited v Shepherd Construction [2007] CSOH 190

ceased to have any delaying effect. In this case, only the latter part of the second delay will be relevant to the calculation of an extension of time.

3.3 Recent guidelines in concurrency by practitioners

Gibson (2008) agrees with the SCL Protocol (2002) on the issue of calculation of EOT in concurrency situation and concludes that the most popular guideline for calculating EOT in concurrency is the use of malmaison approach. Therefore the authors consider that the Malmaison approach is best method suited for the calculation of EOT in concurrency situations.

For the calculation of compensation and compensation periods, Thomas & Wright (2011) tried to establish the principles with the help of conclusions made in 'Keating on Building Contracts, eighth edition (pages 271-6)' and other authors. These are:

1. Reimbursement of loss and expense is allowed if the compensable excusable delay is on the critical path and the non-compensable delay is non-critical;
2. No reimbursement of loss and expense is allowed if a compensable excusable delay is non-critical or not on critical path and a non-compensable delay is on the critical path;
3. No reimbursement of loss and expense should normally allowed if both the non-compensable delay and the compensable excusable delay are on parallel critical paths and are of the same duration;
4. If a compensable excusable delay event occurs first followed by a non-compensable delay event (with both delay events being on the same or parallel critical paths), recovery of loss and expense is normally permitted;
5. When a non-compensable delay event occurs first followed by a compensable excusable delay event (with both delay events being on the same or parallel critical paths), there are grounds to argue that no reimbursement should be permitted.

As indicated by Thomas & Wright (2011) and the authors too agree that the departure from the above guidelines occur time to time but in rare situations only. Therefore, the authors recommend the malmaison and dominant cause approaches to calculate the EOT and compensable periods (or compensation) in a concurrency situation respectively. Also, the apportionment for the calculation of concurrency is widely used in USA, but the UK has not yet started to apply this. Nevertheless, the authors consider that this could be a good method if applied in a controlled and balanced way.

4. Pacing Delays

In the construction industry pacing is best explained as 'work expands to fill available time' which is similar to the saying 'gas expands to fill available space' (Rider & Long 2013). It is not un-common for an employer caused critical path delay to extend the performance of other non-affected contractor's activities, which consumes the available float due to the employer delay. This is called as pacing.

As indicated in the SCL Protocol (2002) and as pointed out by Gibson (2008), the employers are not liable to pay costs to the contractor if a contractor culpable delay is occurring simultaneously with the employer culpable delay. However, it is seen in most of the cases that when the employer culpable excusable delay occurs, the contractor slows their work considerably. As commented by Keane & Caletka (2008), the contractor's rationale in this situation will be "why should I hurry up and then wait?" The name "pacing' rightly emerged from this scenario. For this pacing delay to be considered by the other parties or by the arbitration tribunal, the contractor should make sure to prove that the contractor culpable delay is not an independent delay, but an after effect of the employer's culpable delay (Bramble & Callahan 2011).

AACEI's Recommended Practice 29R-03 (2011)[6] explains that the aspect which separates the pacing delays from the concurrent delays is that pacing is an effect of a conscious choice by the party (either contractor or the employer) to carry out the works at a slow rate. This might be due to their prior knowledge that contemporaneous delay in an activity by the other party is already delaying the completion and therefore, they do not want to complete the works first and then wait for the delayed works to complete. On the other hand, concurrent delays are independent of each other with no conscious effort from both the parties to slow down the works.

4.1 Pacing & compensation

As evident from the above, in a pacing delay situation, the contractor is only consuming the additional float created by an already occurred employer delay. Rider & Long (2013) explains that the right to pacing is acceptable due to the fact that the available float is shared between the parties. The SCL Protocol's (2002) view is also consistent with this as the protocol indicates that the float is recommended to be consumed by the party who requires it first and can be shared between the parties too. However, if the contractor is responsible for the delays due to lack of resources, then this cannot be considered as pacing, as it will be just contractor culpable delays.

Once agreed in the dispute situation, pacing delay changes the compensability of the delays in a concurrent delay situation (Rider & Long 2013). If the contractor's pacing is acting with the employer delay, then the delay is excusable and compensable to the contractor. Similarly, if the employer is pacing with the contractor's culpable delay, then the delay is compensable to the employer but non-excusable and non-compensable to the contractor. Therefore, the identification of pacing is very important in the context of the construction delay disputes.

4.2 Identification of pacing delay

In order to identify pacing delay situation in a typical construction delay dispute, AACEI RP 29R-03 (2011) and Keane & Caletka (2008) provided some guidelines as indicated below. If the contractor is putting forward the pacing argument, they should provide evidence for the below items.

1. A predecessor dependent delay should precede a pacing delay, which is a minimum requirement to have a pacing delay to exist;
2. Evidence that the contractor could resume progress on a paced activity with the original output (or un-paced rate);
3. Evidence of an express decision to pace the works; and finally
4. The contractor should produce evidence that the pacing was a conscious and deliberate decision from their part at the time of pacing. This should be in the form of a letter to the employer with their intention to pace the works.

[6] Recommended Practice 29R-03 – Forensic Schedule Analysis published by AACEI in 2011

Without these four conditions met, a pacing delay will not be identified and recognised in a dispute. Keane & Caletka (2008) considers that when pacing delays are argued with hindsight, it should be treated with both caution and scepticism especially when the assertion is unsupported by contemporaneous records. Based on this, if no documentation is made available to justify pacing delay, then the contractor's concurrent delays shall not be considered as pacing delays and the contractor should face the consequences of the resulting concurrent contractor culpable delays.

5. Windows Impact/Update Delay Analysis Method

Farrow (2001) indicated that experts always prefer a common-sense based delay analysis method which uses contemporaneous progress data over other theoretical methods. Out of all the methodologies available which are used in the industry, the widely accepted methodology is considered to be Tim Impact Analysis or simply called as TIA (SCL Protocol 2002). This is due to the fact that TIA takes account of the progress of the works at the time of the delay, mitigation of the delays, concurrent delays etc. However, Pickavance (1997) considered that 'window analysis', which is similar to TIA, is equally effective as the TIA. Pickavance (1997) noted that the window analysis, which focuses on sequential periods of project performance (windows) on a contemporaneous critical path, has significant benefits over other methods. He commented that since this method is based on the actual progress (not theoretical), it is considered to be a robust method of analysis.

Farrow (2001) indicated that an updated version of the windows and TIA called 'the windows impact/update method' is the best method to calculate the various aspects of delays. Using this impact/update method under window analysis, the delay events are impacted into the contemporaneous progress updated programmes on a month by month basis (the windows) to calculate the monthly entitlement as well as the contractor's actual performance (whether slow progress or acceleration) for that month or model. Kelly (2013) also agrees to the acceptance of windows method as the most effective method for conducting forensic schedule analysis. The windows impact/update method makes the process of calculating EOT periods and compensable periods easy even if concurrent delays are present. That is why Farrow (2001) considers that this is one of the best methods.

The pre-requisites to conduct a windows impact impact/update analysis are:

1. A logic linked proper CPM networked programme preferably in primavera software (called as the 'baseline programme');
2. Periodically (weekly/monthly) updated contemporaneous as-built programmes based on the baseline;
3. A strategy to divide the total contract duration in to a number of windows based on project milestone dates, start/end of a major delay events or based on progress update periods (monthly or every two months etc.);
4. Chronologically listed delay events affecting the project; and
5. Properly networked delay fragnets which represent the delay events;

Once the above stated details of the project are ready, then the expert can start the delay analysis. As the name suggests, the sequence of this window analysis is to impact first followed by updating as explained below. For carrying out the '**impact**' part of the window analysis on window 1, the first step is to insert the delay fragnets (the activities representing the delay events) present in this window 1 period into this programme to time impact their effect. This process is indicated in figure 1 below.

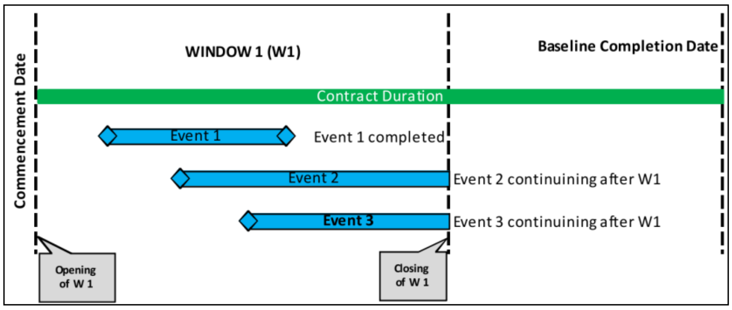
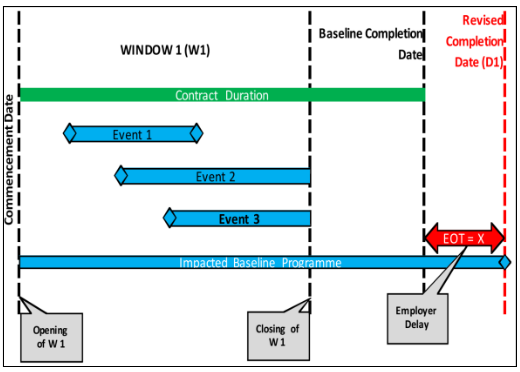


Figure 1 :Example: Impact of delay events for W1

When this programme is rescheduled, if the completion date has moved forward, the difference between the revised completion date and the baseline complete date is the EOT entitlement to the contractor due to the delay events. This process is shown in the figure 2 below.

For the '**updating**' part of the analysis, a copy of this window 1 impacted programme is made and then this programme is updated with actual progress achieved during the first window period. Then reschedule the programme to determine the effect of progress inserted. If the completion date has moved to a later date, then the contractor is culpable for the additional period of delay as shown in figure 3 below. However, if the completion date has moved to an earlier date, then the contractor has managed to mitigate part of the delay.



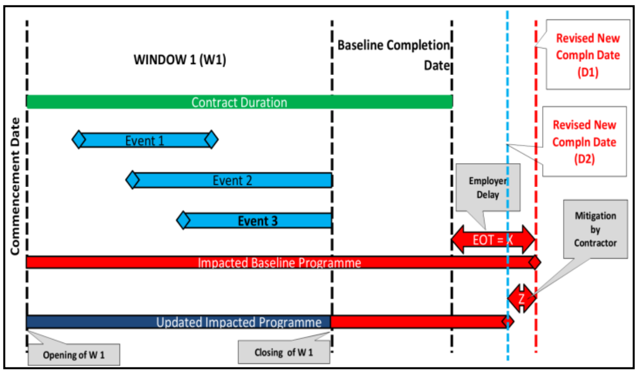


Figure 2 : Impact delay from W1 *Figure 3 : Update delay from W1*

This iterative process is then repeated for window 2 and so on until the last window. As the analysis commences with the baseline programme and ends with a re-scheduled programme at the end of the last window, any effect upon completion date is allocated incrementally to the contractor or to the employer. The total EOT is calculated by considering the sum of the delay results that are calculated in each window (after the 'impact' process) which represents the overall time extension for the project. In each window, a comparison of the 'impacted' programme completion date to the 'updated' (as-built) programme actual completion date determines:

1. The amount of contractor culpable delay in the as-built programme that is subject to delay damages (penalties) if the as-built completion date is later than the impacted completion date.

This means that the concurrent delay due to the contractor culpable delays (slow progress) is the critical delay and therefore, the contractor is only entitled for EOT but no compensation.

2. The amount of acceleration that the contractor has accomplished if the as-built completion date is earlier than the update impacted completion date.

The strength of this approach is that it takes into consideration actual progress and revised programme intent in a logical manner. Issues such as mitigation, criticality, concurrency, and dominance are all taken into account in a transparent manner, leading to a better understanding of what occurred and the circumstances at the time the events occurred. Therefore, the expert reports prepared with this window impact/update analysis provides the tribunal or court enough evidence on the merits on the case with which they can make their judgements.

Once the above analysis of windows is completed, next step is to calculate the various matters related to the delay such as the contractor culpable delays, concurrency, pacing and compensable periods etc. This is explained with the help of a case study analysis in the following section.

6. Case Study Analysis

6.1 The Case study Project & Dispute

In order to test the concurrency and pacing principles as concluded in the study above, a case study project (construction of Tower + Car park) was analysed using windows impact/update method. The total project duration of 1,268 days (original time for completion of 700 days + 568 days of delays) was broken down in to 11 windows as indicated below based on the start/finish of major events.

	Window 1	Window 2	Window 3	Window 4	Window 5	Window 6	Window 7	Window 8	Window 9	Window 10	Window 11
8-Jan-07	31-Aug-07	30-Sep-07	1-Mar-08	12-Apr-08	31-May-08	30-Aug-08	4-Oct-08	26-Mar-09	1-Oct-09	25-Feb-10	28-Jun-10
	Original Time for Completion (700 days)							Extended Duration (568 days)			

Figure 4 : Case study project delay analysis - Splitting of windows

The windows impact/update delay analysis essentially consisted of the following operations:

1. Copy the baseline programme and rename it as programme K01A to start window 1 analysis;
2. To start the 'impact' process, insert the fragnets of delay events present in this window 1 period into this window 1 programme for analysis of their effects.
3. Reschedule the programme to calculate any entitlement to an extension of time. If the completion date has moved forward, the difference between the new date and the original complete date is the entitlement to the claimant due to the delay events for window 1. If there is no change to date then there are no contractor culpable delays.
4. To start the 'update' process of the analysis, copy this impacted programme for window 1 and rename it as programme K01B for updating progress;
5. Update the programme with actual progress achieved during the first window period;
6. Then reschedule the programme to determine the effect of progress being inserted. If the completion date has moved to a later date, then the claimant is culpable for the additional period of delay. If the completion date has moved to an earlier date, then the claimant has

managed to mitigate part of the delay. If the completion date does not change, then the progress is on schedule and the delay is purely excusable and compensable and the culpability for any delay can then be recorded; and finally

7. This process is then repeated for other windows one by one until the last window.

The analysis was performed using primavera (P3) software because this was the same software with which the baseline programme was originally prepared with ‘retained logic’ option selected during analysis as required by contract. Based on the steps stated above, the windows impact/update analysis was conducted.

6.2 Result of analysis & interpretation

A summary table showing the results of the ‘impacting’ and ‘updating’ process is provided in table 1 below. The interpretation of the results with detailed explanation is provided below on how the identification and quantification of concurrent delays, pacing delays, EOT and compensable periods are carried out. For this purpose, similar windows are grouped together for interpretation.

Table 1 – Summary of windows impact/update analysis

Window No.		Programme Name	Description	total delay from window (Cal. days)	Delays Completion		Impact Delay	Update delay (over & above impact delay)	Remarks
					From	To			
8-01-07 to 31-08-07	1	K01A	**Event 2 - Car Park Delays**	83	7-Dec-08	28-Feb-09	83		Concurrent delays
		K01B	Contractor culpable delays (slow progress delays)	87	7-Dec-08	4-Mar-09		4	
01-09-07 to 30-09-07	2	K02A	**Event 2 - Car Park Delays**	26	4-Mar-09	30-Mar-09	26		Concurrent delays (with alleged pacing)
		K02B	Contractor pacing delays (delayed approval of lighting layouts)	42	4-Mar-09	15-Apr-09		16	
1-10-07 to 1-03-08	3	K03A	**Event 2 - Car Park Delays**	127	15-Apr-09	20-Aug-09	127		Excusable compensable delays only
		K03B	No contractor culpable delays (no concurrent delays)	0	20-Aug-09	20-Aug-09		0	
2-03-08 to 12-04-08	4	K04A	**Event 2 - Car Park Delays**	16	20-Aug-09	5-Sep-09	16		Concurrent delays
		K04B	Contractor culpable delays (slow progress delays)	26	20-Aug-09	15-Sep-09		10	
13-04-08 to 31-05-08	5	K05A	No excusable delays	0	15-Sep-09	15-Sep-09	0		Only contractor culpable delay
		K05B	Contractor culpable delays (slow progress delays)	32	15-Sep-09	17-Oct-09		32	
1-06-08 to 30-08-08	6	K06A	**Event 6 - DEWA Power On delay (delayed load schedule)**	38	17-Oct-09	24-Nov-09	38		Concurrent delays
		K06B	Contractor culpable delays (slow progress delays)	82	17-Oct-09	7-Jan-10		44	
1-09-08 to 04-10-08	7	K07A	No excusable delays	0	7-Jan-10	7-Jan-10	0		Only contractor culpable delay
		K07B	Contractor culpable delays (slow progress delays)	32	7-Jan-10	8-Feb-10		32	
5-10-08 to 26-03-09	8	K08A	No excusable delays	0	8-Feb-10	8-Feb-10	0		Mitigation of delays by contractor
		K08B	Mitigation of slow progress delays by contractor	-19	8-Feb-10	20-Jan-10		-19	
27-03-09 to 01-10-09	9	K09A	No excusable delays	0	20-Jan-10	20-Jan-10	0		Only contractor culpable delay
		K09B	Contractor culpable delays (slow progress delays)	54	20-Jan-10	15-Mar-10		54	
2-10-09 to 25-02-10	10	K10A	No excusable delays	0	15-Mar-10	15-Mar-10	0		Only contractor culpable delay
		K10B	Contractor culpable delays (slow progress delays)	34	15-Mar-10	18-Apr-10		34	
26-02-10 to 28-06-10	11	K11A	No excusable delays	0	18-Apr-10	18-Apr-10	0		Only contractor culpable delay
		K11B	Contractor culpable delays (slow progress delays)	71	18-Apr-10	28-Jun-10		71	
			Total Excusable Delays	(sum of impact delays)			**290**		days
			Contractor Culpable Delays	(sum of update delays)				**278**	days
			Total Delay Period	(sum of impact and update delays)			**568**		days
			Total Compensable Delays	(excusable delay with no concurrent delay)			**127**		days

Group 1 – Analysis of concurrent delays (windows 1, 2, 4 & 6)

Review of the summary table above reveals that windows 1, 2, 4 and 6 are similar, in that there are concurrent delays present which means that there are excusable delays occurring concurrently with contractor culpable delays. The explanation of concurrent delay is provided with the help of a typical window (window 1), the same principle can be applied to the other windows in this group.

From window 1, the 83 days of excusable delay was concurrent with 87 days of slow progress delays with slow progress delays being on the primary critical path. This means that even if we remove the effect of the excusable delays from this programme, the project would be delayed due to the contractor's delays from this window by a period of 87 calendar days (from 07th December 2008 to 04th March 2009).

Based on the malmaison approach, the contractor was entitled to 83 calendar days of EOT from this window 1. However, based on the dominant cause approach, the contractor should not receive compensation for excusable delays during window 1 as the main cause of delay during this window was the slow progress delay by the contractor, which was driving the primary critical path. The same logic to be applied to windows 2, 4, and 6. The Claimant's slow progress delays were driving the primary critical path within all these contemporaneous window programmes and therefore, there was EOT entitlement to the contractor of 26 days, 16 days and 38 days from window 2, 4 and 6 respectively but no compensation due to the criticality of the concurrent contractor culpable delays.

Further, the contractor had claimed that they were pacing their works during the windows 1, 2, 4 and 6 period as the car park delay event was delaying the project as a whole and they just used the available float by slowing down their progress. However, this argument by the contractor was not accepted by the expert witness appointed by the employer as the stated slow progress delays were not pacing delays due to the main reasons that the contractor could not provide any evidence to show that they informed the employer at the time of pacing of their intention to pace the works. Therefore, the pacing argument was rejected.

<u>Scenario 3 – Excusable compensable delays only (window 3)</u>

A review of the summary table reveals that in window 3, there was only excusable delay (delay event 3 – car park delays) affecting the window and there were no contractor culpable delays affecting the contemporaneous critical path. Therefore, based on the principles, it is considered that the Contractor is due for 127 calendar days of EOT together with compensation for this 127 calendar days.

<u>Scenario 4 – Only contractor culpable delays (windows 5, 7, 9, 10 & 11)</u>

In windows 5, 7, 9, 10 & 11, there were no excusable delays but only slow progress delays present. Therefore, based on the principles, it is considered that the Contractor was not entitled for EOT for delays for those windows and that the employer could claim damages in the form of LDs/penalties for the contractor culpable total delays.

<u>Scenario 5 – Contractor's Mitigation (window 8)</u>

From window 8, there was no impact of the excusable delays during impacting exercise. However, when progress was updated for the window, the completion date was brought back by 19 calendar days by the mitigation of the previous slow progress delays. Therefore, this mitigation reduced the contractor's total culpable delays by 19 calendar days.

Conclusion of the results

Based on the analysis, the contractor was entitled for an EOT of 290 calendar days due to the excusable delays and compensation for a period of 127 calendar days out of the total 290 excusable delays. LDs were applicable for the contractor culpable delays (278 calendar days). The contractor's claim for pacing delays were rejected due to condition precedents not being met for a pacing argument to be valid which is consistent with the literature review findings.

7. Conclusions

The authors have reviewed and derived conclusions from all the available important case law judgements, work of professional bodies and the interpretation by various authors on concurrency and pacing. The advantages and disadvantages of the various theories before establishing recommended guidelines for practical use have been critically evaluated. The authors suggested that each case of concurrency is unique and therefore a case to case analysis to be carried out first. The use of malmaison approach for granting EOT and dominant cause theory for quantifying compensable periods in concurrency situations was examined thoroughly. The paper proved conclusively that with the windows impact/update methodology, it was very easy to identify and quantify all aspects of delays including concurrent delays.

As a recommendation, the study was limited in that only one case study was considered due to page space constraints. Given a wider context, further research could be carried out to expand the study to a number of case studies representing a wider area of construction disputes.

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Disputes Resolution: Can Bim Help Overcome Barriers?

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Abstract

Many researchers consider disputes as part of the project lifecycle. Although preventative actions exist, it is not utterly possible to avoid them. Once the disputes arise, an appropriate resolution technique should be adopted. Common perception is referring to a resolution method either internally or via a third party; which may also be binding by law. The resolution process requires attention to the disputed claims. Hence, deep investigation of the claims and choosing the appropriate method is crucial for the successful project delivery and reputation of the industry.
Preparation of disputed claims and resolution process also faces many debates. Conducting To effective dispute resolution requires attention to proper preparation and presentation of the incurred events. All the required information should be acquired to estimate and present the claim, for a smooth settlement. As an integrated digital model of the project, BIM, stores all the information of the projects in detail. Retrieval of the required information for the disputed issues can easily be obtained from the model. It is also possible to embed the construction schedule, change orders and variations, specifications and financial data such as cash flow along with the multidisciplinary drawings. As this model stores all the information at every particular time and phase, disputes can be concluded quick and accurate.

In this research, using a case study and literature review, disputes and resolution processes are deeply studied. A BIM model is created to investigate benefits on overcoming the challenges; during claiming, and resolution of the disputes. It is seen that the claims are prepared faster and more accurate in a visualized environment provided by BIM. Furthermore, substantiating and presenting the disputes for the resolution purpose was incomparable to the traditional methods. The conclusions recommend that; even the project did not adopt a BIM model earlier; it can be created for a smooth process, during claiming and resolution of disputes.

Keywords*:* Claims, Disputes, Dispute Resolution, BIM, Construction Industry

1. Introduction

The disruptive effects of claims and disputes on the project lifecycle is an invariably fact. Moreover, the methods used to resolve the issues, whether during the execution, or after the completion, are long and exhausting. The methods are judged as they are old and not capable to fulfil current industry needs. Although it is still not part of the traditional construction methodology, BIM can provide positive impact on the methods' success. The paper aims to highlight frequent occurrence of the disputes and the possible undesired consequences encountered on project lifecycle. Finally contribution of BIM for easy claiming and dispute resolution purpose is presented in order to understand how BIM can change the traditions in the construction industry by creating easy solutions.

2. Research Methodology

A Literature review will be conducted to obtain enhanced information on disputes, and resolution techniques. Dispute triggering reasons will be deeply investigated in order to avoid project disruption. Furthermore, the new trend in the construction market, BIM, will be studied through available publications to understand possible contribution on disputes and resolution processes. All the findings will be filtered through the aim. To provide a sound diagnosis, a case study is also presented which was recently performed within the construction industry. With in-depth analysis of the incurred events, the studied case study will point out the common issues that are transform into disputes and resolved via a popular resolution method; arbitration. The results of integrating BIM in the process will be observed and evaluated. Outlined results will be critically analysed, and discussions will be held to improve the dispute lifecycle using BIM models.

3. Literature Review

3.1 Drivers of Disputes in Construction Industry

In the event of a time or cost overrun or quality dissatisfaction, a claim arises to mitigate the undesired effects. The disturbance caused by disputes to projects is invariably significant. The stakeholders require their projects running smoothly with no risk of investment failure (AAA, 2007). Jahren and Dammeier (1990) conducted a research to identify the major dispute reasons. The risky nature of the construction industry, low bidding system and economic reasons were stated as important drivers. They also mentioned that the sources of these reasons are; different site conditions, payment delays, time delays, errors in tendering and ineffective communication.

The deficiency of contract documents, risks and uncertainties and human factors are also major dispute causes within the construction industry. In capability of contract documentation generates many conflicts and claims that led disputes. Contracts are often ambiguous to parties; scope is not properly defined, specifications are unclear or cost rate evaluations are not provided i.e. in evaluation of prime costs (Chenung and Pang, 2013). If either party assumes that the obligations are not fulfilled, they submit a claim as they believe they are entitled for a time or money compensation (Semple *et al.*, 1994, p.785). There might also be collaborative conflicts transforming into disputes. The client's unreasonable requests, nominated parties' delays, AEC design and supervision delay and consultant's default in providing information on time are commonly encountered reasons. Moreover, the documentation often comes deficient in defining the process for substantial changes in quantities; as well as providing in adequate number of detailed drawings. In addition to the above, inconsistency between contract bill and actual quantities, drawings and specifications and in complete BOQ's may create disputes. In certain conditions, drawings and BOQ's do not match and drawing details are not consistent. Finally, but maybe the most important, is the people factor. There are many cases available where contractor deliberately keeps omissible items in the bills of quantities. The specifications are hidden, or not met on purpose, and the gap between the actual work and BOQ are hidden by the contractor. Acceleration costs of contractors may also be very unrealistic. Not only the contractors are opportunist, but also the clients show strict standing by rejecting the extension of time claims, or financial claims instantly. They tend to avid reimbursement or extension borne from the extra work requests. Furthermore, the project members' psychological conditions should also be good. Being nervous, impatient or overactive may result in some issues, escalated to claims (Chenung and Pang, 2013).

3.2 Commonly encountered dispute types and Reasons

Abi - Karam (2001) stated that, disputes related to the time and/ or cost overruns, scope of the project, budget and schedule are common in the construction industry. The claims are the core of the disputes. Hence Tezalaar and Snijders (2010) stated that, as per Sarat (1984), a dispute arises only when a claim is made from someone. Investigating the UAE market, Zeneldin (2006) stated, the most important claim types that require dispute resolution are; changes, extra works, delays, different site conditions, acceleration and contract ambiguity respectively. However, he also mentioned that the frequency order of the stated claims are ; Contract ambiguity claims, Delay claims, Acceleration claims, Changes claims, Extra work claims and different site condition claims respectively.

Table 1: Common dispute reasons classified

• *Allow the design team to take their time.* • *Enable effective quality control on design procedures.* • *Maintain build ability within the project phases*	*DESIGN RELATED*

• *Clear out the contract ambiguity.* • *Fully understand the contract before signing and get opinion from a third party.* • *Make the necessary input in to the contract as per previous experience.*	*CONTRACT RELATED*
• *Maintain a cooperation and problem solving environment.*	*APPROACH RELATED*
• *Plan for possible schedule bottle necks.*	*PLANNING RELATED*
• *Get variation orders signed before proceeding.*	*CHANGE ORDERS RELATED*
• *Use proper recording system at all stages.*	*INFORMATION RECORDING RELATED*

Source: *Zaneldin, 2006*

3.3 Avoiding Disputes

The disturbance caused by disputes to projects is invariably significant. The stakeholders require their projects running smoothly with no risk of investment failure (AAA, 2007). When an issue rises, the event becomes a conflict where the parties have different opinions. At this very early stage, when the involved parties conflict on certain issues, it should be managed in a convenient manner in order to avoid the disputes. Cheung (1998) mentioned that there are techniques to avoid disputes from arising. The objective of these techniques is to create a coordination platform where team work is efficient. Grisham (2013) also mentioned that the disputed issues can be approached with three strategies, which are, managing, resolving or delaying settlement as per the situation. He also underlined that, due to previous experiences, taking an early action is the best approach.

Appropriate procurement systems are known as helpful in avoiding disputes. Yusof *et al.* (2011) stated that as per Leong (2003), usage of procurement systems has also great advantages, rather than the conflict management and dispute resolution methods, as they prevent the disputes to arise during the project delivery. AAA (2007) also suggested that selection of the procurement method is essential in dispute avoidance. Design and built option was adopted in US by private sector which was followed by the government projects, resulted in less number of cases. Lately partnering also became popular in handling conflicts and avoiding disputes. Stipanowich and Matthews (1997) stated that, approaches like partnering increase cooperation and discussions, puts mutual objectives and avoid adversarial situations. Moreover, Cheung (1999) illustrated a step by step approach to disputes as seen in figure 2. The lower step recommends preventing disputes via methods such as partnering, cooperation incentives and proper risk allocation.

4. SETTLING DISPUTES

Brooker and Lavers (1997) stated that disputes occupy important place within the construction industry. They continued that disputes significantly affect disputants, developers, contractors, sub contractors, suppliers, consultants, owners and future occupiers. Hence, they should be settled with least harm to each stake holder .As per Galloway (2013), the disputes in the construction industry can be settled through different methodologies such as; litigation, arbitration, mediation or negotiation. Cheung (1998) stated that, arbitration and litigation are effective formal dispute resolution systems for construction industry. However, he also stated that, these methods are long lasting and costly; hence Alternative Dispute Resolution (ADR) mechanisms are developed.

Figure 2 illustrates the common dispute resolution methods. They start with negotiation, and escalate up to litigation as a final remedy. Once the steps escalatee, the method tends to be costlier and more adversarial.

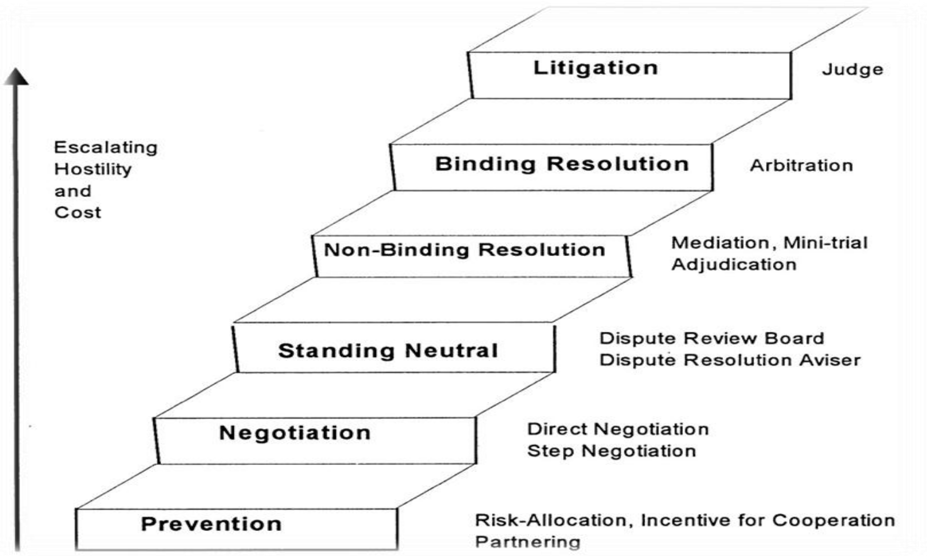


Figure 1: Dispute resolution steps in CI (Source: Cheung, 1999)

4.1 Barriers of dispute resolution

Galloway (2013) stated that, each party in the construction takes a standing due to their own understanding on the signed contract. Hence most of the construction disputes are difficult to resolve. The resolution process is wide open to manipulation from either party. Submitting vast amount of paperwork confuses the tribunal and blurs the image. Retrieval of information is very difficult in a project. Vast amount of information is stored in a project and it is usually not straight forward to substantiate a claim. Moreover, visualization of the causes and effects are the only way to present the claimant’s narration (Gibbs et al., 2011)

Haidar (2011) stated that, proving the entitled claim is a heavy weight on the claimants' shoulders. He continued that, as the evidence and presentation is strong, the chance of winning is higher. The importance of the contemporary records during the resolution process is crucial. However, this side is being abused by the weak participant; generally by the defendant. Submission of much unnecessary paperwork to delay resolution process is a common applied strategy. During the construction of projects, the collaboration of disciplines is not enough and the work programs are not effectively implemented through the process. Although important governmental projects or land mark private sector projects adopt the updated techniques, majority of the construction sector is not using the new tools.

Depending on the location and the type of resolution method, language and translations can also be a problem during claiming. The translation mistakes and difficulties may cause interpretation dilemmas. Due to the diverse nature of different parties involved in the constructions, avoiding conflicts and disputes are not possible. However, it is possible to systematically manage potential issues in better manner, to reduce or avoid dispute occurrence probability at the earliest stages (Yusof *et al.*, 2011).

5. BIMing Disputes

'BIM facilitates the communication of design and the coordination of a working system, cost estimation, and the automated generation of bills. During the construction phase of a project, these models can be helpful in analyzing construction operations by allowing project managers to determine site-management strategies, facilitate contractor coordination, plan site logistics, access routing, and study the integrity of a schedule and construction sequences' (Golparvar-Fard *et al., 2011).* Using BIM models, construction process is faster and more effective. Sharing information is very easy. The design proposals can be simulated, analyzed resulting better solutions. The whole life costing is also under control from the beginning. The quality of production is in higher standards since it provides high flexibility. In case of fabrication, the digitally prepared model can be used for manufacturing process of structural elements and assembly. All the information stored can also be easily retrieved and used during facilities management (Azhar, 2011, p.243)

The structure of a regularly updated BIM model of the project presents all the details of the project in the particular time frame. The process becomes easier to control. BIM minimizes the human participation as it automates the major part of the process. Hence, the perception is that, with BIM usage; projects are better monitored, controlled and updated during the lifecycle (Shourangiz et al., 2011, p.79). Hartmann *et al. (2012)* stated that, quantity surveyors can obtain the estimation data instantly from the BIM model and exert them to cost estimation software. Goedert and Meadati (2008) mentioned BIM as a useful tool to manage and retrieve information for the contractors or clients. They also stated that, apart from visual details, the information such as schedule, cost estimations can be added to BIM model and retrieved when necessary. The model goes beyond the traditional 3D perception. The complete project is structured on a digital platform. All of the elements forming a project are embedded in a model inside out. This is done by combining architectural, structural, mechanical, electrical, plumbing, and HVAC designs under a single model via particular software, and under a proper platform. Moreover, the entire information, cost, schedule, resources, progress and more can be added to the model. The model gets the information tag by doing it so. Gibbs et.al (2011) stated that, as per NBS 2011 report, BIM was defined as rich information model. The information can involve contracts, specifications, staff, schedule, quantities, cost, and design data. Integrating all the parties within the project is an important approach for dispute avoidance. As per Azhar (2011), all stakeholders are encouraged to do so via BIM. This potential of BIM achieves cooperative platform between the parties who were acting adversarial on encountered incidents before.

In the construction projects, usual variation changes result detour from the objectives. Time and cost overrun, quality defects may come out and other unwanted incidents are encountered. Academic studies analyze the sources and impacts of the changes, and it is concluded that; major changes are due to client requests on various reasons such as new ideas, reducing cost or lack of visual perception of the project at initial stages. 2D drawings have limitations, and BIM was able to solve vast numbers of design related incidents. A major advantage of BIM is that new information flows in the work can be integrated to the existing model very efficiently. (Shourangiz et al., 2011, p.79). As per Greenwald (2013), BIM not only enables cost saving and effective time management, but also reduces disputes significantly. This is done through solution of incidents, clash analysis and early detection of issues. Khoshnava *et al.* (n.d) also stated that BIM models significantly reduce the number of events that might become conflicts, as it involves all core elements of data.

As listed in our previous section on disputes, time and cost over runs and design related issues are the major dispute sources in the construction industry. Along with BIM model, the controlled deliverables will result less risk in dispute occurrence. Azhar (2011) mentioned that, as per Azhar and Nadeem *et al.* (2008), using BIM, project cost, productivity, quality, project duration can be controlled within the objectives. The project can even be completed or many months waited, hoping for the settlement of the disputes in a kind manner. BIMing disputes are not very different than BIMing a project. Shen and Issa (2010) stated that, during detailed estimation in a project, huge amount of time is dedicated on visualizing the drawings for understanding and clarifying the related work. They continued, BIM software has built-in cost estimating features. Material quantities are automatically extracted and updated when any changes are made in the model.

Determination and evaluation of the claimed events within the resolution process will be possible through the BIM model. As stated by Azhar (2011), BIM programs include cost estimation options. The quantification of changed items in a project can be easily retrieved. During the evaluation of disputed claims, it can be used efficiently. Greenwald (2013) stated that, the construction industry pays a heavy price for the fragmentation of dispute resolution processes. The solution requires a dynamic approach to the complexity. BIM projects provide new opportunities for significant advances in dispute resolution procedures. As per NBS (2013) research, the BIM also helps breaking the language barriers by the help of combined structured data, and visualization. As a barrier of dispute resolution, the effect of different languages will be minor.

5.1 Case Study

5.1.1 Outline Details of the Project

The studied case involves a residential and commercial building project constructed in Dubai / UAE. The contractor was selected as per the traditional procurement route and via the lowest bid. The duration granted was 13.5 months. Unfortunately, the project incurred many incidents that transformed in to disputes. The duration to complete the project prolonged 2 more years than the contractual time frame. The resolution was made via arbitration causing the client and the contractor to spend effort on the project even after completion.

5.1.2 Data Collection

The reviewed documentation included work schedules, site reports, payment certificates, project NOC's (no objection certificates) and authority permits, correspondences between client and contractor, correspondences between consultant and contractor, 2D drawings and contract documents. The disputed events are investigated in depth, to understand the effects on the project's delivery.

The major disputed incidents were as follows:

- Unforeseen site conditions: Exposed cables during shoring and excavation works. The contractor suspends the works until the local electricity provider changes the routes.

- Change orders from the client: Revised floors and conversion of units from residential to commercial. The works, suspends partially, and faces disruption on linked activities.

- Extra work request from the client: An extra floor added to the building. Project went under revision, and new authority approvals obtained.

- Payments delays: Client suspended interim payments. The issue caused cash flow problems, and the contractor suspended the activity on site.

Table 2: Disputed incidents and delays

Activity	*Start*	*Finish*	*Days*	*Total Days Works Suspended*	*Days Worked with Disruption*	*Days Works Delayed*
Date of Contract	*22-Jan-06*	*22-Jan-06*	*1*			
Final Demarcation	*14-Feb-06*	*14-Feb-06*	*1*			*24*
Commencement Date	*15-Feb-06*	*15-Feb-06*	*1*			
Mobilization Period	*15-Feb-06*	*02-Mar-06*	*15*			
Excavation Works	*02-Mar-06*	*10-Mar-06*	*8*			
Delays due to Exposed Electricity Cables	*10-Mar-06*	*10-May-06*	*61*	*61*		*61*
Works Commenced after Electricity works	*10-May-06*	*14-Jan-07*	*249*			
Disruption of Works due to Additional Floor and Supermarket Revisions (% 66 Efficiency Loss Assumed)	*14-Jan-07*	*31-Dec-07*	*323*		*323*	*214*
Client Stopped Paying to Contractor , Project Delay due to revisions continued	*01-Jan-08*	*01-Feb-09*	*750*		*750*	
Completion Certificate	*10-Mar-10*	*10-Mar-10*	*1*			
TOTAL	*15-Mar-06*	*10-Mar-10*	*725*			

The contractor raised claims which were not incorporated by the client. The engineer's recommendation did not satisfy both parties, and the arbitration method was used as the resolution, as stated in the contract.

From the existing 2D CAD drawings a BIM model was created. The studied documentations and created model provided both qualitative and quantitative measures. This data is used to evaluate the comparative benefit of the BIM model in claiming and dispute resolution. To investigate the advantages of having a BIM model during the claiming and dispute resolution process, a comparative analysis approach was conducted with BIM and no BIM. Also, two BIM models were created to spark the differences of the original and as built situations.

The figure 2 is the framework prepared for the comparative study.

Coyne (2008) suggested that as to analyze delays in constructions, as-built versus as-built analysis can be performed during or after the construction of the project. This analysis method enables quantification of the issues through the planned versus actual situation.

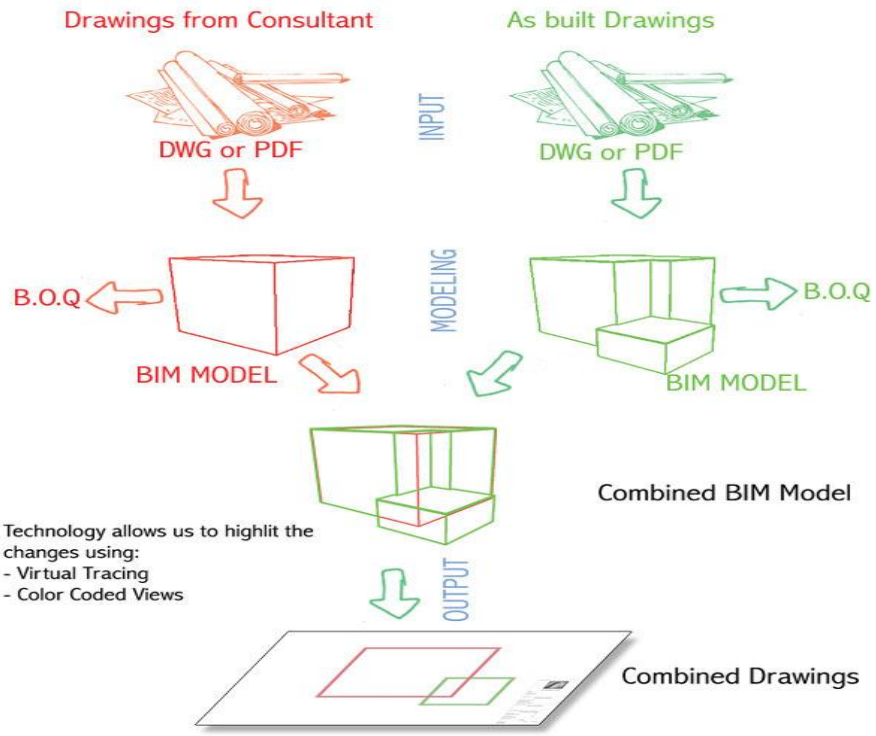
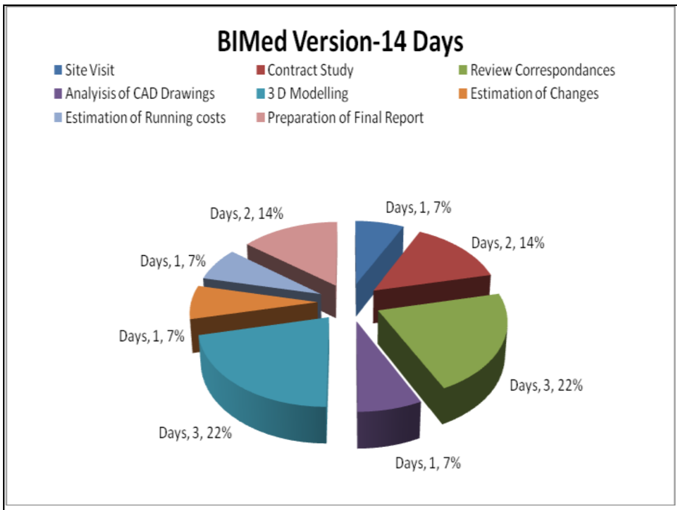


Figure 2: Framework for the proposed approach with BIM

The original and as-built drawings were obtained and modelled. All the information required was then extracted from the models. The combined as built versus original models were used to make the issues explicit during claiming. The obtained BIM models and colour coded drawings were evaluated both qualitatively and quantitatively. Change claims, variations, impacts of events made clearly visible in the comparative analysis. Events were visualized resulting easy to understand, estimate, comment and decide on the incidents. As mentioned earlier, the claims and resolution process counts on documentation heavily, in order to fully understand the real impacts. The models overcome this sophisticated phase.

The comparative benefit was also shown in following pie charts. Figures 3 show the steps and durations taken. The comparison is made between BIM-led and traditional approaches, for claim preparation. The steps are taken in order to submit claims to the arbitrational tribunal. The steps and durations are shown in the pie chart. Total duration taken for the preparations was 27 days, which included site visit, document study and estimations. Same process was gone through further to the creation of the BIM model. The BIM model created as shown in the figure 2 is used during the claim preparation for the dispute resolution. The saved duration was 13 days, being 48% of the traditional method. The major time saving was from the information collection steps, which included site visits and correspondence analysis. The estimations were also found more accurate and made on a faster platform.



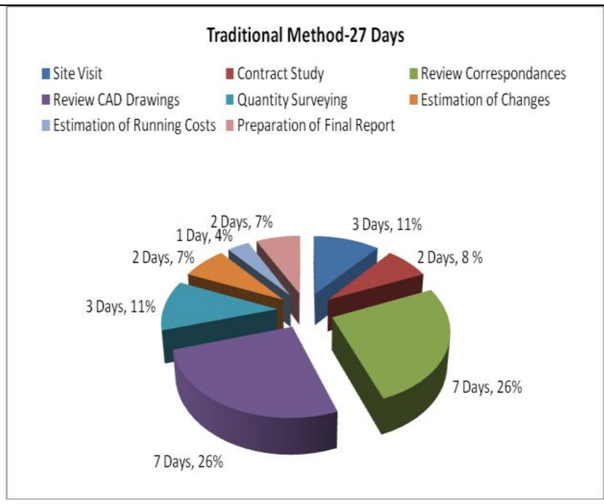


Figure 3: Claim preparation steps and duration in traditional method

5.2 Case Study Outcome

Further to the study, it is seen that; the major causes of the disputes are due to reasons that could be avoided through a properly stored, retrieved and presented information platform. Moreover, substantiation of the claim is actually visualizing the incidents to evaluate the liable and compensate able party. The biggest challenge of the tribunal during the resolution was fully understanding the effects and causes of the incidents. During the arbitration proceedings; we have noted that the process is also quite old and did not acquire new age techniques. The plaintiff and the defendant were trying to claim certain issues that they do not have the right to claim for. Both parties submitted documentation of almost everything; 3 to 4 binders, consisting of hundreds of pages. Considering the number of documents used in a project, it was causing serious disturbance for resolution authority. The discussion between the claimant and the defended usually stuck in certain activities or chronology and the events are being criticized in a tendentious manner. The presentation of the actual situations in a particular time was also great hassle. Although computer aided schedules were being used during the project’s procurement, comparing to a BIM model, the detail was less, and reflection on the arbitration process was low. A BIM model created in the project, even during the dispute settlement process, helped to identify the actual incidents and impacts of the incurred events. The prepared claims were more accurate, easy to present and clearly visible to the resolution authority.

6. Conclusion

Claims, disputes and resolution challenges were studied within the construction industry. Although preventing efforts are there such as collaborating platforms, partnering, usually disputes are not possible to avoid. BIM was evaluated to understand whether it can prevent or ease claiming and resolving the disputes. When there are claims, prepared on disputed incidents, visualization of the incurred events and their consequences can be obtained from the BIM model. This will give correct and clean perception of events. Moreover, the data required for the preparation of the claims will also be accurate as well as easy to obtain. Moreover, as an important time consuming procedure, acquiring the image of the events within a particular period is with less effort if BIM model is used. The literature and the case study explicitly conclude in the same result. Hence, it is obviously concluded that; BIM eases claiming and dispute resolution procedure, since it stores and visualizes the changes, planned and actual sequences, periods and activities. The adoption of BIM in the fore coming projects will be increased as the industry will recognize the model as a problem solving platform beyond commonly known benefits. Even no BIM model exists, as the common practice in the market, it can be created just for dispute resolution process for easy claim preparation, avoiding complexity in claim's substantiation and a visual presentation. The issues can be witnessed, and the documentation is still warm. The party resolving the claim i.e. arbitrator(s), will also benefit in understanding the disputed issues and effects through the model. The model can also be converted into multi dimensional by adding time (4 D) and cost (5 D) to present more details. Creating wider and new ways of work, BIM can make the dispute reasons explicit and will impartially show the liable party. Hence the solutions will be supported by the other stakeholders.

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Collaborative Engineering facilitated through Integrated Project Delivery

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Abstract

The paper discusses a proposal for an integrating partnership for decision making at pre-construction stages of major construction projects. The environment proposed is one that fully utilizes the strengths of intelligent collaborative computer agents that interact with the muti-discipline pre-construction team to interrogate and refine the design solution before construction commences. Better opportunities therefore exist to concurrently view the effect of design choices that impinge on the many contributors in terms of cost and performance of the final built structure. All contributors are collaboratively drawn into the design and pre-construction process. IPD and BIM form essential tools and strategies in this decision environment. IPD linked to the “Big Room” concept will be discussed. Discussion of successful IPD projects managed by some of the largest contractors in California will be presented. A system of design-collaborate-document forms the model for refining the design solution to drive budget downwards whilst maintaining value. Finally, the environment is extendable to continually monitor and assist environmental decisions throughout the life cycle of construction projects. The author's investigation measured the views of practitioners in the main building professions; architecture, engineering and construction management before proposing the collaborative system that is called for. The conclusion of the work is a conceptual model of the system proposed, a definition of the contractors' construction management computer agents and a specification based on scenarios of how they would interact with design agents.

Keywords: Collaborative Engineering, Integrated Project Delivery (IPD), Virtual Design and Construction, Intelligent Agents, BIM, Big Room.

1. Introduction

The Construction Industries in many parts of the world have seen change to offer alternatives to the traditional design-bid-build project delivery system. This movement encouraging change away from traditional contract procurement can be traced back to Sir Michael Latham report, "Constructing the Team" 1994 and Egan 1998. Today many government agencies are insisting their construction projects are approached by a collaborative AEC team who are assisted by computer driven design tools that provide open shareable asset information. One major reason Teichholz (2004) found was that while other industries increased their productivity in the last half of the last century by 120 percent; the construction industry underwent a 20% decrease. A study by Gallaher (2004) carried out at the NIST institute showed that poor data management and data exchange had a significant impact on the final cost of construction projects. Any effective decision model, including BIM, must have relevant information and knowledge

delivered at the right time for fast analysis of different designs using a range of sustainable materials and assessing the impact on construction.
In the USA, the General Service Administration (GSA) through its Office of Design and Construction (OCA) is responsible for providing national leadership and policy direction in the areas of architecture, engineering, urban development, construction services, and project management. It is responsible for $1.7b of new construction work in 2012. Through its Public Building Service (PBS) in 2003 it established a 3D-4D-BIM program that is now supporting applications in over 100 projects. The UK Government Building Information Modeling (BIM) Strategy group has been debating the construction and post-occupancy benefits of BIM (Building (asset) Information Modeling and Management) for use in the UK building and infrastructure markets over the next 5-year period in terms of its cost, value and carbon performance. It has now mandated for 'fully collaborative 3D BIM as a minimum by 2016', and the need for efficiency and industry reform to realize a 'cost reduction of 20% during the term of the current parliament'. This mandate will drive considerable changes in the traditional processes and practices of the UK AEC industry since it is estimated that today less than 10% of firms use BIM software in the UK as compared with 60% in the USA. Meanwhile, a new survey of more than 300 RICS members has revealed a poor up-take of BIM with less than 5 per cent indicating any frequent use.

2. VDC, BIM and IPD

Virtual Design and Construction (VDC) is a collaborative, integrated process that considers both design and construction using a 3D BIM models in combination with schedule data (4D) and cost estimating data (5D) a virtual object is created even before construction starts. As such, it serves as a shared knowledge resource for information about a facility forming a reliable basis for decisions during its lifecycle from project inception onwards. Model, schedule and cost (GSA.2011) have to be coordinated from the beginning.

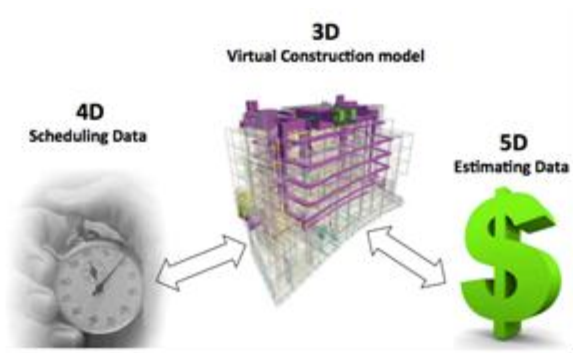

Figure 1: Relation between 3D / 4D / 5D models

Integrated Project Delivery through the Integrated Planning Team offers a solution-oriented approach. At a very early stage (project development, pre-draft phase) the entire planning (design) is carried out by a team that involves not only an architect and a structural engineer, but also consultants in the areas of construction management, MEP engineering, energy technology, building physics, acoustics, façade construction and depending on the type of project further specialists. The final handover of the completed building from this collaborative team is to the Facilities Management team who provides the experience for operating and ensuring economic building performance. Much of the IPD strategy has its root in LEAN project delivery (CRT, 2007).

VDC and BIM have to be implemented from the beginning of a construction project in order to increase the quality of the object, the organization and the process during the building life cycle. An important basic requirement for the model based work method is a sufficient amount of information from the very beginning of a project. In particular, the criteria and constraints of the various contributors to satisfy the client's requirements need to start being articulated and discussed as the model builds. For the approach to work effectively the integrated planning team comes into place. It is essential to include the experience of construction consultants (e.g. construction manager, superintendent) to ensure that the new project benefits from the execution experience. The result is a win-win situation for all members of the team. Furthermore, the building owner has security in terms of cost and schedule as well as optimized operation. During this phase the 3D, 4D and 5D model with a level of detail appropriate for execution are created.

3. Importance of BIM today

In the study, (figure 2) completed by Skanska USA Civil and Skanska USA Building forecast a massive increase of BIM application use within the next five years. Today roughly 40% of their employees in the area of Skanska USA Building state that BIM is already very important for the construction industry. They expect double usage of BIM within the next five years. The in-house study of this construction company in 2010 (1066 interviewees) shows a clear trend for the future.

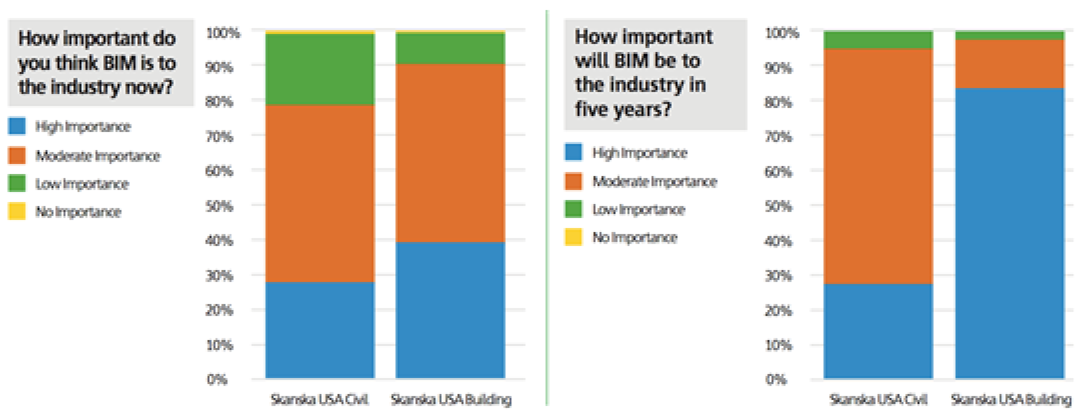

Figure 2: Importance of BIM today and in 5 years

The following results are an extract out of a study done by CIFE institute at Stanford University, called "An Integrated, Virtual Design and Construction and Lean (IVL) Method for Coordination of MEP". In all areas the application of VDC is connected to the principles of LEAN construction. It was found that up to 90% decrease of interface conflicts could be resolved and the number of RFI's and change orders could be minimized with the help of model based work method. Furthermore, improvements in pre-manufacturing could be instigated; conflicts in the field and time resolving them reduced.

From interviewing general contractor Hensel Phelps they reported that 20% of the work in a construction process is dedicated to work tasks that are related to re-work. The application of BIM helped the company to decrease this percentage to 5%. A study of Mortenson Construction (Minneapolis) in collaboration with The Health Sciences Center of Colorado-Denver University project gave another example to demonstrate the efficiency of VDC and BIM linked to the integrated planning approach. Comparison of two very similar projects - biomedical facilities; the one using the conventional approach of constructing, the other using the model based method. A comparison between the construction of these two similar buildings provided the following observations.

- Change orders: The number of change orders was 32% lower than average.
- RFI (Request for Information): Because of virtual planning many RFIs came up in the earlier planning phase and where solved in this phase. RFIs in the phase of foundation decreased by 74% and those in steel construction by 47%. On a total basis this is a decrease of RFIs of 37%.
- Re-work: The subcontractor reported that because of the well-coordinated planning process (including clash detection) prior to execution it led to detailed pre-manufacturing work that led to a reduction of labor cost onsite of 50%.
- Construction process schedule: With the support of the 4D model and therefore possible simulations of the construction process, the project schedule was greatly improved. The project completion happened two months earlier than originally planned and six months faster than the comparable R1 tower.

4. Collaboration of project team members

Through the collaborative usage of the BIM model and integrated project delivery, the model based work method leads to a collaborative, integrated and transparent construction process. All communication goes back to the central model. The model is shared among all project team members and it serves as a common, rich database where all information is structured managed and maintained. Therefore the amount of redundant data is reduced and repetitive date that already resides in the model can be used by all participants. The greatest details has to be paid to forming a balanced team that brings the required design and construction knowledge into the collaborative environment, Hanson Bridgett (2011).

When Disney Concert Hall in Los Angeles was build, 4D models were applied from the beginning. CIFE institute conducted a study within this project and concluded that through working with the 4D model the communication improved dramatically. The GC's project superintendent, Greg Knutson, felt strongly that it was important to construct a team atmosphere, where people solve problems together. He realized that a shared, visual model to externalize and share project issues was a valuable team building tool. But not only the project members in terms of execution team experiences benefits from integrated model based work method, also the relationship between the building owner and contractor improves.

The "Big-Room" is the on-site co-location space that physically brings together designers, builders, and often facility operators to work together. First and foremost, it aims to improve collaboration through greater team integration. Early integration enables a team to deliver a higher performing building, on time and on budget. Through the intense interdisciplinary collaboration that happens, teams are able to design a building with systems that complement and support each other and the goals of the project. Co-location also makes it easier to ask team members for the latest information, reducing the time wasted looking for up-to-date information, or working with outdated information.

Value Stream Mapping was used to optimize the team's compressed schedule. Similar to Lean Construction pull-scheduling, Value Stream Mapping looks at downstream tasks to determine what needs to occur upstream. Because the entire team is present for all phases as Value Stream Mapping, non-value add tasks are easily identified and eliminated from the schedule. Rather than trying to preserve scope, team members focus on optimizing the overall project.

The IPD contract agreement is a multi-party agreement that sets out the IPD principles including early involvement of key participants, setting targets early in the design that all parties agree, joint sharing of risk and reward, joint project management framework, and limitations on liability to increase creativity, innovation and reduce 'silo' thinking. Generally direct and indirect project costs are guaranteed by the owner and all or a proportion of profit is placed in a risk pool that is increased or decreased depending on project targets being meet regarding cost, time and performance.

5. Information, Data and Knowledge in the system

For the VDC system to work effectively, requires domain information, data and knowledge to be brought into the system when required for solving problems and making decisions. Pohl (1993) concluded that the design process could be characterized by five functional elements:

- Information - a search for relevant information that includes past experience.
- Representation - the methods and procedures designers utilized to solve design problems relied on their ability to identify, understand and manipulate objects. Objects have a representable form that encapsulates knowledge that is conveyed as factual data, algorithms, rules, exemplar solutions and prototypes.
- Visualization – that is important since traditionally some form of graphic media is used to convey design intention, generally in the form of drawings. Drawings however are often inadequate in portraying information and can lead to erroneous conclusions, with many misinterpretations and inappropriate conclusions resulting.
- Reasoning - that is central to the design activity. The ability of designers to solve problems is dependent on their interpretation of the issues and the dynamic changing relationship between these issues. Often requiring different expertise to be drawn into the process.
- Intuition – which, in the design process, is often the spontaneous reaction to a thought process that diverts many areas of the human brain? The new generation of design tools e.g. Revit and Navisworks, assist representation and visualization however bringing relevant information into the decision environment in a timely manner is a key to success.

Having the ability to view the artifacts used in the design model as a series of objects, which have implicit attributes and features, gives scope to analyze the design in depth regarding such aspects as manufacture, constructability, cost, schedule, quality, safety, etc. All participating domains reasons with objects, in various groups that can be termed super-classes, which in turn are composed of various classes e.g. methods, actions, activities, construction resources, costs, etc. Objects within each class (Figure 3 below) could encapsulates knowledge about such things as its own function, its relationships with other objects, its behavior within a given environment, what it requires to meet its own performance objectives, how it might be manipulated by the designer within a given design problem scenario, etc. This knowledge is contained in the various representational forms and protocols of the object, e.g. factual data, rules, standard solutions, etc. Object models would be common to architects, engineers and construction managers and could be added to by any of these disciplines. It represents the static, structured, data aspects of the system that can be stored in object libraries.

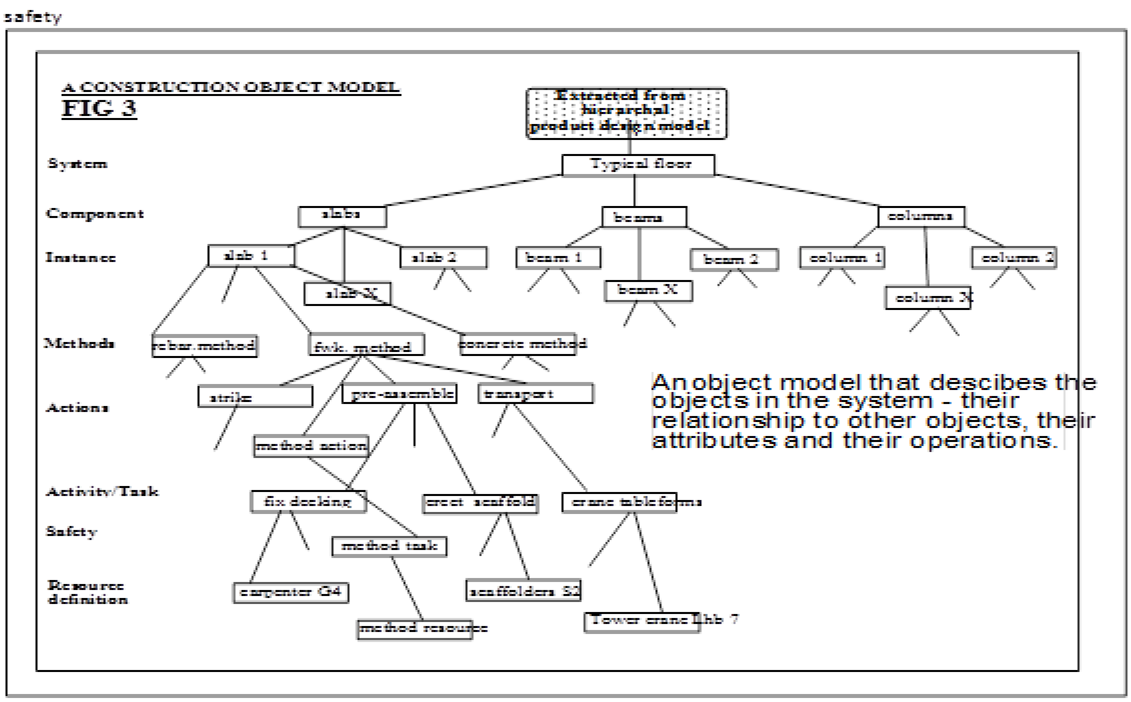

Figure 3: Object class Devolvement

Whereas, Figure 4 illustrates the more dynamic aspect of the system and indicates how attributes are encapsulated within construction super-class objects; in this case, the super-class "equipment" is used. Attributes include not only the shape and related geometrical features of the object, but also non-geometric properties and characteristics such as functions, materials, cost and performance. Within the super-class, ‘Equipment’ all classes of equipment can be represented (e.g. excavators, cranes, pumps, etc.). Each class might have a number of associated types (e.g. with pumps there might be centrifugal, diaphragm, etc.), many different types of attributes (e.g. flow capacity) could then be defined dependent on the level of problem solving and specification of finally generated information.

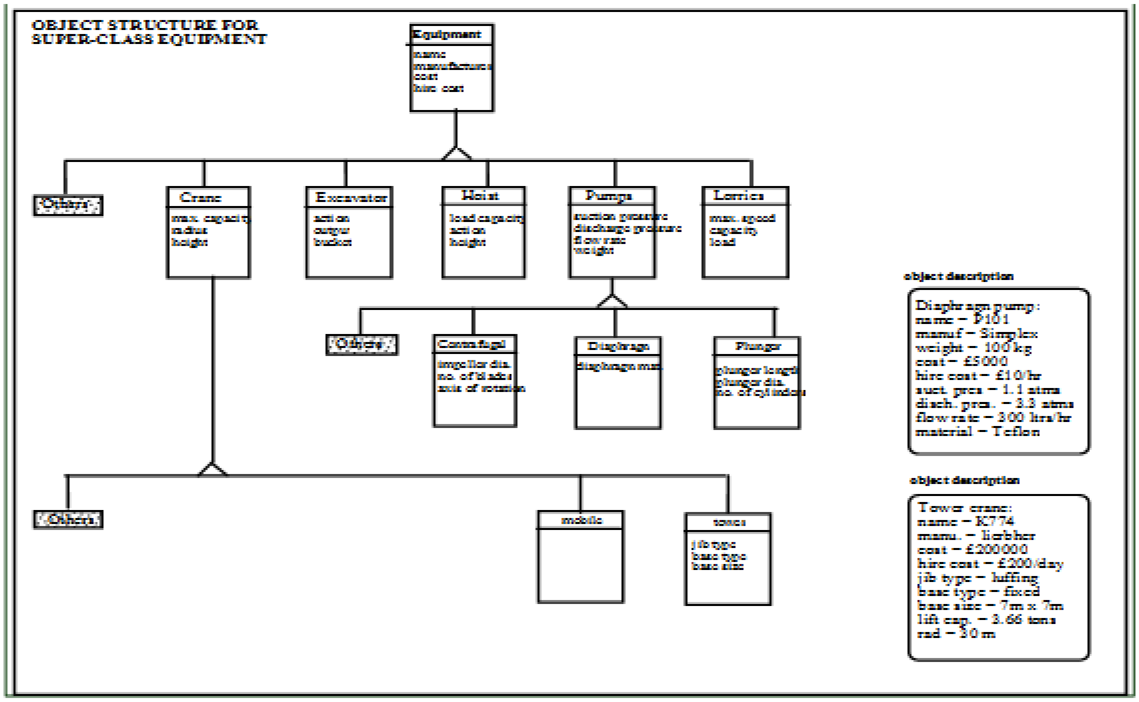

Figure 4 – Example of object structure and information/knowledge stored

6. Intelligent Computer Agent

Jones (1998) proposed a co-operative design agent environment composed of agent families representing the AEC participants, the client, and extendable to all the stakeholders to the project. Intelligence in the context of this research implies that the design system has some means that allows it to anticipate the data needs, information needs or knowledge needs of the human designer(in this case the integrated team). The system would act as an intelligent assistant to the evolving design, creating and aiding the collaborative team and freeing them from being overwhelmed with untimely information and knowledge. Providing such assistance requires an understanding of the various participants' knowledge requirements, the factors that constrain their decisions, and the criteria under which they work. Pohl (1993) called this an Intelligent Computer Assisted Design System (ICADS). The ICADS approach was tested in several working models (ICADS-DEMO1 (Pohl, 1989), ICADS-DEM0 2 (Pohl, 1991), AEDOT (Pohl, 1992). These have provided computer scientists and practitioners with a useful test bed for the development of a body of knowledge relating to software and hardware computer architecture, theoretical concepts and technical implementation issues.

The characteristics such computer agents would possess are:

(a) The agents would be programmed with appropriate problem solving protocols.

(b) Agents would only be considered intelligent when they possess the capacity to plan their own actions. Intelligent agents would therefore have implicit domain knowledge, knowledge of their own needs, knowledge of global goals, the ability to communicate and the ability to take action. They would also have access to objects, which are information entities, but unlike agents, cannot take action. They would bring appropriate domain information and knowledge into the VDC.

(c) Different ‘Families’ of computer agents can be constructed that would support each domain. See section on ‘Agent Families’

(d) Sub-tasks resulting from decomposing the problem are distributed to different domain agent families with the intention that these agents assist the human integrated team participants (termed in the research ‘human agent’).

(e) Each domain family of agents would operate in a narrow domain providing support to requests for assistance. These agents would range from simple to complex processing units each rationally working toward a single global goal or towards separate individual goals that interact. Acting independently in a self-regulating manner, they exist to express opinions about the current state of the design solution in regard the key criteria and constraints of that discipline. The intention is to change incrementally the current state of the design through the interaction among the various agents within the environment. However, the goals are set by the human agent with advice from various autonomous agents that include agent representation of the client. The criteria and constraints of the various participants would be continually analyzed to find a best solution.

(f) Agents representing many disciplines would use their local expertise and available resources to work in parallel on different or co-coordinating tasks to arrive at a solution in the following ways:

(i) They would act as co-operative search agents that liaise with information knowledge bases in the search for alternative solutions.

(ii) Alternatively, they would act as evaluators and solution proposers to express opinions about the current state of the design solution.

(iii) Alternatively, they would give continuous background monitoring and evaluation of the evolving design solution including conflicts.

(iv) Agents would be designed to have implicit domain knowledge, knowledge of their own needs, knowledge of global goals, the ability to communicate and the ability to take action.

(v) Typically, each agent would be represented at the level of detail at which the design facilitator or human agent wishes to reason about the designed system.

7. Agent Families

Complete ‘families’ of computer-agents that represent a particular domain will be built e.g. architect, interior designer, structural engineer, client, landscape architect, safety manager, quality manager, environmental manager, stakeholders, mechanical and electrical engineer, construction manager, project manager, etc. For instance, the family of computer agents and objects would represent the construction management domain (fig 5) and their problem solving activities associated with the production problems of a specific project. Within each family specific agents’ would monitor and offer assistance regarding criteria and constraints imposed in the areas of environmental, quality, safety, cost, production time, etc. For instance, there could be a ‘Safety’ agent residing in a number of domains i.e. Architect, Construction Manager, Project Manager, Quality Manager, each would be representing the criteria and constraints of that domain. Project solution development assisted by computer agents is not intended to automate the design process but rather to pool contributing domain expertise in the search for the ‘best-value’ solution.

This environment would include representation from all the built environment disciplines, agencies and most importantly the Client agent. This interaction enriches the environment with information about the current design state and how it relates to project requirements. In this process the integrated team would direct and guide the efforts of all computer agents to advance the current state of the project solution towards a best-value design solution that is acceptable to all domains computer agents' and the inter-disciplinary project team. The role of the designer or project leader would be that of principal long term or strategic planner while agents would focus mainly on short-term activities.

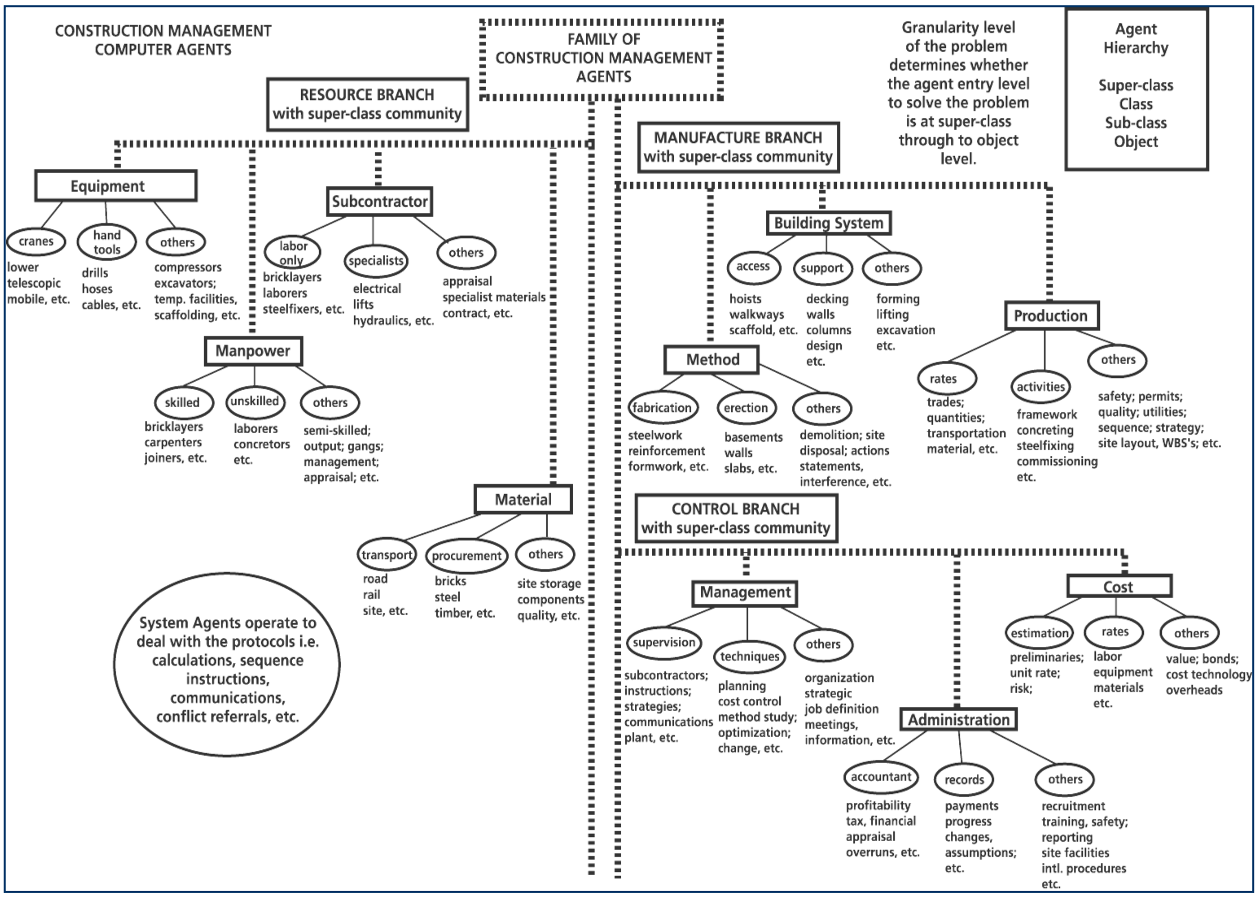

Figure 5 Family of CM Agents

As stated, a family of Construction Management agents that would be designed to sit co-operatively among architectural, engineering and a variety of other specialized agent families. This research has identified three branches of super-class agents (fig 5) that reside under the Construction Management Family:

(i) Resource branch.

(ii) Manufacture branch.

(iii) Control branch.

Each branch would include domain specified super-class agent communities that would divide into agent classes, which represent the entire problem solving activities of that super-class. Each super-class is divided into classes and sub-classes with their relevant object libraries. In the investigation (Jones, 1998), agents representing activities associated with a reinforced concrete building are used. However, once built this family of agents can be used again on other projects and is expandable by adding agents' or changing agents' for other types of buildings.

8. Conclusion

The integrated model based approach will positively impact construction in the 21st century. As discussed many positive experiences and case studies exist. Central to this visual system is now IPD and BIM. Many governments around the world are insisting design delivery and project management use these tools resulting in an acceleration of the use of BIM and IPD. In this way a collaborative team has the tools and information to interrogate and solve many of the cost, constructability, time, quality, sustainability, environmental, safety, etc. issues before construction commences, and continue that monitoring throughout the construction process. The author's research work demonstrates how families of agents can represent the various professional groups in the design and production environment by capturing data, information and knowledge to reside in intelligent agents that interact with one another to find the best solution. That solution can depend on what is perceived as the key criteria for the project i.e. speed of construction; or LEED features; or safety during construction; or final cost, etc. It will often be a balance between multi-criteria and targets established for that project. In this paper a family of construction agents is outlined. The development in the near future as follows:

- 3D, 4D and 5D methods will further establish within construction companies
- BIM tools with integrated construction management function will spread wider
- New professional roles, like the one of a BIM manager, will become more and more important
- Interfaces between ERP and BIM systems will be created
- Suppliers will be integrated into the processes of the construction industry (like it is already happening in the automobile industry)
- Pre-manufacturing which has become possible through BIM will increase
- The application of BIM in the field of modular construction will advance this kind of construction
- More and more building owners will ask for BIM as part of the contract
- Contract and remuneration terms will be impacted by BIM
- Standardization will find its way into the construction industry

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Green Construction Supply Chains for Supporting Green Buildings in Indonesia: Initial Findings and Future Developments

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Abstract

Developments of green buildings in Indonesia's big cities have been promising in the last 5 years. The Indonesian government has been preparing some needed regulations related on the implementation of green buildings since then - two of them have been sanctioned related to the green specification and certification. Yet, recent studies on the effectiveness of the implementations have shown the need of more holistic approach in delivering the green buildings, including the importance of constructors in delivering the green specifications as designed by the owners through the professional designers. The concept of green construction was introduced to the construction practice. Some of the Indonesian big contractors have already tried to practice what so called green behaviour and practices in construction. Yet, the delivery of construction has not been satisfactory to meet all green specifications with some notable weaknesses in producing the construction products efficiently and effectively due to lack of lean construction techniques and green supply chains. Nevertheless, without the availability of the construction supply chain in supporting the lean construction approach, the green value would not be delivered at all. This paper discusses a portion of an on-going three-year research project's initial findings conducted by surveys. The objectives of surveys are to define the structures of the important commodities' supply chains in supporting green construction, i.e., materials, subcontractors, equipment, labours, and also to identify the conducts of green construction supply chain's members. By knowing the structures and also the conducts of the green construction supply chains, further agendas could be determined in developing the green construction supply chains in Indonesia by Government as well as by practitioners.

Keywords: green building, green construction, green supply chains, sustainable construction

1. Introduction

1.1 Sustainable Construction in Indonesia

In Indonesia, a formal initiative to implement the sustainable construction has been started by the Ministry of Public Works in 2009 since it launched what it is called a draft of Agenda 21 for Sustainable Construction in Indonesia. The Ministry of Public Works promoted and suggested the draft Agenda 21 for Sustainable Construction in Indonesia be used by other stakeholders as an initial document to be referred in discussions to develop more detailed and implementable agendas. Moreover, the document should also be a reference for developing strategic actions by all stakeholders as they have the same vision on what each party should contribute to the implementation of sustainable construction (Abduh, Wirahadikusumah and Chomistriana, 2012).

Despite the fact that the government has set initial and necessary initiatives in implementing sustainable construction in Indonesia, the practitioners has been beginning to consider sustainable practices, especially in the area of green buildings. It seems that 'green' terminology is more tempting to be used instead of 'sustainable', and buildings are more controllable compared to other types of construction. However, as pointed out by du Plessis (2003) the construction companies had to change or even remove current practices that were considered as standard practices in construction in order to implement the sustainable construction principles successfully. Moreover, Glavinich (2008) mentioned that one of the most important aspects in delivering sustainable infrastructures is whether the constructors build the infrastructures in a sustainable way. On the other hand, the performance of the constructors depends mostly to the performance of its supply chains.

Green construction is a concept that was introduced to the construction practice as a green way to perform construction in the field by the contractors. The concept is considered as an emerging terminology for contractors that still opens many interpretations, but, on the other hand, also invites innovations. Recent innovative approaches implemented by several contractors represented the easy and more doable approaches taken by the contractors in responding the green construction concept.

1.2 Green Buildings

One of other prominent movements in green construction in Indonesia is the establishment of Green Building Council Indonesia (GBCI) in 2008. This is a not-for-profit and independent organization established by 50 core founders, who were individual professionals and practitioners, and 20 corporate founding members. Those founding persons and organizations are developer, designer, architect, building and facility management, contractor, supplier, architects, mechanical and electrical engineer, interior designer, and landscape. The GBCI is also representing the World Green Building Council (WGBC) in Indonesia.

Until now, there are more than 120 corporate members joined this organization, 3 new green building projects and 3 existing building that had received platinum level of certification, and there are more than 30 green building projects that were registered to be assessed. The assessment system that is published by the GBCI is called Greenship rating tools which consists of three rating tools: for new buildings, for existing buildings, and for interior spaces.

1.3 Green Contractors

Recently, there was a study conducted by the Ministry of Public Works that was aimed to measure the awareness of Indonesian large and medium-size contractors to implement the sustainable construction. In general, they are ready to implement the sustainable construction concept with the average score of 74, out of 100. This finding is, of course, very encouraging for the implementation of sustainable construction in Indonesia, but it is also shown that only maximum 13% of the registered contractors in Indonesia that are ready, while the rest (87%) are small-size contractors and they would have lower level of awareness (Abduh and Imran, 2013).

Some large contractors, as the main subjects in the construction field, had shown their awareness and stewardships to the environment by declaring themselves as green contractors. They have implemented reduce, reuse and recycle (3R) principles, as well as the reducing the use of energy in their construction projects. International certifications for environment management (ISO 14000s) have been their marketing weapons besides the certification of health and safety management from OHSAS nowadays. The practices of reducing the use of papers, catering waste, the use of air conditioning, the use of water and electricity has been their day to day operation in their project sites. Furthermore, what-so-called green contractors in Indonesia already had their own assessment systems to measure the level of greenness of their projects.

1.4 Government Initiatives

The Indonesian government, represented by the Ministry of Environment, has issued a regulation on criterion and requirements for an institution that could publish an assessment system for certifying green buildings in Indonesia. Moreover, the Ministry of Public Works has been developing a standard of green specifications and also rating tools for designing, constructing, and operating green governments' buildings that will be introduced to central and local governments. The green specifications will be a voluntary guideline, but a local government that is ready to implement it could make it a mandatory. In fact, starting year 2012, in the city of Jakarta, as the capital city, green building certification is a mandatory for new as well as existing buildings based on a Governor Decree. Even though the requirement to adopt green building concept in Jakarta is considered mandatory, it is a minimum level of green specifications that are achievable and processed as part of getting building permits for new buildings and operation permits for existing buildings.

Moreover, the Ministry of Public Works has been developing a manual to deliver green projects; rating tools for green construction; a manual to green procurement using design-build delivery system; a standard for green roads; and a green construction supply chains strategy.

2. The Need for More Holistic Approach to Green Construction

Besides enthusiasm from seeing the recent conditions of Indonesia in implementing sustainable construction, some issues should be addressed as a result of some studies conducted recently on the assessment systems, i.e., green building certification and also green contractor assessment. Those assessment systems are formal products that are available nowadays and could govern most of the practitioners in Indonesia.

Even though the government has stepped into the playing field, especially for green building assessment, to influence the direction of initiatives, the practices still heavily focus on the design phase of the building. Whilst, the green contractor assessment tools also have their focuses on the way the contractors practicing their house keeping works on site. Those assessment systems were developed to be implementable easily and then to award the predicate to the assessed parties or projects. They are mostly document-based systems. So, they just become exciting new businesses, and seem to be a monopoly since those assessment systems are the only one available, and the first one to be developed in Indonesia.

While they measure many categories of green buildings and green construction, they are not intended to measure how green operations and processes are during the construction phase. Those assessments systems would be beneficial only to develop green designs as well as green house-keepings and behaviour during construction, but they lack of incentives for the contractors to search for innovations of their operations during construction. For some green projects or green buildings, they might get the green design recognitions and are constructed by green contractors, but the contractors should deploy the project acrobatically in order to fulfil the green specifications already set. The contractors' acrobat considerably will produce waste all the time during construction. At the end, the green construction projects may not be green anymore, even though they received green certifications afterward.

The previously identified problems faced by Indonesian construction practitioners in implementing green construction showed an improvement opportunity. Recalling what du Plessis (2003) emphasized in setting strategies in implementing sustainable construction and also the Indonesian agenda of sustainable construction, the approach to the green construction should be more holistic compared to the existing (Abduh and Imran, 2013).

As mentioned before, the goals of the sustainable construction in Indonesia, and many other developing countries, are to achieve three enablers: value system, technology, and institution. Abduh and Imran (2013) introduced three important aspects or components of green construction to be implemented: Green Behaviour and Practices; Green Construction Process; and Green Supply Chains. Those components are actually correspondent with three enablers of sustainable construction, but with terminologies that are easier to be comprehended by construction practitioners (Figure 1).

Figure 1: Green Construction Major Components (Abduh and Imran, 2013)

In principle, implementation of green construction should begin with the individual behaviour and contractor organization practices or called Green Behaviour and Practices. The big challenge for the contractor to implement this aspect is related to how to manage paradigm shift of the individual and changes in the organization to be greener. To fulfil this green construction component, the contractor should have the value system of green adopted and sanctioned. This component could measure how well the contractor personnel behave in a green way and how well the contractor organization introduce the green practices policy and also make them as a standard operating procedure.

Other important component to be considered in delivering green construction is related to the operations or processes of construction itself at the field. This is a production problem. Therefore, the operations or processes of construction at the field should minimize waste and on the other hand should maximize value to be delivered. This component is called as Green Construction Processes. However, this component is also known as lean construction principle. This component could be addressed by measuring the waste produced by each operation or process of construction in the field and how good is the achievement to the value defined by the succeeding operations or processes and the final customer. In this component, waste could be physical or non-physical.

The last but not the least, there is another component that is very important to support two previous components of green construction, it is called Green Supply Chains. Since most of the production factors of a construction project are related to the availability of materials or commodities (about 70% of construction cost), the management of construction supply chains is very important. As stated by Glavinich (2008), the performance of the construction depends mostly on the performance of its supply chain; therefore, the green construction supply chains management is very important aspect to be considered in green construction. The green materials should be managed by a proper green supply chains. Every member of the construction supply chains should contribute to the achievement of green value defined by the final customer.

3. Green Supply Chain Management

In current practice, Srivastava (2007) identified two types of GSCM: the one that uses product-based approach and the other is the one that uses process-based. The product-based approach tries to modify the product purchased and its by-product: e.g., eco-design, reducing the package, reducing the hazard materials, and accepting the return of its product for recycles. On the other hand, the process-based approach relates to the efforts to modify the practices that are usually performed by the suppliers: e.g., policy of organization in reducing environmental impact, the use of additional criteria in selecting the supplier, and requirement for environmental audit.

Some studies related to GSCM have been conducted in recent years and will develop rapidly in near future. Trigos (2007) had successfully portrayed the GSCM practices in UK construction industry. In general, in UK there were only small numbers of contractors that had commitment in implementing GSCM due to low interest of the construction industry to any innovations, including GSCM. But, the most important thing that the study revealed was that the demand from the owners in UK was still considered low to the contractors for implementing the GSCM in the projects. However, the potential of GSCM in delivering sustainability and economics to the construction companies is very well understood. Moreover, from the study, it was found that the process-based was the most common approach for implementing GSCM in UK construction industry. Some notable problems faced by UK construction industry in implementing GSCM were lack of human resources, short-term planning, limited access to information and expertise, and low demands from owners and government. Ofori (2000) also mentioned the same conclusion for Singapore construction industry with an emphasis in that the GSCM was the key for Singaporean construction industry in delivering green value to the community.

Moreover, it is advisable to consider that in managing the green supply chains its performance is depending on the interaction between its structures and conducts. This approach is widely used in managing supply chains of construction industry in many countries to describe the existing conditions of the structures and members of the supply chains for the purpose of policy development related to managing the supply chains for the construction industry (London, 2008).

4. Objective and Methodology

Some issues related to the management of green supply chains in Indonesian construction industry are identified as follow:

1. What is the structure of the existing construction supply chain for commodities that could support the green construction in Indonesia?

2. What kind of interactions that have happened between members of green construction supply chains in Indonesia?

3. How the performance of the green construction supply chains could be measured as the result of the existing condition of the structure and conduct of its supply chains?

Therefore, there is a need for conducting a research with the objective to portray a comprehensive picture of green construction supply chains' structure, conducts, and performance to support the implementation of green building in Indonesia. By so doing, the strategies and policies needed to implement green construction, especially the management of green construction supply chains, in Indonesia could be derived from.

Moreover, since there are three questions to be answered, the methodology and topics follow the needed information of green supply chain in Indonesia as depicted in Figure 2, i.e., its structure, conduct, and performance. This paper discusses part of the 2013 research topics on the structure of green construction supply chain (T.1.1).

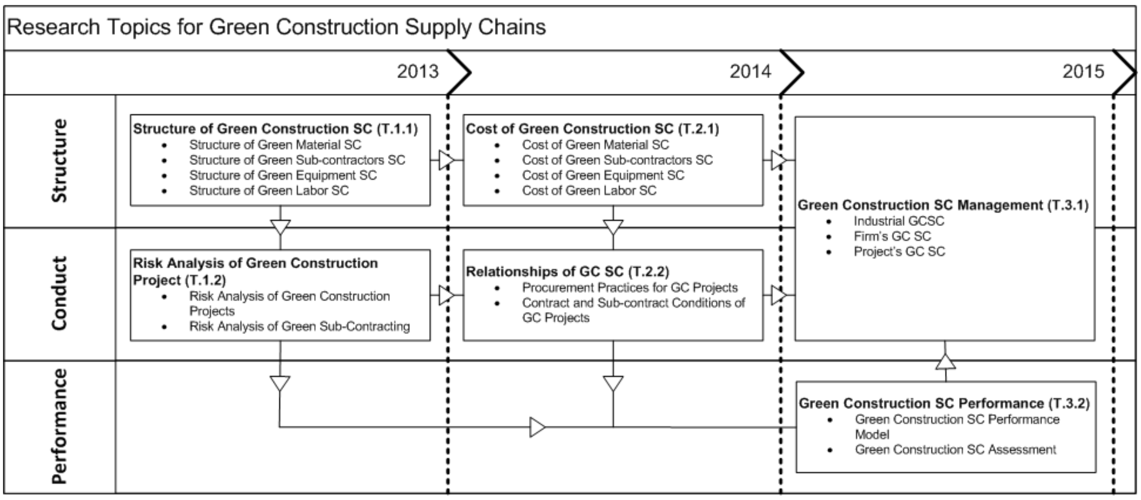

Figure 2: Research Topics in GSCM

However, even though the structure and conduct of supply chain are related to each other, those topics of research are treated as separated to be performed at the same time. Nevertheless, the research topics of performance of green construction supply chain are preceded by those two topics. At the end, the results of all research topics could contribute to the development of government policy in managing the green construction supply chain, and to the development of green construction supply chains management system for contractors in Indonesia.

One of the focuses of the first year of the research (year 2013) was to gather information on the structure of green construction supply chain in Indonesia as depicted in Figure 2 – T.1.1. This research was conducted by the use of several semi-structured questionnaires to the members of each tier of the green construction supply chains. A follow-up interview was used to clarify the answers and to explore the motivation and constraints. There were four groups of commodities surveyed in this research, they are: green materials; green Sub-contractors; green equipment; and green labours. The approach chosen was to start the survey from the contractors that had experience in constructing green buildings, as the first tier, and then to move backward through the contractors' supply chain until reaching its last tier, i.e., the producers. The survey was then conducted to four big-size contractors that have built green buildings in Indonesia, to three sub-contractors related to the four contractors, three green materials' suppliers, two equipment suppliers, and two green products' manufacturers.

5. Research Findings

5.1 Green Materials

One important finding for green materials is the availability of definition of green material itself. The most common used and accepted definition for green material is the material that will not harm the environment when it is used. There is no further explanation in how the material will harm the environment, therefore, the contractors rely heavily on the certification of green material or eco-labelled materials. However, even though the eco-labelling initiative has been issued for 10 years in Indonesia, there are only 13 standards developed and only 5 certifications given so far and none of them are related to construction materials.

Moreover, the contractors of green building also rely on the information given by the GBCI, the entity that will certify the building, on the availability of green materials. There is a list of green materials endorsed by the GBCI that is called 'Green Listing'. This list provide directory on what so-called green materials based on certain developed by the Green Listing Indonesia, a non-government organization. There are 9 categories of commodities listed, and they are intended to support the green building materials. Most of the materials listed in this directory are related to architecture materials as depicted in the Figure 3. Interviews with two green products' manufacturers listed in this directory found that most of them cannot be categorized as manufacturers, instead they are representatives and distributors of the green products in Indonesia. Most of the certifications they had were issued outside Indonesia, and the products themselves could be categorized as imported products with minimum local contents.

Another definition of green material that is used by the contractor is the materials that are available locally or not far from the project site. The definition itself is enacted in the government regulation related to the green building specification. This definition will largely applied to the construction material that is bulk or fabricated, such as cement, steel, timber, sand, aggregate, and asphalt. Some of the producers of the materials already declared themselves to comply with the environment regulation and management, and categorized some of their products as green materials without any third-party certifications.

Interesting finding was also found in the difference perception between members of supply chains on the definition of green materials. The owners of green buildings expected that the green materials could reduce the need of energy during the operation of green building. The contractors argued that the green materials could not only benefit to the operation stage of the green building, but also would minimize the hazards and negative impacts to the environment during construction processes. Moreover, the materials' suppliers proposed that the green materials could not only be considered environmental friendly during their uses in the operation and construction stages of green building, but also during the production process in the factory and use a lot of recycle materials. This is supported by the manufacturer, that the green materials should be produced by minimal use of energy and environmental friendly as stated in the specification or standards.

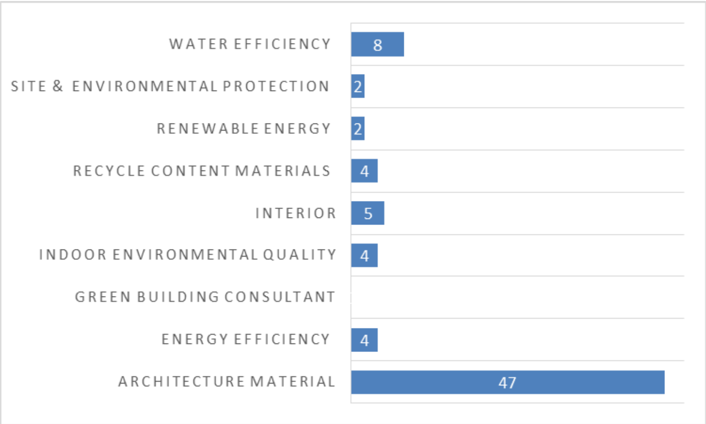

Figure 3: Green Listing Category

In term of supply chain structure, the green materials that are categorized as bulk and fabricated, did not have any specific structure of supply chain. It means that the structure of supply chain of green material is the same as the structure of non-green material. Meanwhile, the structure of 'green listing' products were categorized as monopolistic since there are limited, or even single, suppliers available for each commodities. Importation is also part of the structure of those green materials.

5.2 Green Sub-contractors

Based on the interviews to four contractors, the same answers given to the question whether there are green sub-contractors in Indonesia to support the green buildings. And the answers was no. The contractors themselves did not put more criteria in selecting green sub-contractors for their construction works. If the subcontractors have already had ISO 9000s and 14000s certifications they will be happy to employ them. If not, they still employ the sub-contractor without any further requirements.

The clauses in the sub-contract document between the contractors and sub-contractors did not specify any requirements regarding the application of green construction and how to deliver the objective of green buildings. However, the subcontractors that were interviewed mentioned that the risk of green building project is higher compared to conventional buildings due to additional green specification to be delivered that required more skills and knowledge. Higher risk may imply to higher cost to perform the construction works of green buildings.

Even though there is no such green sub-contractors existed, the contractors that have declared themselves as green contractors will educate or expose the green behaviour practices that they already implemented to the selected sub-contractors. In this case, there is a transfer of awareness, knowledge, practices, and technology from the contractors to the sub-contractors. The contractors believe that this way of doing will improve green practices of the sub-contractors. Inspection and control during the execution by the contractors to the sub-contractors regarding the implementation of green construction were used to make sure that the sub-contractors comply with the green practices of the contractors.

5.3 Green Equipment

Most of the equipment that are commonly used in construction projects use carbon-based fuel, therefore when the equipment suppliers were interviewed regarding the green equipment definition they always answer that the equipment that have change their machine to consume non carbon-based fuel or hybrid. Moreover, the green equipment was also defined as the equipment that could be re-manufactured and produced by recycled materials (scrap).

Even though, the contractors did not have certain formal criteria in selecting suppliers of equipment and selecting the equipment to be used, the contractor thought that the green equipment should be efficient and would not pollute the environment. Therefore, the contractors put emphasis on the millage of equipment to be used in the selection process; maximum 52.000 hours. Yet, not for all circumstances this requirement could be met since for some construction equipment, their availability are very low. During operation of the equipment, the safety requirement is very well addressed by the contractors to make sure the productive use of the equipment and safety for all parties in the construction site.

5.4 Green Labours

Almost the same with the green sub-contractor, green labour is hardly to find in Indonesia. Most of personnel that have certification in green buildings are the professional or possess management level assignment. None of them are the labours who work in the field as skill labour or even the foreman. Therefore, the green labour criteria cannot be used to recruit the labours for the construction works by the contractor. The adequate contract between contractors and the labours is not available.

Green contractors have already maintained several personnel that have attained Green Associate (GA) or Green Professional (GP) certifications from the GBCI to be deployed to their green building projects. All those personnel will have duty to make sure that the green specifications are met and the green practices are implemented in the projects. Yet, they are positioned as middle level management that should transfer all their knowledge to the sub-ordinates and the labours in the field. It is a challenge for green contractors to always educate and train the temporary labours who works in the construction projects. Training program and briefings of green construction were included in safety induction program and morning briefings.

6. Improvements Needed

As suggested by Ofori (2000) to the Singaporean construction industry and Xiao (2006) to the Chinese construction industry, the problems in the initial stage of green supply chain maturity of both countries were identified and improvements were needed in increasing the knowledge of green procurement in general and green supply chain in specific. According to that and based on the previous section regarding the findings of the first year research, it can be concluded that some improvements are needed in order to maturate the green construction supply chain that could support the green buildings in Indonesia:

1. Definition of green material should accommodate various form of construction material; bulk, manufacturer's products, fabricated material. This definition could be integrated with the development of eco-label for construction materials.
2. Emphasis on the use construction materials that are available locally. This would be enforced by the use of incentive for contractors that offer higher local contents in their technical proposal on the bidding.
3. Make the green building market more opened to more participants to participate throughout its supply chains. Demand information on the green building projects and materials needed should be accessible to more parties.
4. Green supply chain management practices should be demonstrated to develop more green sub-contractors and suppliers. Selection criteria for green sub-contractors and suppliers should be first addressed, and then the green capacity and knowledge development to the members of the approved supplier/sub-contractors list should be followed.
5. Competency and training program definitions for construction workers, in any level of management, to be able to conduct as required by green construction are needed. Certification could be one of the strategic ways to increase number of green personnel to support the green buildings.

As seen from the above list of improvements, most of them are returned to the government initiative and role in promoting the green construction in Indonesia. Policies and regulations related to the above improvements are needed. The green contractors are also playing very important roles as champions in implementing green construction. Therefore, the green contractors should refine their practices in managing their supply chain toward green supply chain.

7. Conclusion

Green construction supply chain in Indonesia is still in emerging state. The green building movement recently has been attracting and shaping the existing construction supply chain into green supply chain's direction. However, there is very few notable efforts in managing the green supply chain in Indonesia nowadays. But the practices conducted by the green contractors have put a basis for other members in the supply chain to move forward and join the green construction supply chain in the future. Government and green contractors' roles are very important in this stage to bring the green construction supply chain in Indonesia toward the right direction of development.

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Managing transformation: A focus on Prefabricated Building in the Libyan Construction Industry

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Abstract

"Construction industry development is a deliberate process to improve the capacity and effectiveness of the construction industry in order to meet the demand for building and civil engineering products, and to support sustained national economic and social development objectives". The prefabricated building implementation in Libya is very limited. Most prefabrication projects in the country are handled by foreign companies, except for one governmental company that has been conducted from 1978 to 2006. Many developing countries lack prefabrication technologies but have proposed several policies for mechanization or prefabrication in their respective construction industries. However, prefabricated building is not yet embraced by the Libyan construction industry, the private sector must be encouraged by the government to participate in the development of such structures. Nonetheless, several studies have cited the difficulties involved in technology transfer, including lack of local knowledge on transforming to the prefabricated building successfully. This study conducts a series of semi-structured interviews to identify the best technology transfer practice for prefabricated building products in the Libyan construction industry, especially the precast concrete. The interview results indicated that the presence of foreign companies in Libya can expand the scope for technology transfer and for development of local firms through joint ventures.

Keywords: developing countries, ways to success, local contractors, Libya, precast concrete.

1. Introduction

The conventional on-site construction projects are often marred by many issues on efficiency. Several researchers have voiced out their concerns on the continuing performance decline of the construction industry and the increasing challenges in creating a promising environmental responsibility. Such problems can be resolved by integrating the manufacturing concept into the construction industry, which promotes the efficient utilization of resources and improves various aspects of the construction industry to the extent that the Libyan construction industry can closely reflect those of Europe, Japan, and other first-world countries. Prefabricated building can help resolve environmental issues as well as improve the flexibility of construction designs (Azman et al., 2012). Several studies have also cited numerous benefits of prefabrication technology in the construction industry (Bottom et al., 1994; Yee, 2001; Jaillon and Poon, 2008). The transformation of conventional methods into prefabricated building must be supported to achieve sustainability in the Libyan construction industry.

However, local contractors lack sufficient knowledge on the prefabricated building as a major hindrance in the technology transfer. This paper aims to understand the broad and diverse nature of prefabricated building in Libya by examining the history of these infrastructures rather than by examining their static, measurable characteristics. This paper also aims to identify the best technology transfer practice for the prefabrication products in the Libyan construction industry, especially precast concrete. The key role of government policies, reforms, and incentives in the adoption of prefabricated components must be highlighted given that the development of industrial practices is mediated by governing institutional structures.

2. Basic concept

Technology is defined in the construction sector as the tools, techniques, machines, and actions that are used for transforming organizational input (materials and information) into output (products and services) to meet customer demands (Daft, 2004). The benefits arising from the import of technology in terms of economic and technical characteristics are only a starting point for understanding the overall financial, other resources, and providing information about the technical performance (Seaton and Cordey-Hayes, 1993). The cutting-edge technologies in developing countries usually are imported from advanced industrial countries. The recipient country coordinates closely with the exporting country during the technology transfer process to ensure that the recipient has enough knowledge and resources to utilize such technology (Waroonkun et al., 2005).

Technology acquisition is theoretically defined as the generation of missing technological and managerial competence within companies in developing countries and the reduction of their long-term dependence on foreign capital, skills, and technology (Chatterji, 1990). Chatterji cited the transfer of physical production facilities, human skills and resources, operating procedures, and managerial structures as essential factors in the acquisition of technology.

Technology transfer must be preceded by a knowledge transfer given the importance of knowledge in controlling technology (Richard, 2006). The construction industry must capture and utilize the knowledge that is possessed by managers. Knowledge is recognized as a vital organizational resource that promotes market leverage and competitive advantage (Leonard,1995). Knowledge has become a material that must be “managed.” This resource comprises explicit and tacit components, which consider human knowledge as a product of the fact that people know much more than what they can tell. Maitland (1999) argued that the competitive advantage of a company could be reflected in its ability to convert tacit knowledge into explicit knowledge through organizational learning.

Lall (1996) defined technological capabilities as the skills, technical knowledge, and organizational coherence that facilitated the function of industrial technologies in an enterprise. Technological capabilities reflect the ability of the company to utilize and maintain resources, such as training and research and development (Cohen, 2004). Local technological capabilities can be developed through a threefold process, which comprises acquisition, adaptation, and improvement (Rosenberg and Frischtak, 1985).

3. Methodology

This study adopted a qualitative approach given the limited local knowledge and technical know-how on prefabricated building technologies as well as the lack of literature in the implementation of such projects in the Libyan construction industry. Semi-structured interviews approach is the most commonly used research technique in qualitative approaches, which aims to explore the perceptions of the interviewees toward their surroundings (Bryman, 2008). Given that interviews would provide deeper insight into the industry, the interviewees were carefully chosen from a set of industrial experts with sufficient knowledge and experience in the construction industry (Kamar et al., 2009). A series of exploratory interviews was conducted during the second quarter of 2013 with engineers who worked in public construction companies and/or consultation offices of the prefabricated building projects in Libya during the 1970s and 1980s. The interviews were more of explanatory rather than descriptive to explore the perceptions of these engineers toward the prefabricated building. The twenty-six interviewees were briefly oriented on the available literature from other countries regarding technology transfer and government support for the construction industry, as well as the methods that have been associated with the transfer to enlighten them about the topic and to create a solid foundation for the interviews. Such flexibility of the semi-structured interview approach sheds light on the logic behind the occurrence of certain events (Moore, 2000).

3.1 Sample and data collection

The sample comprised of thirteen former leaders from construction industry, thirteen supervisors and/or engineers who worked in prefabricated projects in Libya during the 1970s and 1980s. Each participant was personally interviewed for an average of one hour. The interviews were conducted in Arabic, were recorded on tape, and were eventually transcribed. Following Ritchie et al. (2003), the transcripts were manually and systematically analyzed. The interviews were conducted in nine steps, namely, recording and transcription, familiarization with the data, identification of theme and concept, arrangement of concepts, synthesis, categorization, construction of thematic matrices, presentation of results, and confirmation of the problem. These nine steps were divided into two phases, namely, key findings and problem substantiation.

3.2 Important factors

Although the number of interviewees might appear too few to underpin new theoretical knowledge, Flyvbjerg (2001) argued that important implications for enhanced knowledge could be deduced from such a small sample size as the researcher was on a constant pursuit for the perfect explanation. The relative importance of such implications could be measured. Moreover, such small sample size could serve as a springboard for more studies despite its limitations (Flyvbjerg, 2001; Yin, 2007).

4. Interview findings

4.1 The experience of the public prefabricated projects in Libya

The shortage of published studies that investigated the implementation of prefabricated projects in Libya. This led to the questioning of all participants about the historical background of the experience of public companies, which is detailed below:

While steel structures of schools, government facilities, temporary houses and railways had been a long time before the independence of Libya, the idea of using precast concrete in the local construction industry mooted during the early 1960s. When the government contracted with a British Office TOMS & CANDY to design two sport complexes, called the Sports City. The government contracted with a Bulgarian company called TECHNO-EXPORT STROY to implement the first project and the first phase of the second project. The first project in Benghazi (Libya’s second-largest city) , contains football stadium accommodates about 55 thousands spectators in addition to tennis playgrounds, swimming pools, sporting hall accommodates about 10 thousands spectators with steel structure roof, parking and other facilities. The Second project in Tripoli the capital city, its first phase contains football stadium accommodates about 70 thousands spectators and a number of other structures. Both projects began in 1964 and finished in later 1967, using (partially pre-fabricated) mixed precast concrete element with conventional method.

Also in early 1960s, the government was looking for solution to build a bridge over a valley called "Wadi Kuf ", it is one of the barriers faced by the road project to link between Bayda and Marj cities. Wadi Kuf Bridge was designed by an Italian civil engineer "Riccardo Morandi", it constructed by Construzioni Stradali et Civili S.A. company. It is 282 meters long central span and total length of 477 meter. It had the longest concrete cable-stayed bridge span in the world at that time and it is a rare type of these bridges that uses prestressed concrete stays instead of conventional wire strand stays (Structurae Website). The project was completed within 7 years from 1961 to 1968 including the time taken in the construction of the partially prefabricated casting yard.

Beside these aforementioned projects, the work was intended to provide housing and eliminate shanty houses through an intensive operational and financial planning. However, conventional methods of construction were unable to meet the huge demand for housing. In the late 1960s, the Ministry of Housing and Utilities or "General Organization for Housing "(known then) launched an ambitious plan for construction of two factories to manufacture components for prefabricated building, both factories were expected to produce up to 1,200 flats every year. These two factories were turnkey projects, in this type of project the complete responsibility for design and execution stages taken by the implementing company, therefore it provides machinery and the associated civil engineering and building work. The Ministry of Housing and Utilities contracted with a French company called DUMEZ BÂTIMENT to implement the first factory in Benghazi, it used a French Tracoba System of load-bearing concrete walls. Upon the completion of the factory in 1974, the Ministry of Housing and Utilities contracted with the same company to use the factory to construct four blocks of four-storey flats with 3,000 units of flats, including infrastructure to project, which completed in 1978. The Ministry of Housing and Utilities then contracted with a Danish company called HQJGAAD & SCHULTZ and an Italian company called RIKI to implement the second factory in Tripoli, they used a Danish Larsen Nielsen System of load-bearing concrete walls. After the completion of the factory in 1976, the Ministry of Housing and Utilities contracted with both companies to use the factory to implement four blocks of four-storey flats with 4,200 units of flats, but only 2,200 units were constructed by 1979.

In 1978, the national general company for prefabricated buildings was established to operate the construction factory in Benghazi. The factory was transformed by the national general company from a prefabricated housing building into a prefabricated school building, administrative buildings, and large multi-purpose halls. The company was subcontracted by Daewoo, a Korean company, until 1989, which was followed by a joint venture between the two companies, which lasted until 1995. The company operated independently from thereon until 2006, after that within the framework of public sector privatization by the government, it merged with several public companies and venturing into conventional construction.

In 1980, the national general company for manufactured buildings was established to operate the factory in Tripoli. The company was contracted by the Ministry of Housing and Utilities in the following year to create 2,000 units, with technical assistance coming from Thomash Ashmidt, a Danish company. However, the company only managed to construct 935 units by 1986 given several obstacles, particularly the insufficient amount of land. When the prefabrication projects became relatively simple in 1985, the company resorted to renting its pieces of equipment and selling its construction materials in order to survive. In 2006, the company merged with the national general company for prefabricated buildings in Benghazi.

After the country adopted the socialist system in 1977, the Ministry of Housing and Utilities established the general company for construction and maintenance of municipal facilities to oversee and implement public utility projects. The company was subcontracted by many Italian companies to design and construct public markets. Many models of public markets were devised, with most of them being prefabricated buildings. The first of these models was the "five-storey" model, in which five public markets were constructed out of metal in Tripoli whereas three public markets were constructed in Benghazi. The second model, the "rapid markets" model, constructed 60 single-storey public markets all over Libya out of metal. The company also created a number of stores to support the public markets, including 23 stores in Benghazi. The third model, "permanent markets," was implemented in 1981. The design of this model was similar to that of the second model, except that the public markets in this model were made out of precast concrete instead of metal. This model aimed to construct 185 public markets all over Libya, but only 10 projects were completed and the remaining projects were stalled at different stages of the project.

The Military Works Company affiliated to the Libyan General Interim Committee for Defense. In 1981, a joint venture was established between the Military Works Company and Lamkiv, a Hungarian military company, to construct military facilities in Libya. The joint company was named the Arabic—Libyan—Hungarian military company for construction. Some projects were constructed based on the prefabricated building system. The branch in the central region created many stores in

Sokna out of metal. The Green Mountain branch established a factory that manufactured precast concrete components and implemented military establishments in the region. The Jebel Akhdar branch actively benefited from the factory in the implementation of some public projects, such as the construction of a bank in Al Qubbah, a bus station in Al Abraq, and an institute of industrial professions in Shahhat. In 1986, the Hungarian military company withdrew from the joint venture, but returned two years later to finish the stalled prefabricated projects except for one project in the Green Mountain branch. After that the projects were implemented by adopting conventional construction methods.

4.2 Anticipated problems for transformation to the prefabricated building

The interviewees agreed that the construction industry should be restructured to achieve a successful technology transfer. Thus, development should consider the whole industry. Ofori (1993) suggested that the whole industry should embrace the development of materials, project documentation, project procedures, human resources, technologies, contractors, and public and private institutions. In addition, developing countries were also facing other challenges related to the paucity of resources, technology, and skills, and to the high poverty and unemployment rates (Van Wyk, 2006).

The interviewees identified the unclear description of prefabrication and the related technical, organizational, and process issues as the main problems in the transformation process. The interviewees were also concerned about the presence of several barriers, such as the inability of the private sector to handle the costs, the unavailability of qualified operators, the unavailability of necessary programs, the technological limitations, the difficulties in the practical application of such concept, and the resistance of industries to change. The influence of cultural aspects, public awareness, and education of workers in the implementation of prefabricated projects also raised concerns, as well as corruption resistance.

5. Discussion and analysis

Many researchers argued that technology transfer could enhance productivity at the project, companies, and industry levels and could promote the long-term economic growth of the host country. However, the interviewees claimed that such benefits could not be applied in the Libyan context, where clear barriers are observed for ventures of Libyan public companies into prefabricated building. Many Libyan public companies fail to achieve a successful technology acquisition, and some companies become counterproductive because of inadequate developments and the lack of a government-implemented strategy, which leads to the withdrawal of support from these companies. The growth of public construction companies is largely supported by foreign companies as subcontractors or providers of technical assistance. Therefore, local construction companies are dissociated from the manufacture of components and the installation of prefabricated building, and instead focus on the management, the coordination functions, and the marketing products that are produced by foreign companies.

Nonetheless, the successful technology transfer between foreign and local companies in a joint venture contributes to the long-term survival of the national general company for prefabricated building. Carrillo (1993) supported that the collaboration of local and foreign companies in

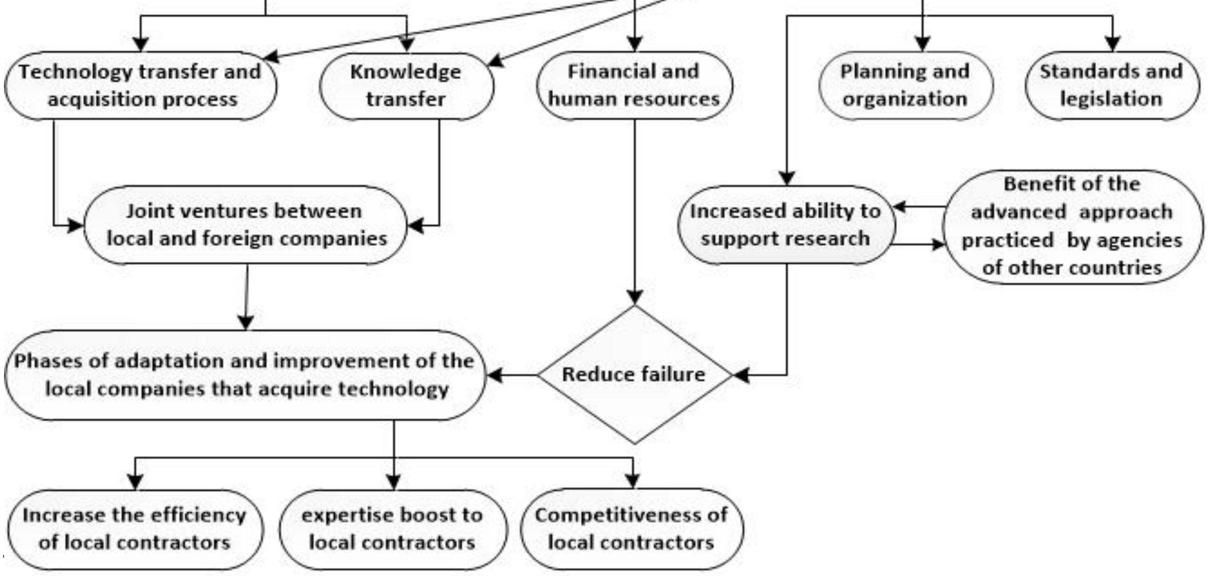

Figure 1. Government support for the transformation of prefabricated building in the Libyan construction industry

The human–financial resources and capacity of the emerging sector must be developed in line with international best practices to promote participation and growth in the private sector. Most of the interviewees declared that the government did not play a major role in the industry. However, the government has a major role to play in promoting and reinforcing institutional arrangements, formulating and implementing national strategies and policies relating to construction, as well as activating laws to deter corruption. The overriding factor in initiating change is therefore the commitment of the government at all levels (CIDB, 2011).

The development strategies that are adopted by many countries become useless if there are no agencies to oversee the long-term reformation of the industry. The agency must involve direct stakeholders and beneficiaries in the planning and implementation processes (Ofori, 2000). For example, delaying the establishment of the Hong Kong Construction Industry Council (CIC) until 2007 also delayed the full adoption of most recommendations that were published by the Construction Industry Review Committee (CIRC, 2001) in their report, which eventually hampered their contributions to potential core industry improvements (Green et al., 2011). Figure 1 illustrates the central role of the government in the transformation of prefabricated buildings in the Libyan construction industry.

6. Conclusion

The ways to achieve success in the transformation to prefabricated buildings in the Libyan construction industry relies on the three implementation stages of technology transfer, namely, acquisition, adaptation, and improvement. Technology transfer can also lead to the reinforcement of local technological capabilities without exception at any stage. It is important to realize that technology transfer does not succeed without governmental adoption of the whole industry. The success of these stages relies on the development of financial-human resources through technical and administrative support. The presence of foreign companies in Libya expands the scope for a technology transfer and an acquisition process between local companies, which can be achieved by forming joint ventures between local and foreign construction companies on the condition that a systematic binding with the foreign party exists.

Technology control is of paramount importance and necessitates the presence of an agency to link interactions among various participants. This agency readily able to diagnose prefabricated building problems. Through the continuous assessment of the strength and weakness of the technology transfer dynamics further supports the three implementation stages and improves the technical know-how of local companies that got the technology. The produced knowledge through research projects support can be used to enhance the soundness of the technology transfer mechanisms, which eventually reduces the consumed time and failure rate in the industry. The Libyan construction industry can learn much from advanced approaches of other countries to develop its respective construction industry, this perhaps strengthens measures to guide the long-term development of its industry.

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Establishing a Center of Excellence to Promote Construction Safety Research, Education and Training in Pakistan

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Abstract

Safety is one of the primary concerns of the construction industry. The accident rate in construction is among the highest in comparison to other industries all over the world. In Pakistan, the enforcement of safety regulations on construction sites is very limited. Procedures for formulating, implementing and monitoring safety rules and regulations are weak and the implementation of safety management systems does not occur on most construction sites. The major obstacles include: lack of safety awareness and knowledge, unfamiliarity and lack of expertise with safety management techniques, lack of commitment by owners and constructors, absence of a safety regulatory framework and a low level of workers' cooperation. Realizing the strong need of construction safety research, education, and training in Pakistan, a 4-year capacity building project was funded by the Pakistan-US Science and Technology Cooperation Program. The major project objectives were: (1) to benchmark the current state of construction health and safety practices in Pakistan and to identify the data needs for continuous measurement of health and safety performance; (2) to develop health and safety guidelines for the Pakistani construction industry; (3) to develop adequate materials for conducting training on construction safety; (4) to conduct an international conference on construction safety in Pakistan; and (5) to improve the existing regulatory infrastructure for worker health and safety in the construction industry of Pakistan. A comprehensive research program was designed to collect relevant data for project objectives using mixed-method research techniques such as surveys, interviews, site observations and focus groups. On the basis of analyzed data, the state-of-the-art of construction health and safety was measured and detailed proposals and implementation plans were prepared for relevant regulatory and statutory bodies and ministries. From an educational perspective, comprehensive health and safety training material were developed and training workshops were conducted in major cities of Pakistan. Over 800 people benefited from these workshops. This paper highlights the project's major accomplishments. This project helped in capacity building of the construction industry and academic institutions in Pakistan. It is hoped that this research will yield positive social impacts in the long run.

Keywords: Occupational health and safety, Construction safety, Safety culture, Safety training, Developing countries.

1. Introduction and Rationale

1.1 Background

Construction is one of the most dangerous industries. Safety statistics for construction indicate high fatality and injury rates all over the world (Wu and Fang, 2012). Although dramatic improvements have taken place in recent decades, the safety record in the construction industry continues to be one of the poorest (Huang and Hinze, 2006). Research shows that the major causes of accidents are related to the unique nature of the industry, human behaviour, ever-changing site conditions, and poor safety management, which result in-unsafe work methods, poorly-managed equipment operations and unsafe procedures (Neale and Waters, 2012). Emphasis in both developing and developed countries needs to be placed on training and the utilization of comprehensive safety programs (Koehn et al., 1995). Safety performance is of vital importance throughout the construction industry (Choudhry et al., 2008a). Construction companies around the globe are implementing safety, health, and environmental management systems to reduce injuries, eliminate work-related illnesses, and to provide a safe work environment for their employees (Choudhry el al., ibid).

While discussing personal risk factors in construction, Ahmed et al. (2000) noted that those who spend their working lives on construction sites have a 1 in 300 chance of being killed at work. The chance of being disabled by injury or serious illness is much greater than other industrial sectors. Every construction worker is likely to be temporarily unfit for work at some time as a result of a minor injury or a health problem after working on a construction site. Research by Choudhry et al. (2008b) demonstrates that constructors in developing countries need to implement safety management systems and to increase the awareness of effective safety practices through education and training.

In developed countries, recent advancements in technology have contributed positively to industry productivity, but on the other hand, also created a more challenging and unsafe work environment. Clearly, construction accidents and the associated damage caused to the employees, property, equipment and morale generate negative effects on construction industry profitability and, to some extent, overall productivity. Responding to this increased emphasis on safety as a result of technological advancements, the construction industry in developed countries has incorporated safety as an integral part in the regulatory framework. The most important step in controlling costs for contractors in developed countries is to run safe construction sites. Contractors are compelled to implement safety as their business strategy, which has led to significant improvements in global construction safety records (Goetsch, 2012).

Developing countries such as Pakistan have yet to respond to recent technological improvements. Lack of response to technology, however, has not resulted in safer construction sites. In fact, a larger share of construction work being performed by the labour force has led to increased numbers of site accidents (Pathan and Ali, 2006). Informal assessments have identified a few major reasons for safety non-performance which include: lack of development of the construction sector in the form of mechanization and industrialization; lack of professional construction management practices which have not only led to unsafe project sites but have also resulted in construction delays, cost overruns, low productivity and poor product and process quality; inadequate safety provisions promulgated by the existing regulatory environment which has failed to establish safety as a major industry objective; insufficient and incentive-less insurance mechanisms which have failed to establish safety as a business survival issue; and an unfavorable business environment which has led to adversarial business relationships among stakeholders resulting in controversies, conflicts, claims and litigation and hence diverting the focus away from issues like safety (Farooqui et al., 2007).

1.2 Construction Safety Situation in Pakistan

Construction in developing countries, such as Pakistan, is more labor intensive than that in the developed areas of the globe, involving 2.5-10 times as many workers per activity (Choudhry *et al*. 2008b, Koehn *et al*. 1995). Typically workers tend to be unskilled and migrate in a group, with or without their families, throughout the country in search of employment. In fact, they are usually divided into various factions. Communication problems related to differences in language, religion and culture tend to compromise safety on the work site (Farooqui et al., 2007).

In Pakistan, there is a significant difference between large and small contractors. Most large firms do have safety policies on paper, but employees in general are not aware of their existence. For the majority of contractors the primary objective is maximizing profit. Unsafe conditions exist on many sites, both large and small, and labourers are subjected to numerous hazards (Farooqui *et al*., 2008). On many sites, no training programs for the staff and workers exist; therefore, no orientation for new staff or workers is conducted, hazards are not pointed out, and safety meetings are not held. Employees are required to learn from their own mistakes or experience. In addition, lack of medical facilities, shanty housing, and substandard sanitation tend to exist on remote projects. Workers undertake a risk while at work and the following problem areas are common: (1) while excavating in deep trenches (with no proper shoring), accidents due to cave-ins often occur; (2) concreting is done mainly by labourers, and cement burns due to the unavailability of protective gloves and boots are common; (3) workers fall from heights due to weak scaffolding and the unavailability of safety belts; (4) workers sustain injuries of the head, fingers, eyes, feet, and face due to the absence of personal protection equipment; and (5) there is improper housekeeping (Farooqui *et al*., ibid).

Lack of understanding of jobsite hazards and poor equipment maintenance are also major causes of accidents. Injuries generally are unreported; however, if necessary, a labourer might receive first aid or preliminary medical care. In most cases, specialized medical treatment or compensation is unavailable. Workers themselves consider accidents as being caused by their own negligence, and generally accept that construction is a dangerous occupation. Nevertheless, major accidents involving the death of a worker may not be reported due to the financial expenses and litigation that could be involved (Farooqui *et al*., 2008). Maintenance and inspection schedules often are not followed. This approach leads to loss of time, idle workers, and project delays. It may also cause damage to property. Breakdown of concrete mixers, vibrators, water pumps, and various pieces of equipment are common. Electrocution is also a major hazard, due to the use of substandard electrical equipment and underground cables. Workers, especially inexperienced workers, take chances, and often do not follow safety norms or use personal protective equipment. Also labourers and staff are sometimes under the influence of drugs. Unfortunately, in many countries crew members are not checked for drugs and alcohol before the start of and during project execution (Raheem and Hinze, 2013, Farooqui *et al*., 2008).

One of the impeding factors that prevent Pakistan from developing a construction safety program is pervasive corruption, a byproduct of the system of bureaucratic controls. As an example, for any accident that takes place on-site due to the lack of safety practices, the particular low-level activity supervisor (engineer/ technician), not the construction manager, is theoretically held responsible and may, in exceptional cases, be subject to physical abuse and harm from the victim's group of friends. In extreme circumstances, the supervisor may also be charged with a criminal offence. However, cash payments are usually accepted in lieu of pressing charges. In addition, because workers are usually non-residents of the local area and are often unaware of their rights, accidents are often not reported to the proper authorities or, if reported, are lost in the local bureaucracy (Farooqui et al., 2007).

In conclusion, the major obstacles of safety regulations implementation in the Pakistani construction industry include: lack of safety awareness and knowledge, unfamiliarity and lack of expertise with safety management techniques, lack of commitment by owners and constructors, absence of a safety regulatory framework and a low level of workers' cooperation. There is an utmost need in the Pakistani construction industry that safety rules and regulations be developed, introduced, documented and enforced. The need for an administrative body for occupational safety and health implementation is evident. There appears to be a major need in the industry to align the mindset of project owners and constructors towards an active safety management implementation; and for the same, safety awareness programs need to be developed and implemented. It also requires arranging formal and informal education and training in safety in the form of graduate education and career development programs.

2. Project Description

Realizing the strong need of construction safety research, education, and training in Pakistan, the Higher Education Commission of Pakistan (HEC) and the Department of State, USA (DoS) under Pakistan-US Science and Technology Cooperation Program (STCP), funded a 4-year (including 1-year extension) project to establish a Center of Excellence to conduct and promote construction safety research, education and training in Pakistan by involving academia, industry, public organizations and regulatory agencies. Details about the STCP program can be found at: http://sites.nationalacademies.org/PGA/dsc/pakistan/. The major project objectives are as follows: (1) To benchmark the current state of construction health and safety practices in Pakistan and to identify the data needs for continuous measurement of health and safety performance; (2) To develop health and safety guidelines for the Pakistani construction industry; (3) To develop adequate materials for conducting training on construction safety; (4) To conduct an international conference on construction safety in Pakistan; and (5) To improve the existing regulatory infrastructure for worker health and safety in the construction industry of Pakistan.

The project commenced in November 2010 and is expected to complete in August 2014. The project team consists of researchers from Pakistan and USA as follows: (1) USA Project PI: Professor Jimmie Hinze (late), University of Florida, Gainesville, FL; (2) USA Project Co-PI: Dr. Salman Azhar, Auburn University, Auburn, AL; (3) Pakistan Project PI: Dr. Rafiq M. Choudhry, National University of Sciences and Technology (NUST), Islamabad, Pakistan; and (4) Pakistan Project Co-PI: Dr. Zainab Riaz, NUST, Islamabad, Pakistan. More details about the project can be found at its website: http://cmsrc.nit.nust.edu.pk/. This paper highlights the major project accomplishments.

3. Project Accomplishments and Main Findings

3.1 Benchmarking of Health and Safety Practices

3.1.1 Current State of Construction Health and Safety Practices in Pakistan

A questionnaire was used as the principal surveying tool. The target groups were senior project managers of large construction firms in Pakistan (ranging from a net worth of 22 million to 2.7 million US dollars). The questionnaire sought data about safety management practices including health and safety policy, safety organization, safety training, safety inspections, safety promotion, personal protection program, documentation and accident prevention. Respondents were asked to answer either ‘yes’ or ‘no’ to each question. A total of 70 questionnaires were distributed, of which 55 (78.6 percent response rate) valid responses were received. The results are summarized in Table 1 while complete details can be found in Choudhry et al. (2012).

Table 1: Questions and Percentage of Respondents with Affirmative Responses

Q.	*Question statement*	*Yes (%)*
1.0	***Health and Safety Policy***	
1.1	*Has your company developed a health, safety and environmental policy?*	*63.6*
1.2	*Does the policy clearly state that decisions on other priorities should give due regard to construction safety requirements?*	*61.8*
1.3	*Does the policy commit the organization to full compliance w. all relevant H&S standards?*	*43.6*
1.4	*Does the policy set targets for health and safety performance including a commitment to progressive improvement?*	*50.9*
1.5	*Does the policy identify key senior personnel for overall coordination and implementation of the policy?*	*61.8*
1.6	*Does your company allocate any financial budget to safety?*	*58.2*
2.0	***Safety Organization***	
2.1	*Is there an organization chart showing the names and positions with responsibility lines for safety performance management?*	*32.7*
2.2	*Is the individual health and safety responsibilities of all employees clearly defined?*	*45.5*
2.3	*Have sufficient competent safety officers and safety supervisors been appointed and engaged for the site?*	*30.9*
2.4	*Are subcontractors required to submit site-specific safety plans?*	*20.0*

Q.	Question statement	Yes (%)
3.0	***Safety Training***	
3.1	*Is there a health and safety training plan?*	*38.2*
3.2	*Is any training given to new employees?*	*29.1*
3.3	*Is safety training a compulsory item within the budget?*	*32.7*
3.4	*Are trainings given to in service employees?*	*43.6*
4.0	***Safety Inspections***	
4.1	*Do safety officers and safety supervisors carry out safety inspections at regular intervals?*	*40.0*
4.2	*Does your company conduct safety audits for project execution?*	*32.7*
5.0	***Safety Promotion***	
5.1	*Are safety bulletin boards provided and located so that every employee will see them during working days?*	*34.5*
5.2	*Are safety signs and posters prominently displayed on site?*	*41.8*
5.3	*Are safety awards given on a regular basis with recognition set for good safety performance by individuals?*	*14.5*
6.0	***Personal Protection Program (Safety helmet, safety shoes, goggles, gloves, ear muffs)***	
6.1	*Has the requirements for the provision of personal protective equipment (PPE) been indicated in the contract agreement and in safety plan?*	*67.3*
6.2	*Has a sufficient stock of carefully selected and appropriate PPE been obtained?*	*56.4*
6.3	*Has an effective system for the issuance, recording, and inspection of PPE and its replacement been established?*	*32.7*
7.0	***Documentation and Accident Prevention***	
7.1	*Has any arrangement been made by your company to keep record of accidents occurring during execution of project activities?*	*50.9*
7.2	*Is there any staff hired to keep the proper documentation of accidents occurring and updating of this record?*	*3.6*
7.3	*Is any policy or plan developed for accident prevention on construction site?*	*30.9*

The survey results indicated that the large construction firms in Pakistan are generally aware of the priority of safety as well as its significance to the industry but lack commitment, cooperation, expertise and familiarity with tools to implement safety culture on their projects. Although a few companies have mechanisms of on-the-job trainings for the workers, there is a general lack of commitment from majority of contracting firms toward conductance of safety related orientation and training. Contractors, generally, are not required by project owners to maintain a safety program on projects. As such, many contractors do not follow formal safety management practices. Consequently, procedures for accident reporting and investigation, mechanisms for implementation of safety work rules, processes for safety record keeping and logging, methods for accident response, and practices for safety performance evaluation are not suitably applied by majority of contractors.

3.1.2 Safety Management Culture of Construction Companies in Pakistan

The purpose of this research study was to subjectively evaluate the prevalent site safety management practices of different contracting companies in Pakistan though their set standards in the form of safety policy manuals. Twenty nine (29) companies were selected on the basis of the categories designated by the Pakistan Engineering Council (PEC), ranging from a net worth of 22 million dollars to 2.7 million dollars (U.S.). All the companies were requested to provide their company's safety policy manual. After analyzing the manuals, data were compared to study the perceptual differences. Readers interested in complete results are suggested to read the following publication, Raheem and Hinze (2013). Though the sample analyzed was not representative of the entire industry, some common patterns were observed in the companies of similar work volume through analyzing their safety policy manuals. Though risk management was mentioned in all the safety policy manuals, it was evident that adequate details regarding standard operating procedures were only provided in the manuals from categories C-A and C-B (large size firms). The manuals from C-2 and C-3 (medium to small size firms) companies showed a lack of details in almost every aspect. This strengthens the perception of the industry that it is too expensive to implement safety on site for relatively small construction companies involved in local projects. The analysis has clearly shown that the details of some very important aspects of safety implementation (standard operating procedures, emergency response plans, training, PPE) are missing from the safety manuals of many companies. It has been inferred from the information obtained from these manuals that the construction companies in Pakistan have different perceptions of identifying problems related to safety management. If they perceive different opinions on various safety problems, the safety policy and law might not be able to solve the problems. In other words, the efforts to improve safety conditions in the Pakistani construction industry will not be effective until conscientious decisions are made by the contracting firms to improve their company's safety management. To trigger this change, rigorous safety awareness and training programs are essential to develop safety culture (Choudhry et al., 2007) in the construction industry.

3.1.3 Data Needs for Health and Safety Performance Measurement

To be able to assess the health and safety performance of the construction industry in one country, it must first be possible to make comparisons with the health and safety performances of the construction industry in other countries. To achieve this, there must be consistency in the manner in which the data are collected. This can be best accomplished if the countries use the same parameters in data collection. For the construction industry in Pakistan, the following data attributes must be collected from each major project (Table 2). More details about this study can be found in Raheem et. al. (2012).

Table 2: Health and Safety Performance Data Attributes

1. General Construction Industry Information to be Captured	
Number of construction workers *Percent of unemployment in construction* *Hours worked per week per worker* *Total hours worked in the industry*	*Number of fatalities* *Number of injuries* *Average daily wage*
2. Construction Project Information to be Captured for the Day of the Incident	
Sector of the industry *Phase of construction* *Percent completion of project* *Number of subcontractors*	*Type of project* *Value of project* *Number of workers on the project* *Number of workers per supervisor*

Weather conditions	*Area of project being constructed*
3. Incident-specific Information to be Captured for the Time of Incident Occurrence	
Age and gender of injured worker *Task being performed* *Location where incident occurred* *Time of incident occurrence*	*Trade of injured worker* *Number of days injured worker was on project* *Was proper protective equipment being worn? Day of the week*
4. Root cause of the incident (standardized list)	
Electrocution (Building Power) *Electrocution (Faulty Existing Wiring)* *Electrocution (Other)* *Falls (From Same/Ground Level)* *Caught In/Between Material* *Cave-In (Excavation/Tunnelling)* *Struck-By Equipment* *Struck-By Material* *Struck-By Other* *Struck Against Falling Equipment* *Struck Against Falling Material* *Misc.: Asphyxiation* *Misc.: Explosion/Fire* *Misc.: Homicide/Suicide* *Misc.: Equip. Mishandling* *Misc. Structural/Equip. Malfunction*	*Electrocution (Faulty Construction Tools/Wire)* *Electrocution (Power-lines)* *Falls (From Elevation)* *Caught In/Between Equipment* *Caught In/Between Other* *Cave-In (Trench)* *Struck-By Falling Equipment* *Struck-By Falling Material* *Struck Against Equipment* *Struck Against Material* *Struck Against Other* *Misc.: Drowning* *Misc.: Natural Causes* *Misc.: Chemical Exposure* *Misc.: Heat Related Stress/Stroke* *Misc: Lightning*

In the Summer of 2013, the project team presented a proposal to the Ministry of Education, Training and Standards in Higher Education to establish “Pakistan Occupational Safety and Health Agency (POSHA)”. One of the tasks of this agency would be to collect health and safety performance data of all major public projects on a regular basis. As of to date, the proposal is under review by the relevant ministry.

3.2 Development of Construction Health and Safety Guidelines

At present, there are no formal health and safety guidelines for the construction industry in Pakistan. The following Occupational Safety and Health (OSH) laws are in place: *Factories Act 1934, Workmen’s Compensation Act 1923, Minimum Wage Ordinance, 1961.* These laws were originally developed for general industries and do not satisfy the needs of the construction industry. As part of this project, we are working on the following two initiatives: (1) Development of construction-specific health and safety guidelines based on best practices from developed and developing countries; (2) A proposal for the Ministry of Education, Training and Standards outlining basic flaws in the existing OSH laws and recommendations for possible revisions/modifications. The initial work on this task is expected to be completed by Mid-Summer 2014. The draft documents shall be submitted to Pakistan Engineering Council (PEC) (the statuary body which controls design and construction industry of Pakistan), and to the Ministry of Education, Training and Standards for review, modifications, and possible implementation.

3.3 Construction Health and Safety Education and Training

The early research studies on the health and safety issues in the Pakistani construction industry urged a strong need for the development of formal and/or informal education and training programs (Farooqui et. al., 2008; Farooqui et. al., 2007). As a result, the project team worked on three initiatives:

3.3.1 Training Programs for Construction Professionals

The project team developed training material on different topics related with health and safety such as: 1) Importance of construction safety; (2) Measuring safety performance and recording information; (3) Job safety and hazard analysis; (4) Developing safety plans and policies; (5) Accident investigation, reporting, and recordkeeping; (6) Introduction to OSHA standards; and (7) Role of information technology in safety planning and management. In the Summers of 2011, 2012 and 2013, the project team conducted several 2 or 3 days workshops in major cities of Pakistan. The target audience were general and speciality contractors, designers, consultants, project administrators (public and private), construction developers, and relevant govenrment agencies. Over 800 participants attended these workshops. All training material were provided to the participants so that they can conduct similar workshops in their own organizations. These workshops proved to be highly successful and could be considered as a first move to promote construction safety in Pakistan. The Center of Excellence namely “Construction Management and Safety Research Center (CM&SRC)” plans to continue these training on regular basis in the future.

3.3.2 Online Construction Safety Course

An online construction safety course consisting of 20 modules, 4 aids and a self-assessment quiz is developed. It is available at the website of the Construction Management and Safety Research Center (CM&SRC). The purpose of this online course is to provide basic and advanced knowledge on construction safety issues and best practices to the practitioners and trainers. The course is free to everyone and the website URL is: http://cmsrc.nit.nust.edu.pk/onlineCourse.aspx. In the coming months, it is planned to enhance the existing modules and add additional modules.

3.3.3 Educational Modules for Teaching Construction Safety in Construction/Civil Engineering Programs

The project team developed educational modules for instructors that teach construction safety concepts in construction and civil engineering curriculums across Pakistan. The following modules are developed: (1) Module A for Civil Engineering Programs: This module provides necessary teaching material (e.g. slides, assignments and a quiz) to teach 6 contact hours on construction safety within a construction engineering and management course; (2) Module B for Construction

Engineering Programs: This module provides necessary teaching materials (e.g. slides, assignments, discussion questions and quizzes) to teach a full course (30 contact hours) on construction safety.

3.4 International Conference on Construction Safety in Pakistan

The purpose of such conference was to bring renowned researchers to Pakistan to allow them to address pertinent issues on construction safety as well as professionally interact with local experts. As a result, the *International Conference on Safety, Construction Engineering, and Project Management* (ICSCEPM-2013) was held in Islamabad from August 20-21, 2013. The ICSCEPM-2013 provided an international forum for researchers, engineers, practitioners, and safety and health professionals to address current issues affecting the successful achievement of safety, construction engineering and project management in construction. Fifty two (52) papers were accepted by the International Scientific Committee for inclusion in the conference proceedings. Around 200 participants attended the conference representing researchers, academicians, administrators, and practitioners from educational institutions, government agencies, contracting organizations, consulting firms, and other construction related organizations. The event was truly global with papers' representation from 19 countries including Australia, China, France, Ghana, Hong Kong-China, Italy, Kazakhstan, Malaysia, Pakistan, Qatar, Saudi Arabia, Singapore, South Korea, Sri Lanka, Thailand, Turkey, Uzbekistan, United Kingdom and United States. Conference proceedings, keynote presentations, conference and workshop presentations, and photos can be viewed using the following link: http://apps.cadc.auburn.edu/icscepm/.

3.5 Improving the Existing Regulatory Infrastructure for Workers Safety

A thorough study was conducted to understand the current operational structure of the Pakistani construction industry. To initiate the formal safety setup in Pakistan, the following suggestions were made to the Pakistan Engineering Council. A detailed implementation plan was also provided to the PEC.

3.5.1 Incorporation of Safety Credit Points in the Contractor License Renewal Process

It is suggested that safety credit points be allocated based on the documentation provided for adopting specific safety practices by the contractor during the three year licensure period. These practices can be as follows: (1) Implementation of safety on site as a contractual obligation; (2) Preparation of a site specific safety plan for each project; (3) The allocation of some percentage of the contract money for worker safety other than to facilitate; (4) The construction work itself (e.g. facilitating access to heights). Funds would need to be reserved in each bill of quantities (BOQ) of a project to provide basic personal protective equipment such as hard hats, safety shoes, protective eyewear, full body-harnesses and lanyards and gloves; (5) Preparation and provision of a mandatory copy of the project safety manual; (6) Contractors to maintain a project-by-project record of fatalities/doctor-treated injuries/first aid injuries; (7) Having a full time safety professional on projects with more than 200 workers on the project site; (8) Qualification of the full time safety professional employed based on the professional safety; and (9) training certifications received. The following is the proposed number of safety credit points for each type of the category. These points are proportional to the professional credit points (PCPs) required for each category. Once the basic scheme has been established, further details will be provided explaining the safety actions and how they should be weighed.

Table 3: Safety Credit Points (SCP) Scheme

Constructor's Category	*Limit of Construction cost of Project (million Rs.)*	*Professional Credit Points (PCPs) required*	*Safety Credit Points (SCPs) required*
C-A	*No Limit*	*150*	*50*
C-B	*Upto 2000*	*100*	*33*
C-1	*Upto 1000*	*75*	*25*
C-2	*Upto 500*	*30*	*17*
C-3	*Upto 250*	*20*	*13*
C-4	*Upto 100*	*15*	*4*
C-5	*Upto 30*	*5*	*2*
C-6	*Upto 15*	*5*	*2*

3.5.2 Improvements in the Standard Contract Documents

It is recommended to include more explicit safety requirements in the standard contract documents by the Pakistan Engineering Council for the parties involved in each project. Currently, very generic language has been used regarding worker safety in these documents. For example, the safety clause in the standard bidding document PEC states: “Due precautions shall be taken by the Contractor, and at his own cost, to ensure the safety of his staff and labour at all times throughout the period of the Contract. The Contractor shall further ensure that suitable arrangements are made for the prevention of epidemics and for all necessary welfare and hygiene requirements”. It is very clear just by reading the statement that the requirements are too broad and there has been no standardized system of safety implementation so the contractor will provide what he deems suitable and hygienic.

4. Concluding Remarks

At present, there are no formal regulations for implementing a safety management system on construction jobsites in Pakistan. An integrated approach is needed to institute a formal safety infrastructure for the improvement of safety on construction sites. Because of the fragmented nature of the national safety culture, there is no well-defined mechanism for injury/fatality recordkeeping or incident investigations. Each contracting firm has its own established rules and methods in this regard. In a nutshell, there is a dire need for improving the national safety culture of Pakistan by devising strong safety regulations and an equally firm disciplinary process for proper implementation. This will in turn help in improving the macro and micro safety climate within the contracting firms in Pakistan. This project is a first step to promote the need and value of health and safety regulations in

Pakistan. The following could be considered as major project achievements: (1) Benchmarking of existing health and safety practices; (2) Identification of data needs for monitoring health and safety performance and development of a mechanism to collect such data; (3) Development of international standard health and safety training material that can fulfil the local needs; (4) Safety training workshops and seminars in different cities of Pakistan; and (5) Development of a detailed plan to improve the existing regulatory infrastructure for workers safety. The existing project will complete in August 2014. There are plans to continue work on some project initiatives until the overall goal of establishing and fully implementing the health and safety regulations in Pakistan is not completed.

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Public Sector Approaches to Sustainability in Ajman, UAE

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Abstract

The public sector has a significant role to play in promoting sustainability due its regulatory role but also its significant spending power. Hence, it will be a key success factor for implementing sustainable procurement (SP) in the public sector and would also create opportunities for its adoption in the private sector. The aim of this dissertation is to investigate the extent that public sector organisations in Ajman/UAE have developed detailed understanding of SP. The research is also to investigate the drivers and barriers for the adoption of more sustainable products and practices. Detailed case studies in two major public departments have revealed good understanding of the concept of sustainability but weak understanding of SP. This would undermine any effort to have more systematic delivery of sustainable projects. The number of initiatives that were successful demonstrated readiness in Ajman public sector to accept SP implementation. Incentives and new regulations as well as support from senior management would speed up the implementation of SP.

Keywords: Sustainability, Sustainable Procurement, Public sector, Drivers, Barriers

1. Introduction

Sustainability has become one of the most significant items on the agenda of nations, corporations, and even the general public. Sustainability agenda was driven by concern for the lack of balance between meeting our current needs for products and services and that of protecting the choices of future generations. Sustainable procurement (SP) has also received attention being concerned with procuring the goods and services that are sustainable and have the least negative impact on the environment with the maximum positive impact on the society. Researchers have argued that the triple bottom line of sustainability can be incorporated into defining the need, evaluating options, design and specifying, supplier selection, tender evaluation, post contract management and supplier development (Hall and Purchase, 2006; Nakou et al, 2006; Morrissey, 2006; Walker and Brammer, 2009). In the past few years the Emirate of Ajman, of the United Arab Emirates (UAE), has experienced strong growth in the construction sector especially for infrastructure such as roads, sewerage systems, water and electrical facilities. The majority of these projects were procured directly by the public sector departments or under their supervision which gives the public sector major influence in Ajman's Market. Although, sustainability has received significant attention evident by a number of initiatives and activities in this field the majority of their projects are still procured following more traditional practices. This research is to investigate current views and understanding of the concept of sustainable development and procurement in public sector organisations and the barriers and drivers to adopt and implement sustainability in Ajman's public sector projects.

2. Public Sector Adoption of Sustainable Procurement

Governments have two main roles to play that would significantly impact the industry's ability to achieve more sustainable solutions. The first role is as a purchaser and the second is as regulator of the market. The role of the government as a regulator is obvious and critical. Equally the different government departments with their significant purchasing powers can be a major driver for more sustainable products and services. Queensland Government's State Procurement Policy (2012) defined SP as "a process whereby organisations meet their needs for goods, services and capital projects, in a way that achieves value for money on a whole life basis in terms of generating benefits not only to the organisation, but also to society, the economy and the natural environment". The United Kingdom Government and the Marrakech Task Force on Sustainable Public Procurement defines SP as "a process whereby organizations meet their needs for goods, services, works and utilities in a way that achieves value for money on a whole life basis in terms of generating benefits not only to the organization, but also to society and the economy, whilst minimizing damage to the environment" (Morrissey, 2006).

The drivers for sustainable can be external and internal to the organisation. Jones (2007) study of private sector identified external drivers to include investors' expectations, the performance of industry, the requirement of the standards, the influences of the non-governmental organizations, the desire to reduce the reputational risk, the competency of suppliers to adopt new process and the enthusiasm to change the whole industry practice. The same study examined internal drivers including the ability of buyers to understand the concept of SP, the willingness of the procurement team to work with the other related teams, and a number of organizational factors related to its leadership, organisational goals, practices, size and strategy of the organization. Walker and Brammer (2009) argued drivers for SP include public organisations familiarity with policies and clear understanding of the concept of SP, overcoming concerns that SP is more expensive especially with the tight budget constraints facing most public organizations, providing incentives to change in public organizations to overcome the inertia reinforced by long established practices supported by deeply rooted procedures, and the availability of suppliers able to deliver sustainable products and services to public sector clients.

Augenbroe and Pearce (1999) and Nakou (2006) argued that the measures and strategies for energy conservation, resources saving, waste reduction, improving indoor and outdoor atmosphere quality, in addition to policies and initiative to enhance value for money and the availability of environmentally friendly technology play an important role in encouraging the adoption of SP. The introduction of new format of contracts and procurement arrangement, the use of life cycle costing to evaluate project proposals, moving toward integrated supply chain management and introducing key performance indicators that will be client oriented are key drivers for the implementation of SP policy (Winch & Courtney, 2001). Market pressures should not be underestimated where the disruptive innovation needed to develop new products and services is likely to be viewed as a threat to the competitive position of long established businesses. For example, the market for wastewater treatment in the UAE was dominated by conventional methods of treating wastewater using electro mechanical technology with key players making a huge investment to develop their capabilities in using such an approach. It is not surprising that such companies reacted negatively to the proposed use of new methods of treating the wastewater in a sustainable and environmental friendly way that will maintain a green practice and enhance the bio diversity aspect. It did not help that public clients were reluctant to adopt such new sustainable methods due to the cost of implementing such new methods, and lack of confidence in the performance of such methods, the larger land needed for its implementation. Jones (2007) research explains that such barriers are related to a number of issues which include knowledge gaps, limited resources, weak supplier commitment, lack of clear road map for adopting SP and competitive pressure. Snell (2008) highlighted that in a number of UK public departments there is still a lack of awareness for the SP definition and the lack of the necessary skills and supplier engagement. Walker and Brammer (2009) work sheds light on the complexity of such issues by emphasizing the importance of considering manufacturers and suppliers' ethical behaviour and social responsibility, the end of life option for the services or the products that would include recycling, reusing and disposal methods, resources requirement, design requirement, the distribution and production logistics and transport and durability of the product/service. Pollington (1999) added the importance of understanding and absorbing the cultural values of the customers and the end users.

3. The Research

The research has adopted a case study approach to be able to engage and understand public sector organisations in an area that has received very little attention from researchers in the region. The case studies have been selected in order to be able to investigate the current understanding and experience of public organisations, which plays key role in influencing the sustainability agenda in Ajman's public sector, in procuring public projects.

3.1 Case Study 1: Ajman Municipality & Planning Organization

There is no doubt of the important role the municipality plays not only in developing and monitoring compliance with laws and directives, which would include those related to the environment and health, but also in their procurement of important public projects. Interviews with more than 20 employees at different levels of the hierarchy in several departments were conducted. The research asked specific questions to evaluate the levels of understanding and awareness of the relevant issues. The interviewees expressed general understanding about sustainability and sustainable development evidenced by a number of projects and initiatives that were initiated to address critical environmental issues. Such initiatives were reviewed to ascertain the drivers and barriers that face the procurement process. Despite the number of such initiatives the interviewees were not able to articulate a clear idea of the concept of SP. This may explain the number of problems that the Municipality sustainability initiatives have faced.

There was an example of an initiative from local groups to reduce the wastes dumping at the landfill. However, such initiative did not reach the implementation stage because there were no supporting legislations that would enforce the execution of such initiatives. The initiative proposed by a private investor was to collect and recycle waste paper for a fee the investor is to pay to the Municipality. The Municipality was interested and encouraged the proposal because, in addition to the fee it will collect from the investor, it will reduce its expenses in transporting this type of wastes to the landfill and will reduce operation and maintenance cost of the dumping activities at the landfill site. So the Municipality encouraged the investor to go forward and establish his factory. However, the investor was disappointed by the poor market demand. He was challenged with the resistance from the end users who refused to buy his recycled products which undermined the feasibility of the project and it was subsequently discontinued. This indicate the need to enhance public awareness of the importance and relevant of sustainability goal to the wellbeing of society.

Another example was related to the Municipality decision to privatize its wastes transportation. It was believed that this decision will be a win-win situation where the private sector is motivated to introduce new ideas in reducing the waste impact on the environment and the community. The municipality went forward and issued the necessary legislation to support the implementation of this initiative but due to the fact that no market research the Municipality ended up with no company expressing interest in such opportunity to simple fact no such companies operate in Ajman. This is another indication of a weak local market in this field. Interviewees explained how a partnership, initiated by a private consortium, between the public sector and private sector proved successful in the “Abattoirs’ Fats initiative”. The usual practice at the Abattoir was to dispose the fats separated from the animals and the Abattoir’s wastes at the landfill which needs to happen at the same day. The private consortium proposal was to buy this fats and wastes and convert them to good and useful material that would be sold to other industries. There was a great demand for this product and after 3 years of operation it is generating revenue to the Municipality of 400K AED per annum. From the above examples it can be argued that the Municipality seems to rely more on the private sector to take the initiative and deliver whole solutions. This would reduce the exposure to commercial and technical risks as well reduce the influence of internal management systems on the procurement of such new ideas. This conclusion is supported by evidence from interviews where the interviewees raised doubt about the ability of the Municipality to change its procurement system to able to procure more sustainable projects. Although there is flexibility that would allow the introduction of criteria other than the cost interviewees believed such flexibility is quite limited and is not available for procuring all the products and services. Interviewees from the contracts and purchasing department team stated that the main criterion for selection of products and services is the cost. However, other criteria are considered when the procured service or product is related to technical departments. However, the technical department has to justify the inclusion of other criteria. Once proper justification is provided then the contracts and purchasing department will process the procurement order for the selected item regardless its cost. Internally there seems to be significant interest in making the organisation more environmentally friendly through the adoption of an energy conservation policy which includes a campaign to raise awareness among the employees.

There was consensus among the interviewees that the organisation lacks the necessary legislations to transform its traditional procurement to SP. There was also a view that more effort is needed to raise awareness of the concept especially at senior management level and they were confident that top management would support it. More effort is need to raise awareness in society which would create a market more receptive to sustainable products and services. The drive to embrace sustainability reporting and corporate social responsibility adaptation by the government would help the government play a crucial role in moving the sustainability wheel at a faster pace, according to interviewees. Its role could include enacting necessary legislations, subsidizing sustainable services, encouraging suppliers to innovate for sustainable products and services through offering discounts, tax reduction, trade license facilities and easier renewal permissions, and through the promotion of more public private partnerships (PPP). However, interviews with senior management indicate that although sustainability and SP are good ideas but they are not sold on that principle to consider an overhaul of its procurement systems.

3.2 Case study 2: Ajman Sewerage Organization (ASO)

ASO is concerned with the building, operation and maintenance of infrastructure critical to dealing with sewerage in the Emirate. Interviews were conducted with ten employees in this organisation at different management levels. The understanding of the concept of sustainability and sustainable development was more focused on the environment such as saving water and energy, using recycled paper, reducing pollution, minimizing wastes, green buildings, and local sourcing for the services instead of importing. However, when asked about their understanding of sustainable procurement their responses indicate lack of clear understanding. Top management believed the role of ASO is to serve the community and protect the environment which supporting the sustainability and sustainable development agenda. There was a strong conviction among interviewees that ASO is very “sustainable” providing good service to the community by utilizing local resources, offering job opportunities and enhancing the market of Ajman which is seen critical to ASO success. The core business of ASO is to collect the wastewater and treat it to quality levels that make it an attractive and sustainable source of water that could be used in many applications such as irrigation, construction, firefighting and district cooling. Due to environmental focus of its business as well as being a public organisation ASO had to consider the environmental impact of its project on the society through requiring that an environmental appraisal is carried out for its activities. The interviewees believed that the main drivers for adopting sustainable practices were the legislations governing ASO which would have strengthened the second drivers of top management support for this concept. This would have created an organisation that is sensitive to the risk of being seen to harm the environment and hence greater effort is exerted in the procurement of high quality material and equipment to reduce risk and increase certainty on the likely outcome of ASO projects. The organization's strategy is believed to have significant influence on the ability of ASO to implement SP. This strategy helped the adoption of clear and uncomplicated procedures to implement SP. For example, ASO decided to accept the suppliers who were accredited by a number of international accreditation systems rather than develop its own and add more complications and cost to its suppliers.

The lack of necessary legislation and laws that enforce the implementation of sustainability and requires public organisations adopt SP was considered the main barrier by the interviewees. For example, surplus treated water produced from the treatment plant is discharged to the sea. This treated water has an impact on the marine life and could contribute to negative phenomena. So although there are some initiatives to utilize all of the produced treated water, still there is no legislation that will enforce 100% utilization of treated water and zero discharge to the sea. When the different action and diffusion mechanisms implemented in other countries were discussed a number of interviewees argued that although is wise to learn from other experiences Ajman/UAE should consider carefully what is appropriate. The discussions with the interviewees raised a number of suggestions as a way forward. The first is for the government to support sustainability by offering subsidies to sustainable services as well as promoting such concepts across the education system. Secondly, to require clear commitment from the top management of public organisations through developing clear strategy on how the organisation can be sustainable. Thirdly, providing demonstration projects where the tools and practices that have delivered sustainability can be shared in a clear and simple message to the general public.

4. Discussions and Conclusion

The general understanding of sustainability and SP at the case studies raised concerns that although the concepts of sustainability was not a major concern but understanding how to deliver it, i.e. SP, was poor. This would require more intensive awareness, education and elaboration on these aspects to prepare capable resources with the required level of knowledge and skills to tackle the SP implementation. It was very interesting to know that there were many sustainable initiatives implemented already in Ajman's public sector. However, these initiatives were scattered and not integrated to a general and common sustainable strategy. The results of both case studies indicate that the most important factors that will affect the implementation of SP at Ajman's public sector were government support, necessary legislations, understanding the SP concept, the financial impact of SP and the society awareness of sustainability aspects. One of the challenges that were raised during the discussion was that public organisations need to define what sustainable service or product in their context means which should pave the way to provide clear guidance to contractors and suppliers. That is why it is necessary to educate and train the employees about sustainability and SP to build the capacity within the organization to develop a relevant approach to sustainability. There was support for legislations that demands sustainable products and services which would create the much needed market demand and drive. Without creating a bigger market for sustainability then it is likely to continue to see such products too expensive to procure. Greater focus on life cycle costing rather than lowest capital cost should contribute to more positive cost benefit analysis of sustainable products. The hidden and indirect costs resulting from the operation and maintenance activities are not considered by the different public departments. Although the SP meant to many interviewees as procuring expensive services and products, however, when the real and hidden expenditures are presented then it will be realized that it is more efficient to procure sustainable products and services. It is a fact that the upfront cost of the sustainable service/product is more than the traditional service due to the inclusion of a premium for the design and technology. However, for the whole life cycle cost that include operation, maintenance, replacement, renewal and disposal costs then the sustainable service proves to compete the traditional service. Government support and encouragement in form of incentives, subsidizing of sustainable services, believe in sustainability and adopt sustainable policies on personal and corporate level is crucial for successful implementation of SP. In addition to that it is to emphasize upon the top management commitment and the alignment of SP in the whole organization strategy. Top management support has to be communicated to the whole organization through setting up the corporate vision and simple procedures of implementing SP. There is a lack of awareness and understanding for sustainability and SP aspects. There is an urgent requirement for education, awareness and corporate social responsibility adaptation on different community level.

Based on the findings and the analysis presented above, general and specific policies can be adopted. The general policy can include sustainable urban development, developing educational and awareness campaigns for the different community sectors starting from homes up to the universities, developing awareness campaigns and master classes for the employees at the different public departments and drawing the legislative framework for the necessary laws and local orders or administrative orders that will enforce the implementation of SP at the public sector. An effective and supportive mechanism that can be used is to have a central procurement and inventory control department among the public sector departments. Through a centralized procurement department, sustainability aspects can be adopted more efficiently bearing in mind that size of Ajman market. There are many benefits, which can be obtained when such mechanism is implemented. The first benefit is the merging of the skills, knowledge and experience of different teams in one team, which will empower the public sector and increase its competency. The second benefit will be in the financial aspect. When many departments are procuring common products or services, the number or quantity of the procured items will be bigger than one department order. This will encourage the suppliers to offer attractive products and services that are in line with the sustainable criteria. This will increase the public sector marketing power and its influence. The third benefit will be in form of reducing the administrative costs as instead of many procurement departments in every organization, there will one central procurement department serving the public sector in Ajman.

The central joint procurement concept can be efficient in many ways beside the above mentioned benefits. One of way of looking at it will be through its ability to facilitate the introduction of sustainable products and services in all the departments because even if some departments will be reluctant or not convinced about the sustainability benefits, they can be persuaded when they will realize that being a member of joint procurement will give them the privilege of procuring the same items with reduced prices. That will achieved when the supplier will bid for huge bulk order instead of individual order. Another way will be the call for more innovative products and services. The supplier/manufacturer will find it attractive to be innovative and creative in supplying/manufacturing products/services that are in line with the sustainability and environmental friendly. Also, when the demand for sustainable services is increasing then the price for these services will reduce naturally. At the same time, the market will be more attractive and encourage the suppliers to introduce new brands of products and technologies that are sustainable and available in other countries. Another key value for the central joint procurement will be the ability to standardize the sustainable demand criteria and thus enacting the necessary laws and regulation to enforce the implementation of SP

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Managing International NGO Projects

Context, cultural competence and its impact on performance

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Abstract

The increased global awareness of poverty and inequality issues has increased demands for Non-Government Organisations (NGO) and their expertise in international development projects. However, despite higher requirements to accountability, improved project frameworks and a more professional management staff, too many international development projects tend to fail. This issue has raised concerns that such projects need a distinctive set of values, skills and competences for effective project management within the complex NGO context. The paper's aim is to explore the contextual factors and cultural competence that may influence project managers' ability to lead international development projects successfully. Due to limitations of existing theory, an empirical qualitative research was applied. In that regards, a case study approach was chosen where the researcher followed an international project manager amongst the Maasai people in Kenya for six weeks. Based on the literature review, field observations as well as 12 interviews 6 contextual factors were highlighted as most influential on project performance: *the complex web of stakeholders, power balances, different cultures and traditions, inequality and limited access to resources, the community's motivation and willingness to change as well as the local decision-making process*. Moreover, findings indicate that the cultural competence can support a process that may increase the awareness and knowledge of contextual factors that again may improve the project managers' ability to establish relationships, to communicate and approach challenges and opportunities more effectively.

Key Words: International development projects, project management, NGO, cultural competence

1. Introduction

The inequality between the rich and the poor has been a global concern for decades and is a well debated and a discussed topic amongst powerful leaders as well as the ordinary man on the street. As an attempt to quantify the extent of this issue, the UN conducted a research indicating that more than 1.2 billion people are living for less than a dollar a day, which is defined as the minimum income of survival in the third world (UN, 2012). Additionally, approximately 900 million grown ups are not able to read or write and 125 million children do not have access to primary education and hence lack the adequate opportunities to get proper jobs later in life. The unfortunate situation pin point the great challenges as well as the importance of international Non-Government Organisations (NGO) development projects that, seen in a broad and simplistic perspective aim to decrease the large gap of social and economic inequalities on national as well as international level (Anderson, 2010).

However, despite the increased growth, trust and responsibility of NGOs, many such projects still tend to fail (Allerton, 1997; Diallo & Thuillier, 2005; Bennet et al., 2000; Keyley et al., 2006). Evidence shows that poor performance of development projects and the disappointment of the beneficiaries tend to be the rule rather than the exception (Ika et al. 2012, cited in Hermano et al., 2012, p. 22). Supportive of such statement, Allerton (1997) found that 50% of the international expatriate workers assigned for a specific project in a local country, either broke off their assignment or failed to reach their project goals. The failures led to extensive conflicts with the donors, damaging reputation in the local community, mistrust and hence problems initiating new projects in the respective area (Bennet et al., 2000). As an attempt to identify the reason behind the high rates of failure Keyley et al. (2006) found the *lack of ability to adapt to the foreign and unfamiliar context* and *the willingness to stay through the project duration* as main contributing factors. Taking these findings into consideration, one may draw a parallel to the following statement given by Hofstede et al. (2011) "our own culture is like the air we breathe, while another culture is like the water- it takes special skills to be able to live and work in both elements" (p. 23).

1.1 Scope of research

Despite the increased awareness regarding the contextual challenges in international projects, it is surprising to realize how limited the research is on the set of skills, knowledge as well as contextual approaches required to succeed with international project management (Lewis & Opoku-Mensah, 2006; Miguel, 2004; Diallo & Thuillier, 2005). For the same reason, and perhaps in the NGO sector especially, the success factors and effective management practices seems unclear (Bennet et al., 2000; Diallo & Thuillier, 2005; Hermano et al. 2012) and leaves a gap that raises the following questions: In an unfamiliar and new context- what competencies and knowledge should Project Managers (PM) encompass in order to be prepared and hence succeed with international projects within the NGO sector? What are the main challenges? Moreover, as cultural issues are stated as one of the main challenges in International Development (ID) projects: How can cultural competence influence the PM's managerial ability to collaborate and achieve project goals? These are some of the questions that led to the following research problem: *"In the NGO context- how can contextual factors and cultural competence influence the PM's ability to lead ID projects successfully".* Figure 1 summarises the main scope of this research.

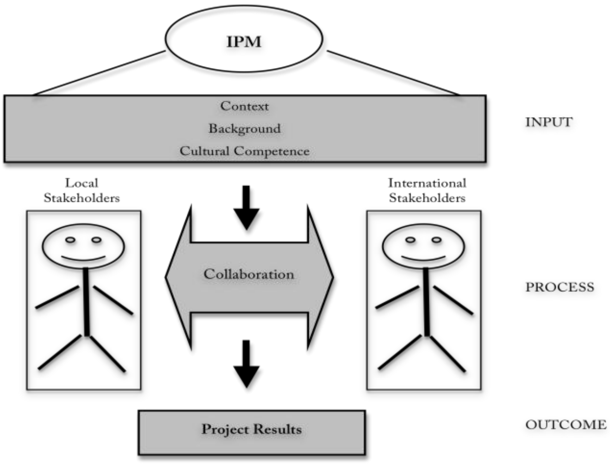

Figure 1: Illustration of the research framework

2. The Theoretical Framework

In order to investigate the unique drivers within the NGO context and hence the potential challenges and opportunities that may influence the ID projects and hence the ways they are managed, the SWOT and PEST tools were assessed (Lynch, 2000). Secondly, it was pre-assumed that every ID worker has his/her own cultural background whose mindset, expectations to colleagues and standards of living are brought into the collaboration. Consequently, one may suppose that cultural competence has an impact on the managerial ability to lead. Accordingly, each of the "input" factors (new context, individual background and cultural competence) was thought to potentially influence the ability to communicate cross-culturally and lead the people involved towards the goals of the project. The project process in this case mainly concerns the collaboration between the key stakeholders defined as the sponsors (who pays), the organisational unit (who carries the final responsibility) and the local community (who benefits from the project outcome). Finally, the potential relation between the previous steps and the project results was explored.

2.1 Cultural Competence

This research investigated the elements of "cultural competence" based on the simple definition provided by Romney (2008) who describes it as "*the knowledge, attitude, and skills required working with people from different cultures"* (p. 142). In order to become culturally efficient, Simkhovych (2009) claims the PM needs to develop "*the ability to relate with people from different cultural backgrounds as to maximize the chance of mutual beneficial outcomes*" (p.88). In order to understand the process of becoming culturally efficient, Campinha-Bacote (2002) pinpoints the criticality to "*continuously strive to achieve the ability to effectively work within the cultural context"* (p.181). For this reason, her "Cultural Competence Model", developed originally for the health care sector, views cultural competencies as an ongoing process that involves awareness, knowledge, skills, cultural encounters and the desire/willingness to understand the counterparts. Those five aspects are interdependently connected. If one dimension is lacking, the cultural competence of the PM may be reduced and hence cause misinterpretations and therefore affect the collaboration negatively (Campinha-Bacote, 1999).

3. The Research Method

Due to limitations in the existing literature on the topic, as well as it would enable the opportunity to closely observe, identify unknown factors and compare the theoretical findings to a real life project, an empirical research was conducted. The main aim is to explore the relationship between the (input, process and output) constructs more in depth and subsequently identify potential gaps between previous theories and practices that may be crucial for successful project management within this field. Based on the nature of the research problem, a qualitative design and a case study method were selected. In order to acquire the sufficient data, the author followed an international PM in the field for 6 weeks. Based on the participative field observations supplemented by 12 interviewees sampled from a variety of stakeholder groups, the qualitative study gave greater insight in the research problem and provided findings that will be presented later in this paper.

3.1 Brief introduction of the case study / research context

The selected Kenyan/Norwegian organisation (later referred to as SC for anonymous reasons) is a partly voluntary and professional based international NGO initiating various projects to create awareness on human rights, educate and provide essential health services to the Maasai community in Kenya. The SC projects are initiated and executed in alignment with the UN's Millennium Development Goals commissioned by the UN Secretary-General in 2002 "*to develop a concrete action plan for the world to reverse the grinding poverty, hunger and disease affecting billions of people*" (UN, 2014). The main collaborative actors in this case study are 1) *The Norwegian team* that fundraises the projects, communicates with the sponsors and reports to *the Director of the Board in Norway* 2) *The Kenyan team* that performs field activities and reports to the local coordinator 3) *The local coordinator* who is responsible for the communication with the Maasai community and the performance of the Kenyan Team 4*) The International Project Manager* who is the funder of the organisation, keeps an overview and has the final responsibility of all the projects 5) Last but not least, the Maasai Community Board who represents the Maasai people /the beneficiaries involved in these projects.

The Maasai community encompass a unique group since they live in a traditional and simple way, far from the civilization with leadership structures and decision making processes that differ significantly from the western way of thinking. The Kenyan context showed to be particularly interesting since there is a large number of NGOs operating in the country whose work currently account for almost 50 % of all the development services provided to its population (Mutsune, 2009). Moreover, with its 43 tribes as well as hundreds of sub clans encompassing different cultures, mindsets and work procedures (Miguel, 2004), the context provided the opportunity to identify and analyze the cultural dimension more in debt and hence increase the significance of this research.

4. Findings and discussion

4.1 Unique contextual factors – how does it influence the collaboration and project performance?

Due to the limitation of space the focus in this paper is on the more general findings regarding contextual challenges the PM faces and how cultural competence may aid the PM to face and handle these challenges more effectively.

4.1.1 “Different contexts, understanding and impact on collaboration”

In the observed NGO context, many of the local team members tended to live under poor conditions that seemed to cause lack of sleep, inaccessibility of clean water or sufficient food. Consequently, in some cases, the local workers seemed to lack energy and be less motivated to back up colleagues, communicate effectively or find creative solutions to problems; in other words be less likely to achieve the western team set targets. Hence, the lack of physiological and safety needs is expected to affect the person’s ability or energy to work towards idealistic visions (supported by Maslow’s motivation theory from 1943), which is expected by the western members of the project team (as indicated by the PM). For these reasons one may therefore argue that the fulfilment of fundamental needs (e.g. food / water, sleep, feeling of safety and belonging) as essential for effective collaboration in multi cultural NGO projects. Observations in this case study indicate that the lack of fundamental needs have led to frustration of the international members of the project team with the perceived inefficiency of the local stakeholders which and in some cases created quite severe conflicts. For this reason the managerial awareness and sensitivity of these issues can be critical in order to establish a collaboration that can meet the needs and expectations of both teams.

4.1.2 Contextual knowledge and risk / uncertainty assessment

Another example of how managerial awareness/knowledge of context and the ability to communicate cross cultures may influence the performance is illustrated below.

Table 1: Story told during an interview with the IPM: "The corrupt container"

> "We were transporting a container from Norway to a hospital near Nairobi that contained equipment worth around 300 000 dollars… donated by a hospital in Oslo. The expected time of delivery was totally 3 months. After 1 month the container stranded in Nairobi. The port authorities claimed a significant amount of money to release it. Since the SC has a strict corruption-policy, we refused to pay any bribes. Instead we tried everything to avoid the payment and hence risk misuse valuable sponsor money. She said: "*To make a long story short; we were forced to walk the long bureaucratic way and ended up by talking to a minister of the government who finally helped us release the container and transport it to the final destination. The project was delayed by 1 ½ years!*"

When asked during interviews in the aftermath of this incident, the local coordinator admitted to have almost "*given up many times*". One Norwegian team member said: "*I was honestly thinking; are they doing enough? Why can't they just go to the police*? *There must be more effective options!*" According to the director of the Norwegian board, who had to keep the donors informed along the process, was "frustrated" and "ashamed". The local coordinator, who was responsible for the container after it arrived the Kenyan port stated "*I felt mistrust and unrealistic requirements from my Norwegian colleagues…they don't know how things work here*". The different points of views may show how contextual challenges may lead to a lack of motivation, mistrust to colleagues, doubts and frustration if not understood properly. According to the PM, the focus on careful selections of teams and relationship building has been crucial in order to prevent repetition of similar situations. Subsequently, involving the stakeholders in the risk assessment and project planning has not only increased the trust between the sponsor and the NGO, but also created a mutual understanding of context (both ways) and hence established more realistic expectations to project performance and outcome.

4.1.3 Challenges of different backgrounds

In a local-international co-operation in NGO projects, the international workers normally come from a well-developed part of the world and may therefore are not likely to have the experience of living without, for example, clean water, effective health care, security, a "proper" accommodation etc. Consequently, the international team members may experience "culture shocks" that may hinder the project from running effectively (Kealey et al., 2006). In contrast, the local team is used to the customs, the political and socio cultural environment, legal systems and other factors that the international team may spend time getting used to (if they get used to it at all). The example below may illustrate this point:

Table 2: Observations from the field diary: “It takes a whole day to withdraw money from the bank!”

> “I was going to the bank to receive money from the Norwegian board. The money was transferred physically in a bank in Norway and I was told that the money would be in the local bank the next day. When I got to the bank- I was told that they had no money left! The system had collapsed. When I asked when I could expect to withdraw that specific amount, he just replied that he didn’t know; maybe tomorrow”. I was furious. How could I pay for the transport we were using for the mobile clinics 5 days after? And the salaries? We solved the problem by driving 6 hours to Nairobi to get the money from a different bank. It took us the whole day and night. It was a frustrating experience”

As the Norwegian team worker expressed frustration over the delays and the extra effort, the Kenyan colleagues tended to view these issues as “a part of life”. The example shows one of many observed situations where the context seemed to challenge the stakeholder expectations. When asked how they coped with this challenge, the interviewees tended to agree that the vision and strong purpose of the project were crucial. This is supported by Khang and Moe (2008) who identified a strong and meaningful vision as one of the critical success factors of ID management. This raises the question: In International Development work- is creating a strong vision enough to succeed?

4.1.4 The complexity of development projects- a managerial challenge

In comparison to construction projects where progress and results are less difficult to monitor and control (Ochieng & Price, 2009), the goals of development projects are often related to change of social patterns, beliefs and traditions, which is less concrete and hence complicates the ability to measure performance effectively (Lewis, 2007). As a matter of fact, in many cases, the results of development projects often occur a long time after the project is finalized (Brown et al., 2004). However, in addition to measurement difficulties, this research revealed other factors that may challenge the international project manager to reach the developmental goals. In some cases, these factors even hindered goal actualization. The main findings related to this issue will be discussed below.

4.1.5 Differing motivations to change

As observed in this case study the governmental representatives (part of the Kenyan team) seemed to view successful change as nation building improvements contributing positively to the national budget in the long run. In contrast, the International Project Manager saw successful development as effective implementation of the project scope, which based on the western values and beliefs, would improve the community. As for the third party, the Maasai community, the maintenance of traditions, fundamental beliefs and ways of living seemed significantly more important. As quoted by an elderly community leader in the aftermath of a project conflict; “*... our main duty is to ensure the survival of our people...when you send our children to schools they never come back to live in the traditional way…!”* The divergent perceptions of what is considered as a positive change and the differing motivations to achieve it may illustrate the complexity of development goals. However, as stated by the PM; "*development involves change in a society that again concerns people… without their willingness to change, there is no change…. and the project will fail*". In other words, the willingness to change needs to come from within and cannot be imposed by external institutions or people. For this reason one may argue the importance of the beneficiaries' motivation as well as involvement in every step of the project process as crucial in order to succeed with ID projects.

4.2 Cultural Competence- a necessity in ID project management?

Kealey et al. (2006) argue that the complexity of culture may increase when people from different contexts and different cultural backgrounds are expected to "*interact, produce and innovate together*"(p.39). Interestingly though, the most influential collaborative challenges on performance did not seem to take place between the Kenyan and the Norwegian team. Instead, the co-operation between the projects teams and the Maasai community (the beneficiaries) tended to be the most challenging, especially during the implementation process. According to the IPM, the reasons behind the experienced project complications may be partly related to the 1) lacking awareness of the complexity of change aspects and 2) limited presence in the field seemed to have disallowed direct interactions that otherwise could have revealed hidden agendas and underlying motivations at an earlier stage. Additionally, the IPM admits the missing attentiveness to the role of the elders in the Maasai community as another crucial factor. As the elderly and their opinion is highly respected by the majority of the people in the community, they appeared to be the final decision makers in crucial matters (which limited the actual decision-making power of the Maasai community board). Since the elderly seemed to view the upholding of old traditions and practises as unifying aspects to maintain the uniqueness of the Maasai people (see statement in last section), change and development may be perceived as a threat. Subsequently, this aspect does not only pinpoint another complex side of developmental change, but it may also emphasise the importance of understanding the underlying power and decision-making processes within the society if development is a desired outcome. Moreover, it may support the statements above arguing development as a process that happens over time, and in some cases even generations. Nevertheless, the observations

Table 4: Observation from the field diary: "Conversation between PM and local coordinator (LC)"

PM: It is important to involve the local board as well as the Maasai council in all the decisions…actually we want them to be the main decision makers in the project…

LC: Why?

PM: I want them to feel ownership to the development that is happening in their own village…Isn't that obvious?

LC: Maybe it is obvious to you. Let me ask you: What is ownership?

PM: Ownership is involvement, commitment and…. of course it comes with responsibility…or the inner motivation to participate.

LC: Exactly! It is something you want them to have so they can be more responsible…committed?

PM: Maybe you're right! But, hey, we are helping them, right? Shouldn't they feel happy to participate?

LC: The organization has done a lot for this community- there is no doubt. However, to me, ownership is a theoretical concept…or a nicer and more appealing word for responsibility. The question is- do you think these people have the energy or capacity to put on extra responsibility?

PM: Thank you, I will think about this…

presented above highlight the importance of contextual (and cultural) awareness and knowledge in order to co-operate effectively. Supportively, Campinha-Bacote (2002) claims the deficiency in awareness of cultural aspects as well as a lack of knowledge may lead to misunderstandings and hence initiate conflicts and hidden agendas that otherwise could have been avoided. Table 4 illustrates cultural competence as a process to mutual understanding. The example above may show how dialogue may increase awareness and knowledge. Moreover, it also indicates how cultural competence may minimize mis-conceptions, increase the contextual understanding and hence enable a more constructive collaboration.

4.3 Direct interactions and the importance of presence in the field

Indeed, the willingness to learn and the motivation to understand the counterparts seem to be crucial in order to become more culturally competent. Just as important appears the ability to communicate cross the cultural layers, establish loyal relationships, gather the right teams and motivate colleagues to strive towards the same strong vision. In order to achieve these skills, PM needs to be present in the field to have the opportunity to directly interact with the different stakeholders. Without the physical presence, especially where oral communications and building of personal relationship is important, the opportunity to become aware of crucial aspects of work and then to act in time critical project issues tend to be limited. In other words, all the five dimensions (awareness, knowledge, willingness learn, skills and presence in the field) seem to impact the process of gaining cultural competence, which again strongly indicates to have an influence on project performance. As stated by the IPM during the interview: *You can't gain knowledge without awareness…knowledge can't be gained without willingness to learn. In order to learn you need to observe, be open and communicate directly, which require presence in the field…. and again presence in the field give grounds for awareness…. its an never ending circle*"

5. Summary and Conclusion

The empirical research revealed a number of contextual factors that have influenced IPM's ability to manage the project effectively. One of the main challenges related to the collaboration is identified as the complexity of different cultural backgrounds and experience of working context, which may lead to unrealistic expectations and demands that are difficult to fulfil. Additionally, the different cultures and traditions seemed to affect the communication style, the priorities, the attitudes and behaviour in work situations. Accordingly, each of the stakeholders groups tended to have divergent expectations of the developmental goals, which seemingly influenced their motivation and needs. For this reason, the ability to balance the needs and expectations between the different stakeholders while maintaining coherent collaboration towards common project goals seems like a major IPM challenge. Moreover, the research indicates that in order to succeed with development projects, there has to be a change of attitudes, ways of living or acting within the community: "*If there is no change there is no development*" (stated by the PM). Subsequently, achievement of development goals may be dependent on the community's motivation and willingness to change. In contrary, a lack of local involvement in the idea initiation may lead to hidden agendas, conflicts and project failures. For this reason, the results of this research imply that the ideas of the projects should be initiated by the community and not by the sponsors or INGOs, which seems to be a common practice in this sector. In order to identify the desired areas of development, the empirical findings implied the importance of identifying the right people with influence of decision-making processes in the community. In the case study, the collectivistic structure, the hierarchical role of the elders and the deeply rooted traditions seemed to impact the development performance on many levels. For this reason, the IPM's ability to identify the most influential people within the society and establish forums for trustworthy and direct dialogues seemed critical to reveal underlying cultural and contextual aspects. However, the research also indicates that traditions evolve as the new and more educated generation is starting to replace older leaders and hence becomes the new decision-makers in the future. The research therefore concludes that the cultural competence is a process that can improve the awareness and knowledge of contextual factors that again may increase the ability to establish relationships, to communicate and approach challenges and opportunities more effectively. Most interviewees agree that the presence in the field, establishing trustworthy relationships and effective communication as helpful factors to minimize the risk and uncertainties this context may encompass. For this reason, one may support Campinha-Bacote's (2002) cultural competence model stating that all 5 dimensions are interdependently important to become culturally efficient and hence be able to lead international development projects more effectively in the future. The research recommends for international development management considers the understanding of the uniqueness of NGO projects and its context to be a significant success factor. Although having people with know-how may go a long way to create the needed awareness and knowledge, the case study demonstrated that presence in the field with opportunities to continuously interact with the local partners make grounds for discovery of new knew knowledge that could impact the project. Hence, it is important to pay attention to all the dimensions of cultural competence in order to encourage a collaborative environment to interact, innovate and produce together. In a continuously changing context it is important to view the cultural competence as a process that continuously enables the PM to reveal new information, give grounds for learning and improved skills that allows a more effective approach to deal with the contextual challenges and hence reach the development goals. Figure 3 provides a summary of the conclusion.

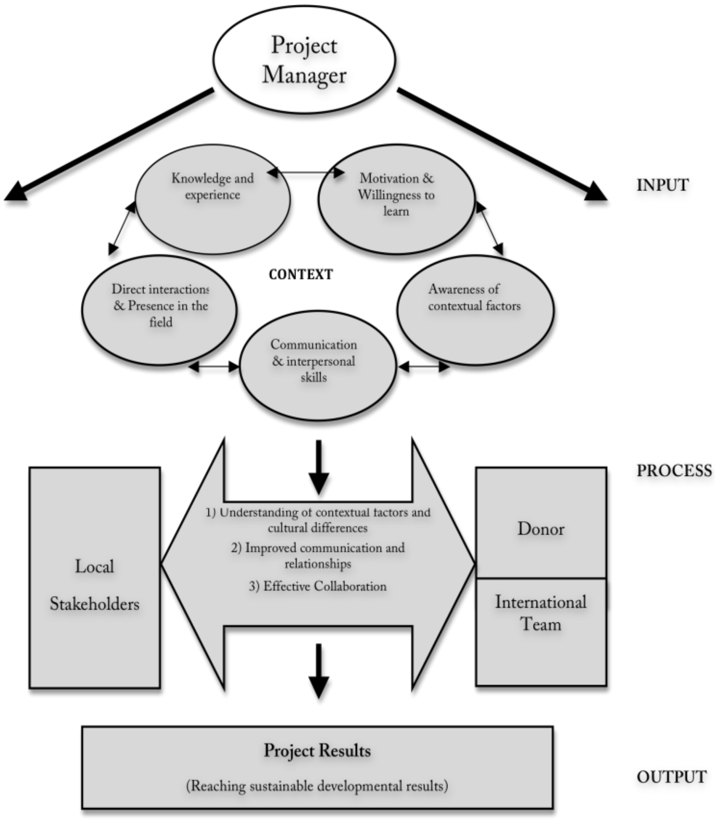

Figure 3: The input and process of developing competence

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Identification of Barriers to Public Private Partnerships Implementation in Developing Countries

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Abstract

Public Private Partnerships (PPPs) have become an increasingly important method of delivering infrastructure projects in the last decade and are now used in over 40 countries. The adoption and implementation of PPPs in less mature economies can pose different challenges to that of mature economies. Thus, successful PPPs are designed with careful attention to the context or the enabling environment within which the partnerships will be implemented. The growth of PPPs has in many countries increased the availability of resources, the efficiency, and sustainability of public services especially in the fields of transport, energy, water, telecommunications, and health. In developing countries a number of barriers influencing the implementation of PPPs caused diminishing interests of both local and foreign private investors. The purpose of this paper is to identify the barriers in implementing PPPs in developing countries. The paper adopted past research studies and documentary reports as a means of identifying the barriers to PPPs implementation. Thus, the identified barriers are subjected to a pilot survey. The barriers are categorized by using SLEEPT approach, that includes; social, legal, economic, environmental, political, and technological factors. The paper identified technological barriers, economic barriers, and social barriers as the most influential barriers to PPPs project implementation in developing countries. Therefore, recognition of the barriers and its elimination by the stakeholders in PPPs will allow the partnerships to function effectively and ensuring successful implementation of present and future PPPs.

Keywords: Barriers, implementation, infrastructure, PPPs, stakeholders

1. Introduction

In an increasingly competitive global environment, governments around the world are focusing on new ways to finance projects, build infrastructure, and deliver services (CCPPP, 2007). PPP is being considered and becoming the preferred method for delivering pubic infrastructure projects throughout the world (Gunnigan and Rajput, 2010) as exemplified by the fact that over 40 countries have adopted PPPs (RICS, 2012). PPP is a tool to bring together the strengths of both public and private sectors. Akintoye and Liyanage, (2011) assert that PPPs are commonly used to accelerate economic growth, development and infrastructure delivery, and to achieve quality service delivery and good governance. Despite the increasing adoptions of PPP based procurement systems all over the world, many countries and regions are still experiencing a number of barriers against its successful implementation particularly developing countries, thereby slow down the implementation and even diminish the interests of private sector entities.

Therefore, it is required to identify the barriers for implementing PPPs in details to prevent the constraints from appearing in the future PPPs. It is important for the governments and other stakeholders to recognise likely barriers in the implementation of PPPs and to build in strategies to cope with the constraints to allow the partnership to function effectively. This formed the basis of this paper with a view to identifying the barriers to PPPs implementation in developing countries. It is against this background, that the theory of constraints developed by Goldratt in the early 1980s is used to underpin the study. The theoretical concept is summarised as: every system must have at least one constraint; and the existence of constraints represent opportunities for improvement (Goldratt, 1988). However, a constraint is defined by Goldratt, (1988, p. 453), as "anything that limits a system from achieving higher performance versus its goal". Thus, constraints can involve people, information, regulations, policies, laws, procedures, supplies, equipment to mention a few (Dettmer, 2000). The theory involves: identify the constraints; exploit the constraints; evaluate performance among others (Goldratt, 1990). Since 1980s the theoretical body of knowledge has grown significantly and has been successfully applied in different fields ranging from manufacturing, accounting/finance to construction industry particularly in project management.

2. The concept of Public Private Partnerships

The concept of using private capital to provide public facilities has existed for centuries in countries such as UK, US, France, Spain among others (Howes and Robinson, 2005; Yescombe, 2007). Thus, in recent time many countries have developed PPP programmes for provision of public infrastructure facilities and services. This has resulted to significant increase in the volume and number of PPP projects across the globe since 1990s. Prior researchers and a number of professional bodies and organisations have defined PPPs in various forms. This has led Li and Akintoye, (2003) to state that there is no unified definition of PPP but all definitions have common characteristics. Yescombe, (2007) asserts that PPPs must be seen within the overall context of the public sector reform which encourages contracting-out public services to the private sector. Therefore, the arrangement of PPP is structured in a way that it is intended to provide greater flexibility to achieve the provision on public infrastructure objectives by altering traditional public and private sector roles with a view to taking better advantage of the skills and resources that private sector firms can provide.

However, Yescombe, (2007) states that there are a number of alternative names for PPPs as follows: Private Finance Initiative (PFI), a term originating in Britain, and now used in Japan and Malaysia; Private Participation in Infrastructure (PPI), a term coined by the World Bank, however it is little used outside the development-financing sector; P3/3Ps/P^3, a term used in North America; Private-Sector Participation (PSP) a term also used in the development-financing sector; and Privately-Financed Projects (PFP) a term used in Australia. Therefore, there are various PPP models that are used across different countries. This includes:

- Build-Operate-Transfer (BOT): This model combines the responsibilities of Build-Transfer with those of facility operations and maintenance by a private sector partner. At the expiration of concessionary period all operating rights and maintenance responsibilities revert to the government (Howes and Robinson, 2005; Deloitte, 2007).

- Design-Build-Finance-Maintain (DBFM): The private sector designs, builds and finances an asset and provides facility management or maintenance services under a long-term agreement (CCPPP 2007).

- Design-Build-Finance-Maintain-Operate (DBFMO): The private sector designs, builds, finances, and provides facility management services as well as operations under a long-term agreement (CCPPP 2007).

- Build-Own-Operate (BOO): The private sector or concessionaire finance, builds, own and operates a facility without the transfer of ownership to the public client. (Howes and Robinson, 2005).

- Divestiture: Under this model, the private sector takes ownership over all assets and has control over all investment, maintenance and operations decisions subject to regulatory oversight. (Deloitte, 2007).

However, Deloitte (2007) further identifies a hybrid PPP model that includes alliancing, bundling, integrator, and joint venture. Table 1 presents a sectoral classification of PPP models adopted in different countries.

Table 1: PPP Models adopted in different countries in various sectors

Sector	**Country**	**PPP models**
Transport	Australia, Canada, France, Greece, Ireland, Italy, New Zealand, Spain, UK, Russia, US, Turkey, Singapore, China, India, Sri Lanka, Brazil, Argentina, Chile, Mexico, Peru, South Africa, Nigeria, Zimbabwe, Togo	DBOM, BOT, Divestiture, BROT, ROT, BOO, BLT
Water, wastewater, and Sewerage	Australia, France, Ireland, UK, US, Canada, Turkey, Singapore, India, China, Malaysia, Indonesia, Brazil, Mexico, Peru, Algeria	DBO, BOT, BROT, ROT, DBOO, Divestiture
Education	Australia, Netherlands, UK, Ireland, India	DBO, DBOM, BOOT, DBFO/M, Integrator
Housing	Netherlands, UK, Ireland	DBFM, Joint venture

Sector	Country	PPP models
Hospitals	Australia, Canada, Portugal, South Africa, UK	BOO, BOOT, Integrator
Defence	Australia, Germany, UK, US	DBOM, BOO, BOOT, Alliance, Joint venture
Prisons	Australia, France, Germany, UK, US	DBO, BOO
Energy	Turkey, Bulgaria, Romania, Ukraine, China, Singapore, Bangladesh, India, Sri Lanka, Pakistan, Vietnam, Thailand, Philippines, Malaysia, Indonesia, Argentina, Brazil, Botswana, Kenya, Tanzania, Zambia, Rwanda	BOT, BOO, BLT, ROT, Divestiture
Telecommunications	Singapore, Philippines, Thailand, India, Malaysia, Indonesia, Ukraine, Russia, Turkey, Brazil	Joint venture, BOT, Divestiture

(Source: Deloitte, 2007; World Bank 2012)

Table 1 indicates the governments in many countries ranging from mature economies to less mature economies have found that partnership with the private sector is an attractive alternative to increase and improve the supply of public infrastructure facilities.

2.1 Barriers of PPPs

Despite the huge recognition of PPPs and its increasing usage in infrastructure development, the experience of both the public and private sector with PPP has not always been positive (Kwak et al. 2009). A number of PPP projects are either held up or terminated particularly in developing countries. This has triggered previous researchers to conduct studies on barriers to PPPs implementation across the globe. Table 2 reveals a selection of previous researchers' findings on barriers to PPPs implementation.

Table 2: Examples of identified barriers to PPPs implementation by few previous research studies

S/n	Authors and Year	Findings
i	Li et al. (2005)	Lack of suitable skills and experience; lengthy bidding and negotiation process; lack of competition; and lack of well-established legal framework.
ii	Zhang (2005)	Social, political, and legal risks; unfavourable economic and commercial conditions; inefficient public procurement frameworks; lack of mature financing engineering techniques; public sector related problems(e.g., inexperienced government and lack of understanding of PPPs); and private sector related problems (e.g., most people, including investment banks still prefer traditional procurement routes).
iii	Chan et al. (2006)	Lack of suitable skills and experience; and lengthy bidding and negotiation process.
iv	El-Gohary et al. (2006)	Public opposition.
v	Corbett and Smith (2006)	Lack of competition; lack of suitable skills and experience; lack of innovations in design; and lack of flexibility.

S/n	Authors and Year	Findings
vi	Chan et al. (2010)	Lengthy delays in negotiation; lack of experience and appropriate skills; and lengthy delays because of political debate.
vii	KPMG (2010)	Barrier to competition and procurement inefficiencies.

However, none of the previous researchers had fully categorized barriers to PPPs implementation by using PEST (Political, Economic, Social, and Technological) approach or its variants, such as SLEEPT (Social, Legal, Economic, Environmental, Political, and Technological), PESTLE (Political, Economic, Social, Technological, Legal, and Environmental) among others. It was only Zhang, (2005) that partially categorised his findings as social, political, and legal risks among others as a barrier to PPPs implementation. Thus, it is important to categorize barriers to PPPs implementation by using SLEEPT approach, because it is a very useful and widely used tool that helps to understand wider business environment, and enables business leaders worldwide to build their vision of the future. Also, Kotler (1998) claims that PESTLE or SLEEPT is a useful strategic tool for understanding market growth or decline, business position, potential and direction for operations. However, SLEEPT approach has not been adopted in categorizing barriers to PPPs implementation but it was not new in PPPs research studies, for instance Gunnigan and Rajput, (2010) adopted SLEEPT approach to compare the complexities of implementing PPP projects in Europe and India. Also, Eaton et al. (2007) used SLEEPT approach to examine the suitability of a UK PFI model within the Czech Republic, the republic of Ireland, Palestine (Gaza-West Bank), Portugal and Turkey. Therefore, understanding and enhancing knowledge of PPPs continue to be a matter of significance and importance. Thus, this paper becomes imperative with a view to identifying and categorizing the barriers to PPPs implementation by using SLEEPT approach in order to provide a holistic approach to PPPs environment.

3. Research methodology

This paper adopted literature review, documentary evidence, and pilot survey as part of a broader study in developing a PPP stakeholder framework. A comprehensive literature review and documentary evidence enabled the identification of fifty seven barriers to the implementation of PPPs in developing countries. The identified barriers were categorized by using SLEEPT approach (Social, Legal, Economic, Environmental, Political, and Technological). However, the identified and categorized barriers were subjected to a pilot survey with a view to testing its applicability in Nigeria. This is supported by Fellows and Liu (2008) who assert that questionnaires should initially be piloted, i.e. completed by a small sample of respondents. Thus, face-to-face pilot survey was conducted on six respondents that were purposively selected, based on their vast involvement and experience in PPP infrastructure projects in Nigeria. The respondents included primary stakeholders in PPPs comprising of public authorities (MDAs-Ministries, Department, and Agencies), local lenders/ local banks, concessionaires, and consultants. The designed pilot questionnaire was a multiple-choice type on a five-point likert scale. The preliminary section of the questionnaire gathered background information on respondent profiles while the other parts were structured in relation to the purpose of the paper. A reliability test was also conducted on the research instrument using Cronbach's alpha, Spearman-Brown coefficient, and Guttman split-half coefficient. This is supported by Garson (2009) who argues that more than one reliability coefficients may be used in a single research setting. Therefore, the reliability coefficients values of Cronbach's alpha (0.948), Spearman-Brown's split half coefficient (0.968), and Guttman's split half coefficient (0.967) proved that the instrument used for the pilot survey is reliable. The data collected for the study were subsequently analysed using descriptive statistics.

4. Findings

The study's outcome is based on a pilot study. Thus, table 4.1 reveals the demographic characteristics of the respondents. Out of six respondents, two belong to public authorities (MDAs i.e. Ministries, Department, and Agencies), two to local lender/ local Bank, one to concessionaire, and one to consultant. Five of respondents have either a bachelor's or master's degree and one respondent has higher national diploma. This indicates that the respondents are mature, educated and prudent to give their consents without prejudice in participating in the pilot survey. The years of industrial experience indicates that three of the respondents have between 11-15 years of industrial experience, one respondent has over 20 years, one has between 6-10 years, and one also has between 0-5 years of industrial experience. Thus, the approximate average years of respondents' industrial experience is calculated to be 12 years. This shows that the respondents have adequate industrial experience to supply reliable information. However, respondents involvement in PPPs infrastructure project indicates that; two respondents were involved in over 6 PPP infrastructure projects, one respondent involved between 5-6 number, one respondent involved between 3-4 number, and two respondents involved between 1-2 number of PPP infrastructure projects. In overall four out six respondents representing approximate 67% were involved in over 3-4 number of different PPP infrastructure projects. This shows that the respondents have vast knowledge and experience in PPP infrastructure projects. It can be deduced that the information supplied on PPP infrastructure projects by these respondents are reliable and dependable.

Table 4.1: Demographic characteristics of respondents

Item	Category	Frequency (n)	Percentage (%)
Stakeholder's category	Public Sector Authorities (MDAs)	2	33.33
	Concessionaires	1	16.67
	Local Lenders/ Local Banks	2	33.33
	Consultants	1	16.67
	Total	**6**	**100.00**
Highest academic qualification	HND	1	16.67

Item	Category	Frequency (n)	Percentage (%)
	BSc	2	33.33
	MSc	3	50.00
	PhD	-	-
	Total	**6**	**100.00**
Years of industrial experience	0 - 5 years	1	16.67
	6 - 10 years	1	16.67
	11 - 15 years	3	50.00
	16 - 20 years	-	-
	Above 20 years	1	16.66
	Total	**6**	**100.0**
Have you been involved in PPP procurement system	Yes	6	100.00
	No	0	00.00
	Total	**6**	**100.00**
Number of PPP project involved- in	1 – 2	2	40.00
	3 – 4	1	20.00
	5 – 6	1	20.00
	Above 6	2	40.00
	Total	**6**	**100.0**

Table 4.2 reveals the initial identifications of barriers to PPPs implementation and are based on a pilot study. The table indicates descriptive values of categorized barriers by using SLEEPT approach (Social, Legal, Economic, Environmental, Political, and Technological). The table reveals that technological barrier has the highest mean value ranking of 32.83. This indicated that technological barrier was the most important barrier to PPPs project implementation in developing countries. However, technological barrier has to do with PPPs project delivery; this includes lack of experience and expertise in both public and private sector, shortage of professionals to handle PPP projects, unavailability of large construction companies to deliver PPP projects in some developing countries among others. These led some developing countries to strongly depend on the experience and expertise of PPP professionals, foreign construction companies from mature economies. Economic barrier with the mean value ranking of 31.83 was second most barriers to PPPs project implementation. This has to do with the perceptions of developing countries as high risk economy by foreign investors, macroeconomic fluctuations in currency, inability of local institutions to provide long term financing among others.

Social barrier with the mean value ranking of 27.17 was third in the table as barrier to PPPs project implementation in developing countries. This includes public opposition/public resistance, cultural impediments include behaviours of people towards PPPs, societal discontent against the private sector among others. Social barrier has responsible for cancellation and delays of a number of PPPs project in developing countries. Environmental barrier with the mean value ranking of 19.33 was the least barrier to PPPs project implementation, this is because most governments in developing countries have realised the importance of PPPs in delivering infrastructure. Thus, most governments are concentrating in providing an enabling environment and favourable investment to make PPPs attractive to investors.

Table 4.2: Descriptive values of barriers categorized using SLEEPT

Categorized Barriers	N	Minimum	Maximum	Sum	Mean		Std. Deviation
	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic
Social	6	0	43	163	27.17	5.941	14.552
Legal	6	22	34	160	26.67	1.783	4.367
Economic	6	25	38	191	31.83	1.815	4.446
Environmental	6	14	23	116	19.33	1.202	2.944
Political	6	23	32	162	27.00	1.291	3.162
Technological	6	18	44	197	32.83	3.516	8.612

The percentage representation of categorized barriers using mean value is shown in figure 1. Thus, the figure reveals that technological barrier has the higher percentage. This shows that technological barrier is the most barriers affecting PPPs project implementation in developing countries followed by economic barrier, social barrier, legal barrier, political barrier, and environmental barrier respectively.

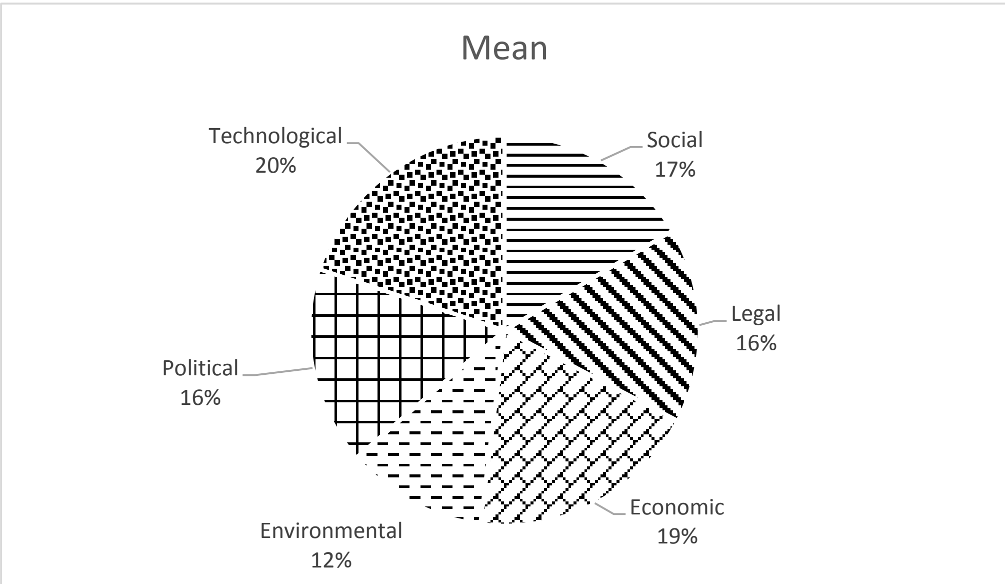

Figure 1: Percentage representation of categorized barriers

5. Discussion of findings

The findings are initial identifications of barriers and are based on a pilot study. The paper identified fifty seven barriers to PPPs project implementation in developing countries. Thus, the identified barriers were categorized as follows:

Social barriers: The paper revealed social barriers, including public opposition, cultural impediments, societal discontent against the private sector, public resentment due to tariff increases, lack of confidence and mistrust in PPPs among others which is similar with Gunnigan and Rajput (2010) that social and cultural norms within a nation are significantly alter the behaviours of people, and ultimately affecting the PPPs operation and structures, and public opposition has led to many cancellations, both before and after the concession award. The finding is in contrast with Gibson and Davies, (2008) that identified internal partnership relationships in mature economies. Therefore, it becomes necessary that all the stakeholders' for instance, primary stakeholders in PPPs implementation in developing countries to identify the public interest goals before embarking on any PPPs project.

Legal barriers: The paper identified weak /poor enabling policies, poor regulatory frameworks and enforcement, weak institutional capacity and PPPs strategy, weak judicial framework/weak judiciary for resolving PPP disputes among others as legal barriers to PPPs implementation in less mature economies. This finding is similar with Li et al., (2005) that identified lack of well-established legal framework as one of barriers to PPPs project implementation. This indicates that some governments in developing countries undertake PPPs without overall PPP policies, which leads to ill-defined goals and a greater likelihood of problems with the projects implementation.

Economic barriers: Perceptions of developing countries as high risk economies by foreign investors, inability of local institutions to provide long term financing, difficulty in obtaining foreign exchange/foreign exchange risk, inadequate domestic capital markets among others were identified as economic barriers to PPPs implementation in developing countries. This finding is in contrast with Corbett and Smith (2006) and Chan et al. (2006) that identified high transaction costs and high bidding costs as barriers to PPPs project implementation. Therefore, it necessary for governments in developing countries to create stable economic and financial supports with a view to inducing confidence in both local and foreign PPP investors.

Environmental barriers: The paper identified environmental barriers as follows; land acquisition problems, lack of coordination between national and regional governments, lack of transparency and accountability, accusations of corruption and corrupt tendencies among others. The finding is in contrast with Li et al. (2005) and KPMG (2010) that identified lack of competition as barrier to PPPs in mature economies. Thus, it becomes imperative for governments in developing countries to create an enabling environment and favourable investment to make PPPs attractive.

Political barriers: political reneging, politicization of the concessions, lengthy delays due to political debate, lack of strong political commitment for PPPs among others were identified as political barriers which is similar with Kwak et al. (2009) that inadequate involvement and incapability of governments to manage PPP projects lead to project failures in developing countries. The finding is in contrast with Gibson and Davies, (2008) that identified local political opposition as a barrier to PPPs in mature economies.

Technological barriers: The paper identified technological barriers as lack of experience and expertise in public sector and private investors, inconsistent risk assessment and management, shortage of professionals to handle PPP projects, provision of incomprehensive up-front project information by public sector among others. These findings are similar with Li et al., (2005) and Mahalingam (2010) that lack of suitable skills and experience, and lack of project preparation capacity on the part of the public sector among others are barriers to PPPs project implementation. This shows that developing countries rely on mature economies professionals' expertise and skills to develop and structure their PPPs. However, the paper identified more barriers to PPPs project implementation in developing countries which is in contrast with KPMG (2010) that identified competition and procurement inefficiencies as barrier to PPPs in Australia.

6. Conclusions

Understanding and enhancing knowledge of PPPs continue to be a matter of significance and importance. It is on this note that this paper identified and categorized into six the barriers to PPPs implementation in developing countries. This includes; social barriers, legal barriers, economic barriers, environmental barriers, political barriers, and technological barriers. However, the paper identified technological barrier followed by economic barrier and social barrier respectively as most significant barriers to PPPs project implementation in developing countries, while environmental barrier was the least. The paper concludes that there are more barriers to PPPs project implementation in developing countries. This has made the PPPs project implementation in developing countries to be characterised with controversies, cancellations, delays, and renegotiations. The limitations of this paper includes the using of a pilot survey, this indicates that this is not a conclusive study but a study that will lead to a broader study. But the findings of the pilot were significant and interesting, and show good potential for the broader scale study. Having identified and categorized the barriers to PPPs project implementation in developing countries, it will help the stakeholders involved in PPPs practice to build in strategies to cope with the barriers with a view to safeguarding the present and future PPPs implementation. Therefore, the huge recognition of the barriers and the strategies to eliminate the barriers by the stakeholders in PPPs will allow the partnership to function effectively and ensuring successful implementation of PPPs in developing countries.

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Decennial Liability in Construction:
Law and practice in the United Arab Emirates

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Abstract

Decennial liability arises in cases of traditional construction procurement where the engineer or architect prepares the design and oversees the construction works. FIDIC Red Book and other standard contracts provide for the limitation of contractor's liability. Apparently, this will have some impacts on the cost due to the contractor's risk calculation. However, this paper shows that the enforcement of such provisions in the United Arab Emirates UAE is not straightforward.

In Dubai, most employers tend to sell premises on map (off-plan sales) or shortly upon completion. The question becomes whether the subsequent owners can benefit from decennial liability. If not, how can the employer benefit from such a liability in cases where the defective premises had been already sold out? The privity principle strictly applies under the law of United Arab Emirates UAE. The paper argues that subsequent owners may have similar rights against the employers who can shift the liability to the contractor.

Keywords: Decennial Liability, Dubai Construction Law, Contractor's Liability, Privity Principle, Defect's Liability.

1. Introduction

The construction traditional procurement method (Design-Bid-Build) is widely used in the UAE and the Gulf region. Decennial liability arises under the traditional method where the project is designed and supervised by the same engineer/architect.[1] Here, both the engineer and the contractor will be jointly liable for any partial or total collapse or for any structural or safety defects for ten years from the time of delivery.

This paper argues a number of issues related to decennial liability under the UAE law. It discusses the possibility of contractually limiting or excluding such a liability and whether its period can be contractually changed. It also discusses the engineer's liability where the design is defect-free and the collapse or structural defect is purely related to defective workmanship.

The issue of scope of liability occupies a significant part of this paper. This is discussed in relation to the types of defect, the parties responsible and the scope of compensation. It is questionable whether the subcontractor can be held liable towards the main contractor under the provisions of decennial liability.

The issue of privity arises when discussing the liability of the contractor towards the end user. The paper argues that there seem to be a number of ways to circumvent the rigorous application of privity principle in this field.

2. Overview of civil liability

Civil liability can arise out of either a breach of contract or a breach of duty of care. The UAE Civil Transactions Law Code (CTC) provides for the contractual liability under its general rules of contract. Parties are required to honor their contractual promises in good faith.[2] Where a party is in breach of contract, the aggrieved party may claim specific performance. Specific performance is the primary remedy for breach of contract under the UAE law. Article 380(1) of the CTC states that "An obligor shall, after being given notice, be compelled to discharge his obligation by way of specific performance, if that is possible."

However, in certain cases, the court may allow damages instead of granting specific performance. Article 380(2) states that "provided that if specific performance would be oppressive for the obligor, the judge may, upon the application of the obligor, restrict the right of the obligee to a monetary substitute unless that would cause him serious loss." Article 338 of the CTC states that "a right must be satisfied when the legal conditions rendering it due for performance exist, and if an obligor fails to perform an obligation, he shall be compelled to do so either by way of specific performance or by way of compensation in accordance with the provisions of the law." Therefore, damages can be awarded for breach of contract

[1] The UAE law uses the term "engineer" to refer to the person who makes the design and/or supervises the work. For the sake of simplicity, the term engineer will be used throughout this paper to refer to both the engineer and the architect.
[2] Article 246(1) of the Civil Transactions Code states that "The contract must be performed in accordance with its contents, and in a manner consistent with the requirements of good faith."

where the obligation is oppressive or impossible to perform. This is evident in cases of late performance where damages can be the only available legal remedy. Where the obligation requires personal skills and the obligor rejects performance, the court will have no choice other than awarding damages. Furthermore, parties may agree in advance or after the occurrence of breach of contract on damages as the absolute legal remedy. As discussed below, most standard construction contracts include terms of liquidated damages.

Contractual duties can be of purpose or care. While the former requires the debtor to achieve a certain result, the latter can be satisfied by paying reasonable care. Duties of care are evident in the cases of medical contracts. The failure of the physician to cure does not raise legal liability unless the negligence is proved. In construction projects relations, duties are mostly of purpose. It is difficult to argue that the duty in construction contract is a one of care only. Article 878 of the CTC states that "The contractor shall be liable for any loss or damage resulting from his act or work whether arising through his wrongful act or default or not, but he shall not be liable if it arises out of an event which could not have been prevented." Both contractors and consultants are required to provide a product in compliance with contract. Here, it may be sufficient enough to prove the defects and the resulting losses. As discussed below, in cases of agreed (liquidated) damages, the claimant may not even need to prove losses. The claim can be for the agreed amount due to the breach.

Tort liability is based on three elements: an unlawful act or omission, damage and causal link between the act or omission and the damage. The harmful act, as demonstrated by the official Explanatory Memorandum of the CTC, is "going beyond the limit at which a person should stop, or not reaching the limit which a person should reach, in an act or withholding from an act, which results in harm."

Damages are the primary remedy in tort. Article 282 of the CTC states that "Any harm done to another shall render the actor, even though not a person of discretion, liable to make good the harm." Apart from certain cases, the liability is generally strict. The aggrieved party needs to prove that the loss was caused by an illegitimate act. Losses resulting from legitimate acts cannot be compensated for. Article 104 of the CTC states that "the doing of what is permitted by law negates liability, and no person who lawfully exercises his rights shall be liable for any harm arising thereout."

Where the act amounts to both a breach of contract and a violation of law, the aggrieved party may choose to sue in either contract or tort. The harmful act does not need to be a criminal or an administrative offence. Criminal and civil jurisdictions are entirely separate in UAE law. Not every wrongful act constitutes a crime under the criminal law in the UAE. Therefore, a person may be found liable in tort, without being convicted in the criminal courts. However, if a wrongful act committed by an individual constitutes a crime under the UAE Federal law No. 3 of 1987 (the Penal Code), the judgment delivered by a criminal court will be useful in a subsequent civil claim in tort. Article 297 of the CTC states that "Civil liability shall be without prejudice to criminal liability provided that the elements of criminal liability are present, and no criminal penalty shall limit the scope of the civil liability or the assessment of the compensation."

3. Overview of decennial liability

Decennial liability is a term used to describe the joint liability of the contractor and engineer for defective "buildings or other fixed installations" where the engineer designs and supervises the work. The terms of "building or other fixed installations" are broad enough to include infrastructure civil works such as roads, bridges, water canals, sewage systems, etc.[3] Article 880(1) of the CTC states that

> "If the subject matter of the contract is the construction of buildings or other fixed installations, the plans for which are made by an architect, to be carried out by the contractor under his supervision, they shall both be jointly liable for a period of ten years to make compensation to the employer for any total or partial collapse of the building they have constructed or installation they have erected, and for any defect which threatens the stability or safety of the building, unless the contract specifies a longer period. The above shall apply unless the contracting parties intend that such installations should remain in place for a period of less than ten years.

According to this article, decennial liability can only arise in the traditional procurement (Design-Bid-Build) of buildings construction or other fixed installations. Here, the employer enters in consultancy contract with the engineer to design and supervise the whole work. The FIDIC White Book "Client/Consultant Model Service Agreement" is commonly used for this purpose. The consultant helps in selecting the contractor, through a tendering process, with whom the employer ultimately signs a construction contract.

Having said that, the engineer who is not required to supervise the work will not be liable for defective workmanship where the design is free of defects. Article 881 of the CTC states that "If the work of the architect is restricted to making the plans to the exclusion of supervising the execution, he shall be liable only for defects in the plans." However, if the engineer/architect is required to prepare the design and supervise the work, he will be jointly liable with the contractor for the defective work regardless of whether the design is defective or free of defects.

The employer can commence a legal action for any major defect affecting stability or safety of a structure, both against the engineer and the contractor without being obliged to decide whether the defect is of a designing or structural nature. The outcome of a legal action could be either that liability is apportioned between the architect and the contractor, or that only one of the two parties is liable.

The trigger events of decennial liability, i.e. partial or structural collapse and defects threatening the stability or safety of a structure, are not defined by the CTC. The judge or arbitrator may need an expert opinion to decide whether a certain defect falls within the scope of decennial liability.

Decennial liability can still arise even though the defect is due to soil defects. The duty of the contractor to make the proper soil investigation prior to commencement of work is presumed here. The consent of the employer cannot be used as a defense. Article 880(2) of the CTC states that "The said obligation to

[3] Said Hanafi, "Contractors' Liability under the Civil Codes of Algeria, Egypt, Qatar and the UAE", (2008) *International Construction Law Review*, 221, 228.

make compensation shall remain notwithstanding that the defect or collapse arises out of a defect in the land itself or that the employer consented to the construction of the defective buildings or installations."

Decennial liability is a contractual[4] strict liability. Proof of negligence is not needed. When it is established that there is a structural or a safety defect, both the contractor and the engineer will be jointly liable even if they worked by the book. The contractor or the engineer may defend themselves by proving the external cause. In the UAE case of 125/Judicial Year 1, 2007, the Union Supreme Court held that "if the contractor is in breach of the performance of the works entrusted to him under the muqawala (construction) contract or if what he has performed is contrary to the conditions and specifications agreed with the employer, then he will be liable for any damage or loss arising out of his act, whether or not there was an infringement or a shortcoming. His liability will be negated only by proof of an extraneous cause." Similarly, the same Court held, in the case of 336 and 407/Judicial Year 21, 20 March 2001, that "the obligation of the architect or the contractor is an obligation to achieve a result, namely to build a sound and sturdy building, for the period specified in the Civil Code, namely ten years from the date of handover, where it has not been previously determined…. Breach of such obligation is proved by simple proof of that result not having been achieved, without the requirement to prove any default."

Still, can the subcontractor be held liable under the provisions of decennial liability? Under UAE law, the contractor may subcontract the work or part of it unless agreed otherwise. Subcontractors can be either domestic or nominated. While the former is selected by the contractor, the latter is selected by the employer. Contractors usually need to secure the employer's or engineer's approval for their domestic subcontractors. Two main questions may arise here: first, does decennial liability arise under subcontracts? Second, can the contractor be held liable for losses caused by the nominated subcontractor?

Although the subcontractor may have no role in selecting the nominated subcontractor, standard contracts' terms usually provide him with the right to object. Of course, he will be required to provide reasonable justification for his objection. One of such justifications is the absence of an indemnity clause in the subcontract. FIDIC Red Book allows the contractor to reject the nominated subcontractor if the subcontract does not provide for the latter's obligation to indemnify the contractor for his liability towards the employer that arises out of the defective subcontracted work.

Such an indemnity clause will help much in cases of the contractor's decennial liability that arises out of the defective subcontracted work. The main contractor stays responsible for the proper performance of the sub-contracted work regardless of whether the subcontractor is domestic or nominated. Article 890 of the CTC states that "(1) A contractor may entrust the performance of the whole or part of the work to another contractor unless he is prevented from so doing by a condition of the contract, or unless the nature of the work requires that he do it in person. (2) The first contractor shall remain liable as towards the employer."

[4] The Union Supreme Court held, in the case of 336 and 407/Judicial Year 21, 20 March 2001, that "the liability of an engineer has its bases in the contract made between him and the employer, which results in his being liable for errors in planning or flaws in implementation, this being a contractual liability laid down by law in respect of every muqawala contract for building, whether or not specifically provided for in the contract." See Said Hanafi, "Contractors' Liability under the Civil Codes of Algeria, Egypt, Qatar and the UAE", (2008) *International Construction Law Review*, 221, 227.

It should be noted here that the decennial liability provisions do not apply to the subcontract. The article speaks clearly about the relationship between the owner and contractor. Obviously, the owner is not a party to the subcontract. Therefore, it is significant for the contractor to protect himself against such a liability by an indemnity sub-contractual clause or a "back to back" term.

The decennial liability period is a warranty period for ten years from the date of delivery. As a mandatory rule, parties may not agree on a shorter period. Article 880(1) clearly states that "…they shall both be jointly liable for a period of ten years …. The above shall apply unless the contracting parties intend that such installations should remain in place for a period of less than ten years." Therefore, the ten years period shall always apply unless the project is intended to last for lesser period.

Decennial liability period is different from the limitation period within which the claim must be filed. Although the general limitation period in UAE is 15 years, the limitation period for decennial liability claims is three years.[5] Therefore, if defects appear at the end of the tenth year of handing the constructed work, the owner will still have a period of three years within which he may bring a civil action before the court.

Decennial liability, unlike limitation periods, cannot be affected by unforeseeable events and judicial claim or proceeding. Articles 481[6] and 484[7] of the CTC determine the cases where the limitation period is suspended or interrupted. They have no application to decennial liability period.

4. Scope of compensation and limitation clauses

Under UAE law, the scope of compensations is linked to the actual loss. Article 292 of the CTC states that "In all cases the compensation shall be assessed on the basis of the amount of harm suffered by the victim, together with loss of profit, provided that that is a natural result of the harmful act." In the case of 125/Judicial Year 1, 2007, the Union Supreme Court held that "articles 282, 291 and 293 provide that any harm done shall render the doer liable to make good the harm, and that the indemnity shall in all cases be commensurate with the harm suffered and loss of profit, provided that that is a result of the harmful act. Loss of opportunity suffered by the employer in a muqawala contract in the exploitation and enjoyment of his building by unjustified non-performance on the part of the contractor of his obligations under the muqawala contract, or defective execution of the work precluding enjoyment of the land, will be an element of damage in respect of which an indemnity will be payable to the employer, if such opportunity was probable, and he has in fact been deprived of it. The law does not preclude missed

[5] Article 883 of the CTC states that "no claim for compensation shall be heard after the expiration of three years from the collapse or the discovery of the defect."

[6] Article 481 of the CTC states that "(1) The running of time for prescription shall be suspended if there is a lawful excuse whereby the claim for the right could not be made. (2) The period during which that excuse subsisted shall not be taken into account in the prescription period."

[7] Article 484 of the CTC states that "The prescription period shall be interrupted upon a judicial claim being made or by any judicial proceeding being taken by an obligee to enforce his right."

earnings being taken into account provided that the aggrieved party had a hope of making such earnings, provided that such hope was based on reasonable causes."[8]

Is it possible to limit the scope of compensation? Construction contracts may cap the contractor's liability by a fixed percentage, typically 10% of the contract price. In principle, this is permitted expressly by the CTC. Article 390(1) of the CTC states that "the contracting parties may fix the amount of compensation in advance by making a provision therefor in the contract or in a subsequent agreement, subject to the provisions of the law." In UAE, the Judge acquires the discretion to vary the agreed sum. Either the obligee or obligor can prove that the actual loss suffered is more or less than the agreed sum. The Judge has a wide discretionary power to adjust the agreed upon liability between the parties to match the loss occurred. Article 390(2) of the CTC states that "the judge may in all cases, upon the application of either of the parties, vary such agreement so as to make the compensation equal to the loss, and any agreement to the contrary shall be void." Having said that, the UAE judges are often reluctant to vary an agreed limit of compensation. This is due to the fact that the UAE law recognizes the freedom of contract principle that should be respected by the court as long as it does not contradict with public policy. The main benefit of a limitation clause is the shifting of the burden of proof. In normal circumstances, the claimant has to prove the existence of the damage; the penalty clause, instead, is deemed as a presumptuous method of proof whereby the defendant can always rebut the claim.

In the case of decennial liability, any limitation or exclusion of liability clause will be held invalid. The contractor's liability for major defects cannot be limited or excluded. Decennial liability is a matter of public policy. Article 882 of the CTC states that "any agreement the purpose of which is to exempt the contractor or architect from liability, or to limit such liability, shall be void". Of course, this does not apply to settlement of decennial liability disputes. If decennial liability arises, parties may settle the dispute amicably.

It is worth mentioning that the calculation of damages is a matter of fact and within the sole discretion of the trial judge. The Union Supreme court held, in 36/Judicial Year 21 155, that "The assessment of damage and the consideration of the surrounding circumstances in assessing the compensation to make it good are matters of fact within the independent discretion of the trial court, provided that the judgment is based on sound grounds sufficient to support it." Similarly, in 128/Judicial Year 25 144, the said court held that "It is settled law that the assessment of damage and the determination of the amount of compensation to make it good are matters of fact within the independent discretion of the trial court, provided that it states the element of damage and the extent of the entitlement of the aggrieved party to compensation for them."

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[8] Similarly, in the Abu Dhabi Court of Cassation, in the case of 721/Judicial Year 3, held that "under the provisions of articles 282, 291 and 293 of the Civil Code, any harm done to a third party requires that the doer make good that harm. Harm is in all cases to be assessed in accordance with the damage sustained by the aggrieved party, together with loss of earnings, on condition that that is a result of the harmful act. Compensation may also be awarded for loss of opportunity of the building owner to exploit the land and have the benefit of it by reason of non-performance by the contractor, without justification, of his obligation arising out of the muqawala contract made between them, or by reason of his defective performance whereby it becomes impossible to make use of the building. This is one of the elements of damage for which compensation must be awarded in favour of the building owner."

However, this approach does not apply to cases where the lower case awards or does not award for a specific kind of loss. Here, the Supreme/cassation court will have a jurisdiction and a duty of supervision.[9] The Supreme Court will also have discretion to look into the reasoning of the lower courts. This includes the absence of reasoning for excluding evidence.[10] In addition, the court must, on assessing the physical loss sustained by a party by way of actual loss or loss of profit, state the source from which it has derived those elements of compensation.[11]

5. Decennial Liability Period & defects liability period

Standard contracts usually include a provision for a defects liability period (Notification Period). Usually, this period is one year from the time of delivery. The work is deemed delivered when the engineer issues the taking over certificate (TOC). Within the defects period, the contractor will be liable for all sorts of defects resulting from defective workmanship. Obviously, this period overlaps with the decennial liability period which lasts for ten years starting from the date of delivery. While the contractor's responsibility for minor defects usually ends when the engineer issues a completion statement by the end of the defects liability period, his joint liability with the engineer for structural and safety defects (decennial liability) continues to run for the rest of the ten years.

The starting date of the decennial liability may be disputable in multi-units projects. Here, the employer may argue that the period starts at the time of delivery of the whole project. In such cases, the judge or arbitrator needs to consider the date when the unit was actually used, could have been used, by the employer or beneficiary, such as a subsequent buyer. Obviously, decennial liability will start at that date regardless of whether the employer has actually used the unit or not. This issue becomes more persistent in multi-stages projects. In some projects, the employer may sign a separate contract for the underground work. When the underground work is finished, the question becomes whether the decennial liability period starts to run, for this particular work, from that moment or from the date when the whole project is

[9] The Union Supreme court, in 303/Judicial Year 21, held that "In the present case, the appellant claimed loss of income on the grounds that he did not have the use of his car following the accident. This is a proper head of claim under articles 282 and 292 of the Civil Code. There was no justification for the finding of the lower court that the insurance company is not obliged to pay for the hire of an alternative car if the insured car is out of commission." Similarly, the Dubai Court of Cassation, in 51/2007, held that "Article 292 of the Civil Code provides that in all cases indemnity will be assessed according to the harm and loss of profit sustained by the aggrieved party. For that reason, the trial court is obliged to examine all of the elements going to make up the loss at law, and those that could come into the calculation of the compensation on the basis that the specification of those elements is a matter of law in which it is subject to the supervision of the court of cassation."

[10] The Dubai Court of Cassation, in 251/2007, held that "although the assessment of compensation for material and moral damage due to the aggrieved is a matter within the discretion of the trial court, nevertheless if the applicant for compensation submits acceptable evidence of one of the elements of damage for which he applies for compensation and the court sees fit to exclude that evidence and to assess damage on a different basis, then it must give its reason for not adopting that evidence, failing which the judgment will be tainted by a defect in reasoning."

[11] This was stated by the Dubai Court of Cassation, in 28/2008, where the Court held that "although it is well settled that the trial court has jurisdiction in respect of the assessment of the value of compensation for all losses sustained by the aggrieved party, nevertheless the court must, on assessing the physical loss sustained by a party by way of actual loss or loss of profit, state the source from which it has derived those elements of compensation, and if the court awards an overall lump sum figure without stating the basis of such assessment, i.e. the evidence and documents placed before it in the case, in such a way as to demonstrate the facts of the loss and expenses and loss of profit sustained, then the judgment will be in error in the application of the law and tainted by a defect in reasoning."

delivered. The CTC does not provide a clear-cut answer to this question. However, one may argue that decennial liability provides a ten years warranty from the date when the premises become ready to use. Finishing the underground work is just a stage to be followed with other works.

After the credit crunch 2008, many projects were suspended in Dubai. As an expo 2020 host city, most Dubai projects are back to life now. New contractors are aboard with fresh construction contracts. If a safety or structural defects appear later, all sorts of issue will come up. The new contractor will argue that he is not responsible for the previous contractor's faults. The old contractor will argue that the ten years warranty (decennial liability period) started to run from the date of suspension. Therefore, new construction contracts, made for the purpose of completing existing works, should predict such issues and provide for precaution measures. Such contracts may provide for the duty of the new contractor to test the existing work and confirm its suitability & sustainability.

6. Privity of contract and decennial liability

Liability may be shifted down the chain to reach ultimately the contractor. "Back to Back" terms can be efficiently used here. Such terms are used to shift the liability from a party to another down the chain.[12] By this way, liability will ultimately reach the employer who can sue the contractor for defective workmanship or the consultant for defective drawings or both the contractor and the consultant under the decennial liability rule, as previously mentioned. In order to support this method, Article 26(1) of the Law No. (27) of 2007 Concerning Ownership of Jointly Owned Properties in the Emirate of Dubai states that

> "(1) With respect to the construction contract provisions in the Civil Transaction Federal Law No. (5) of 1985, the Developer remains liable for 10 years from the date of completion certificate of the building to repair and cure any defects in the structural elements of the Jointly Owned Property notified to him by the Owners Association or a Unit Owner. (2) The Developer, in respect of a development or part of a development undertaken by him, remains liable for 1 year from the date of completion certificate of the building to repair or replace defective installations in the Jointly Owned Property which, for the purpose of this Article, include mechanical and electrical works, sanitary and plumbing installations and the like."

On the face of it, this sounds a good choice to shift the liability to the person who was actually responsible for carrying out the construction properly; however, this choice may not be always available. For example, if one of the parties in the chain disappears or becomes insolvent, the chain will be broken

[12] Antonios Dimitracopoulos, "Can any owner of a building pursue the contractor under his 10 yearlong defects liability? CATCH ME IF YOU CAN" March 2004, Al-tamimi, available at http://www.westlawgulf.com, "one possible method would be through a chain of contractual clauses (commonly referred to as "back to back") linking the last owner to the contractor. These clauses would act effectively as a warranty of the stability and safety of the structure initially for ten years and then on a sliding scale as time passes and ownership changes. In that scenario, like a string of dominos, the consecutive warranties would be called upon until they reach the last claiming party who would be the employer and who, under the decennial liability provisions, does not actually have to also be the owner. This option can activate the contractor's liability as set out in Article 880 (of the UAE Civil Transactions Code) but does very much depend on the way this liability is conveyed from the employer to the next owner and onwards to any last owners."

and, thus, liability cannot be shifted through the chain. This is why the last owner may need a direct action against the contractor for defective workmanship.[13]

Although it is obvious that there is no direct contractual relationship between the last owner and the contractor, one may envisage a number of situations where the former can bring an action in contract against the contractor under UAE law. The CTC provides for the so-called "contracts made in favour of third parties". This type of contract grants the third party beneficiary an action against the undertaker for breach of contract.[14] One may also rely on the CTC provisions to argue that contractual rights can move to last owners automatically upon the transfer of title.

6.1 Contracts Made in Favour of Third Parties

The "contracts made in favour of third parties" provide for the contractual benefits to be conferred *directly* on a third party.[15] Seemingly, one may argue that this theory may apply in cases where it is obvious that the construction contract is made in favour of a third party. In certain projects, such as commercial buildings of residential compounds, it is obvious that developers (employers) invest in construction and gain their profit by selling the units. The contractor is aware that the premises will ultimately be utilized by a subsequent buyer. However, the contractual rights here are conferred on the developer first and there was no right conferred directly on the subsequent buyer.

For Article 254 to apply, the contractual right must be conferred *directly* on the third party by the undertaker. This was stated clearly by the UAE Union Supreme Court, in the case of 250/Judicial Year 20, where it held that "the effect of the provisions of article 254 of the Civil Code is that in a stipulation in favour of a third party, the stipulator contracts with the undertaker in his name for a personal benefit in the performance by the undertaker of the obligations contracted for towards the beneficiary, without the beneficiary becoming a party to the contract. The beneficiary derives his right directly from the contract itself as made between the stipulator and the undertaker, which stipulates obligations in his favour as beneficiary. He may be specified in person or by description as a future person, or he may be capable of being identified at the time that the contract takes effect."[16]

[13] The same argument may be raised in cases of designer's liabilities towards the subsequent or last owner. See White N., Principles and Practices of Construction Law, Practice Hall, Ohio, 2002, p.333.

[14] The UAE Union Supreme court, 791/Judicial Year 3 held that "This is in accordance with the rules of stipulation for a benefit in favour of a third party in articles 254 and 256 of the Civil Code. It is permissible for a person to contract in his own name with a third party for rights stipulated in favour of a third party, if he has a personal, material or moral interest in the enforcement of it. Such stipulation will result in the third party acquiring a direct right against the undertaker for the performance of the stipulation, and he may make a claim against that person for performance of it unless it has been agreed otherwise."

[15] Article 254 of the UAE Civil Transactions Code states that "(1) It shall be permissible for a person to contract in his own name imposing a condition that rights are to enure to the benefit of a third party if he has a personal interest, whether material or moral, in the performance thereof. (2) Such a condition shall confer upon the third party a direct right against the undertaker for the performance of that condition in the contract enabling him to demand the performance thereof unless there is a contrary agreement, and such undertaker may rely as against the beneficiary on any defences arising out of the contract. (3) The person making the condition may also demand the performance of the condition in favour of the beneficiary, unless it appears from the contract that the beneficiary alone has such a right."

[16] Similarly, the Union Supreme Court, in the case of 264 and 346/Judicial Year 20, held that "Articles 1026(1) and 254(1) and (2) of the Civil Code show that in a stipulation of a benefit for a third party, the stipulator contracts with the undertaker for a personal

The source of such a right is the contract itself. Therefore, it is significant for the parties to make it clear at the time of making the contract that the benefit is to be conferred directly on a third party and the latter will have the right to enforce the contract. The Commentary on UAE Civil Code (Ministry of Justice) states that "the stipulation in favour of a third party involves a true departure from the rule that the benefits of contracts are restricted to the contracting parties to the exclusion of others. The undertaking party is under an obligation to the beneficiary in whose favour the stipulation is made, and that person thereby acquires a direct right, notwithstanding that he is not a party to the contract. In that way, it is the contract itself that is the source of that right." Nevertheless, it is not necessary for the beneficiary to exist or be mentioned in name at the time of making the contract as long as he is identifiable at the time when the rights are due to be conferred on him.[17] In order for the beneficiary to have such a direct right, he must accept such a right and notify the undertaker or the stipulator of his acknowledgement.[18]

Conferring the contractual rights directly to a third party is not the norm in construction contracts where the contractual rights are conferred first on the employer. The employer may choose to sell the units through off-plan sales. Here, the buyer cannot be a third party beneficiary under Article 254. Off plan sales are usually made after the construction contract is signed. In cases of off-plan sales, the property is still delivered to the developer first. Thereupon, the reliance on the theory of "contracts made in favour of third parties" to grant the last owner the right to sue the contractor for defective workmanship does not seem helpful.

To sum up, the theory of "third party beneficiary" will not provide a ground for the end user to sue the contractor for decennial liability for the following reasons. Firstly, parties to the construction contract must stipulate at the time of making the contract that a third party will acquire the benefit of the contract. Here, it is not enough that the benefit of the contract is conferred on a third party. Parties must agree at the time of making the contract that a third party will have the right to enforce the contract.[19] Secondly,

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benefit in the performance by the undertaker of the obligations contracted for towards the beneficiary, without the beneficiary becoming a party to the contract. The beneficiary will acquire a direct right out of the contract itself made between the stipulator and the undertaker, which stipulates certain obligations in his favour with him as the beneficiary…". In view of the aforementioned judgments, it can be noted that although the third party beneficiary is not a party to the contract, he acquires a direct right against the undertaker. Having said that, it is necessary to note that the beneficiary is not a total stranger to the contract as he is the beneficiary to it and acquires direct rights against the undertaker. The Union Supreme Court made this point clear by stating that the third party beneficiary "…will not be a stranger to the contract but will be the beneficiary party to it." The UAE Union Supreme court, 791/Judicial Year 3.

[17] Article 256 of the CTC states that "in imposing a stipulation in favour1 of a third party it shall be permissible for the beneficiary to be a future person or future body, and the beneficiary may also be a person or body not specified at the time the contract is made if such beneficiary is ascertainable at the time the contract produces its effect in accordance with the condition."

[18] The Commentary on UAE Civil Code (Ministry of Justice) states that "if the beneficiary duly accepts the stipulation, he may notify the undertaking party or the stipulator of his acknowledgment. Such acknowledgment is a legal disposition made unilaterally. It does not have to satisfy any particular form, nor has the legislature specified any particular time in which it must be done. Notice may, however, be given to the beneficiary to declare within a reasonable time what his intention is, and the right of the beneficiary will become binding or incapable of annulment immediately upon his announcing his acknowledgment, and it will be a direct right the source of which is the contract. This will produce two results: The first is that it will be open to the beneficiary to claim performance of the stipulation in the absence of an agreement to the contrary. As the person imposing the stipulation has a personal interest in such performance he is different from a voluntary agent in that regard, and it is likewise open to him to make the demand himself, unless the contract provides otherwise. The second is that it is open to the undertaker to rely as against the beneficiary on any defences arising out of the contract."

[19] Andrew Van Niekerk, "Construction Law", Al-Tamimi, October 2006, available on http://www. westlawgulf.com "Essentially, the difference between Article 254 of the UAE Civil Code and the United Kingdom Act is that under the latter it is not sufficient

the benefit must be conferred on the third party *directly*. As previously mentioned, this is not the usual case in construction contracts where the developer is the first owner who sells the project or its units to third parties.

6.2 Contractual Rights Transferred to Last owners by the rule of law

Article 251 of the CTC states that "If the contract gives rise to personal rights connected with a thing transferred thereafter to a special successor, such rights shall be transferred to such successor at the time at which the thing is transferred if it is one of the appurtenances thereof and the special successor was aware of those rights at the time of the transfer of the thing to him."

The employer's right for conforming performance of construction contract can be argued to be transferred automatically with the transfer of title. There is no clear-cut court decision to support this interpretation of the Article 251 in construction contract. Actually, this Article applies usually to maintenance contracts, power provision contracts, etc. that are needed to keep the plant functioning. There is nothing, however, preventing this Article to apply to cases of defective workmanship as the right to defects-free construction is one the employer's rights under the construction contract.

Article 251 speaks about contractual rights transferable to a special successor. The special successor is the person who acquires a particular right over a particular thing from his predecessor. Under this meaning, one may strongly argue that the right for defects-free construction is a contractual right on a particular thing that is transferred to the last owner upon the passage of title.[20]

In interpreting Article 251, the Union Supreme Court states that "the effect of the provisions of article 251 of the Civil Code is that if a contract creates personal obligations or rights connected with a thing that thereafter is transferred to a special successor, then those obligations and rights will also be transferred to that successor as from the time that the thing is transferred, if it is one of the appurtenances thereof, and if the special successor was aware of them at the time of the transfer of the thing to him. A finding of fact as to whether the special successor had knowledge of the prior disposition before transfer of the ownership of the thing to him, is a matter of fact within the independent discretion of the trial court, provided that its judgment in that regard is based on sound grounds sufficient to support the judgment."[21]

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for the obligation to amount to a benefit for a third party but it must further be apparent from the contract that the parties intended for the term to be enforceable by the third party. Whereas under Article 254, such right is created automatically where it is recorded as a condition of the contract that the right is to vest with a third party, unless there is a contrary agreement."

[20] Commentary on Civil Code by the ministry of justice provides: "A special successor is a person who acquires from his predecessor a particular right over a particular thing, such as a purchaser or a donee or a usufructary. If the predecessor makes a contract relating to such thing, all of the rights and obligations resulting from that contract pass to the special successor by three conditions: Firstly, that the date of the contract precedes the date of the acquisition by the successor of ownership of the thing; the contract must be of ascertained date. [JW: this is probably meant to mean ascertained latest date]. The second is that the rights and obligations arising out of the contract must be appurtenances of the thing; that will be the case if such rights are supplementary to it, such as contracts of insurance, or if the obligations limit the freedom of use of it, such as an obligation not to erect a building. Thirdly, the successor must have been aware of the rights and obligations passing to him."

[21] The UAE Union Supreme court, 434/Judicial Year 24. See also the decision of the Union Supreme Court, 351/Judicial Year 3 where it was held that "It is likewise settled law under articles 250, 251 and 252 of the Civil Code that the effect of a contract extends to the contracting parties and to a general successor, unless it appears from the contract or from the nature of the

7. Conclusions

Under the decennial liability provisions of UAE law, both the contractor and engineer are jointly liable for any partial or total collapse or for structural and safety defects. Such a joint liability requires the engineer/architect to design and oversee the work. Decennial liability is part of public policy and, thus, it cannot be excluded or limited. However, parties may extend the period for more than ten years. The period can be shorter only in cases where the building or establishment is intended to last for less than ten years.

The period of decennial liability starts from the date of delivery. This is usually the date of issuing the taking over certificate (TOC). Obviously, this period overlaps with the defects liability period that can be found in most standard contracts in UAE. The defects liability period is usually one year, from the date of the TOC, within which the contractor will be liable for all sorts of construction defects.

The ten years period is a guarantee period. Thus, it does not fall under the rules of suspension and interruption of limitation period. The law also provides for the limitation period of claims based on decennial liability provisions. Such claims must be filed within three years from the date when the partial or total collapse occurs or when the structural or safety defects appear.

In cases where the contractor subcontracts the work, he stays liable towards the employer for any defective performance of the subcontracted work. Even in cases of nominated subcontractors, the contractor will not be released from liability towards the employer for the defective subcontracted works unless agreed otherwise. The employer may also require the subcontractor to issue a warranty in his favour and/or in the favour of end user in order to have a direct action against him. The contractor may choose to use the “back to back” terms under which he can shift the decennial liability to the subcontractor. The contractor may require a sub-contractual indemnity clause that cover’s his decennial liability with regards to the subcontracted works. If such a liability arises, the subcontractor will have to indemnify the contractor.

The employer may sell the building or its units to subsequent buyers. This can be upon completion or by the so-called off-plan sales. Under Dubai law, the developer becomes liable towards the buyer for structural defects up to ten years from the date of delivery. Liability for defective construction may be shifted down the chain till it reaches the contractor. In some cases, such a chain becomes broken due to the disappearance of one of the parties or due to the limitation period. If this becomes the case, the ultimate buyer will need a direct action against the contractor. This paper argues that decennial liability may move with the premises under Article 251 of the CTC. Furthermore, if the construction contract was initially made in his favour, he will have a direct action against the contractor. This requires both parties

transaction or from a provision in the law that such effect will not extend to a general successor. If a contract establishes personal rights connected with a thing that is thereafter transferred to a special successor, such rights will be transferred to the successor at the same time as the thing passes, if it is one of the appurtenances thereof, and if the special successor knows of them at the time of the transfer of the thing to him. So far as concerns obligations created by the contract, they will not pass to a special successor unless they are part of the appurtenances of the thing passing to such successor, and are specified in his favour [translator’s note: but phrase obscure] as imposing restrictions or narrowing his scope.”

to the construction contract to agree that the benefit of the contract will be directly conferred on a third party. A statutory protection for consumers is always recommended. Indeed, it is submitted that the last owner should be given a statutory right to sue the contractor for defective construction.

Innovation development for highly energy-efficient housing

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Abstract

Buildings account for 40% of EU final energy demand and policy developments like the Energy Performance of Buildings Directive are stimulating the innovation development for nearly zero-energy housing. However, businesses switching to innovative products for highly energy-efficient houses is a process that is poorly understood. To accelerate nearly zero-energy housing, all obstacles that currently restrict the distribution of innovation - experienced by end users, businesses and policy makers - must be defined and tackled simultaneously. These barriers and opportunities have been described in detail in a market study, three business innovation studies, three studies on end user experiences and three policy studies. These studies were recently assembled in a book.

The enterprise studies confirm that collaboration between companies is essential to innovation, even beyond the usual ad-hoc knowledge application and the individual collaboration during demonstration projects. One major obstacle is the transfer of the necessary technical knowledge and skills by the few pioneers to the other companies. Manufacturers, in particular, play a key role in the adoption of innovation and the transfer of new insights to small and medium-sized enterprises, which are a key target group for the market introduction of new concepts in the building sector.

Only a small group of occupants is interested in the energy savings and new forms of sustainable living. The study shows that end users can be motivated by low energy costs and improved living quality. They may be adequately satisfied with their homes, particularly with the high level of comfort.

The policy studies confirm that the government should play a more active part in getting energy-efficient housing off the ground, especially house renovations: the business community should be encouraged to develop more innovations which requires financial resources.

Manufacturers and suppliers switching to innovative products for ultra energy-efficient homes is not a standalone process of companies promoting technologies which consumers then use. Innovation is a diffuse process which must be approached from a policy perspective as well as the demand and supply perspectives.

Keywords: innovation, housing, low energy, passive house, policy

1. Introduction

The debates about climate change and security of energy supply, perceived opportunities for a 'greener' economy and policy developments like the Energy Performance of Buildings Directive (EPBD, 2010) have all revived interest in energy efficiency and related innovations. Significant potential has been recognised for reducing energy use through innovation, especially in such energy-intensive sectors as the construction sector, where a large part of the energy use goes to residential buildings. Achieving policy objectives related to climate change and energy will require significant carbon reduction in residential buildings, particularly with regard to energy demand for space heating. For this reason, this study investigated innovation opportunities and challenges related to the adoption of highly energy-efficient housing concepts, particularly passive houses, which largely reduce the demand for space heating.

Regarding the experience of limited diffusion of integrated design concepts in the previous decades, it is logical to consider whether we can expect enterprises, users and policymakers to move smoothly into this required transition. Some researchers (for example: van Hal, 2000; Femenias, 2004) have noted that, if we are not careful, we might remain in a demonstration phase with regard to sustainable housing without ever progressing into the mainstream market. On the one hand, the state of the art regarding available energy efficient technology solutions is already relatively advanced. On the other hand, the implementation of highly-energy efficient buildings is still at an early market development stage in most European countries, and it is proving difficult to diffuse integrated concept solutions beyond the demonstration phase (IEA, 2006; Rødsjø et al., 2010). Worldwide research by the International Energy Agency has revealed the strong influence of the passive house concept on the achievement of a market development of highly energy efficient housing (IEA, 2006; Rødsjø et al., 2010; Haavik et al., 2012).

In addition to differences between newly built construction and renovation, some countries (e.g. Austria, Germany, Switzerland) and regions (e.g. Brussels Capital Region, Vorarlberg Region) were found to be quicker than others (e.g. the Netherlands) are to adopt highly energy-efficient housing concepts (e.g. passive houses), as illustrated in Figure 1. Like the Netherlands, Belgium began relatively late with the adoption of the passive house concept, although it managed to develop its market more rapidly than was the case in the Netherlands. Given the author's considerable experience with the introduction of passive houses into the market in Flanders, northern Belgium, it was possible to use these experiences to explore various questions related to adoption and diffusion.

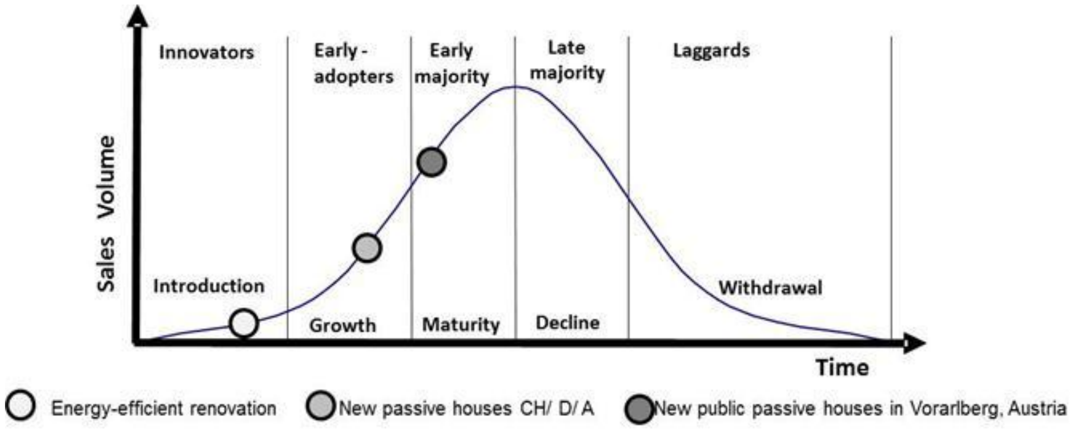

Figure 1: The Product Lifecycle Curve, illustrated for the development of passive houses

This paper summarizes and discusses the main results of an extensive study (Mlecnik, 2013). The goal of this study was to develop a more general definition of barriers to and opportunities for the introduction and continued market development of highly energy-efficient housing concepts (in particular passive houses), in order to define recommendations for accelerating their adoption and diffusion. The empirical part of the study focused primarily on finding recommendations for the market for single-family housing in countries and regions in which the development of energy-efficient concepts is lagging behind. Innovation opportunities and barriers related to the promotion of highly energy-efficient housing concepts were investigated, in order to define pathways towards the elimination of barriers to their adoption and diffusion. This was accomplished through the empirical investigation of the viewpoints and experiences of enterprises (Part A), end-users (Part B) and government policymakers (Part C), in order to identify various factors that could lead to a rapid increase in the adoption and diffusion of innovative concepts (e.g. passive houses).

From the theoretical side, the available work focuses primarily on exemplifying, interpreting and developing the innovation adoption theory developed by Rogers (2003). As such, the study also provides a deeper understanding and conceptualisation of various issues that could lead to improvement of innovation theory, by using practical goals and real market, end-user and policy experiences as a laboratory. The traditional theoretical perspective of the enterprise or the customer as an adopter of innovation is expanded to include groups of enterprises and policymakers. Another theoretical challenge involves considering innovation theory beyond the level of individual technologies towards the concept level. The study challenged Rogers' innovation diffusion theory to take more explicitly into account the experiences developed in other theoretical fields (e.g. construction innovation theory, enterprise network theory and environmental behaviour research).

2. Research approach

To structure the research in relation to the applied theories and key concerns regarding market development, the main research question was subdivided into three primary questions as follows:

Which challenges and opportunities are related to the innovation adoption of highly energy-efficient housing concepts, particularly passive houses (main question), as observed from the supply side (Part A), the demand side (Part B) and the policy side (Part C)?

Various issues related to technology innovation, business innovation and government policy were studied within the context of specific sub-questions, and pathways were suggested for the integration of highly energy-efficient housing concepts as innovations by analysing technological, societal and policy factors that can stimulate or hinder the diffusion of innovation.

Analysing demonstration projects involving single-family housing, the first part of the study identifies innovations that enterprises associate with passive houses and highly energy-efficient renovations. Innovation theory is then developed further within the context of the examination of a supplier's innovation-adoption process, in order to explore systemic innovation opportunities. The path of collaboration between enterprises is then further explored for an emerging market (highly energy-efficient housing renovation). In addition, opportunities and barriers related to the transition from an innovator market to early adoption are examined, using the experiences of a passive house enterprise network.

The second part of the study addresses the viewpoint of the demand side. The first study in this part examines the innovation adoption experiences of end-users, based on post-occupancy evaluation research for various categories of newly built nearly zero-energy homes in the Netherlands. To ascertain the need for quality assurance and for improving passive house certification, the subsequent study then draws upon the experiences of end users with certified passive houses. To support the emerging market for highly energy-efficient renovation, the decision processes of owner-occupants regarding innovation adoption involving highly energy-efficient renovation are further examined.

The third part of the study aims specifically to derive lessons from European policies and policy initiatives that could stimulate the adoption of highly energy-efficient housing concepts. To this end, the first study in this part is based on the examination of the definitions of nearly zero-energy houses that are contained in the market and policies of European member states. A consequent study puts particular emphasis on the adoption of labels in governmental policy. In addition, opportunities for increasing innovation adoption through communication channels are explored, as exemplified by the activities of the previously discussed passive house enterprise network.

Several research methods are used to explore the issues mentioned above, depending upon the specific research issue being addressed. In addition to literature study, data are collected from existing Belgian and Dutch residential demonstration projects in order to identify innovations and end-user experiences in newly built passive houses, nearly zero-energy houses and highly energy-efficient renovations. Additional empirical data are obtained through questionnaires directed towards companies, end-users and policymakers, along with database and web searches, and interviews with demonstration project stakeholders (e.g. end users, architects and enterprises). Lessons are also derived from the author's action-based experiences with innovation guidance for enterprises, the establishment of a passive house network and the development of a market for passive houses in Flanders, northern Belgium.

The general research approach is illustrated in Figure 2.

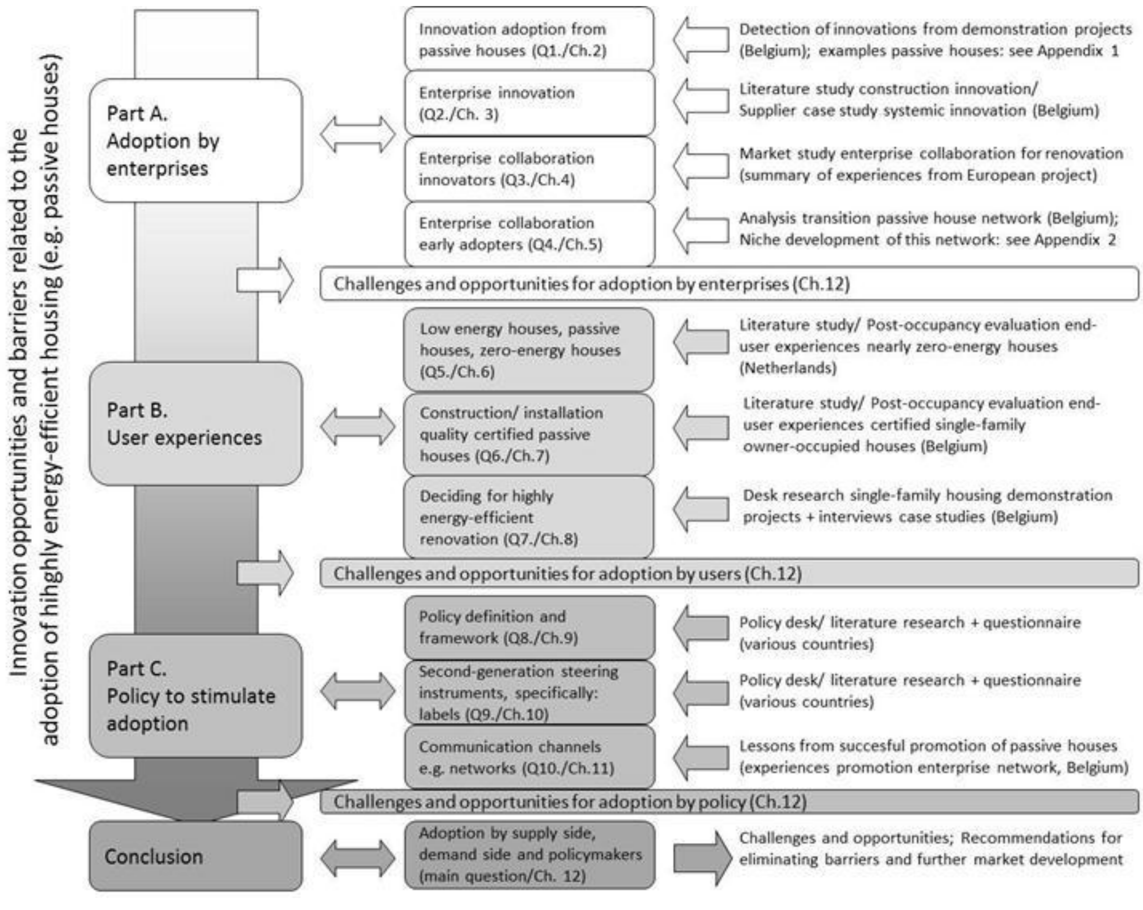

Figure 2: The three main components of the research approach, the main topics covered in each of the ten studies, the research input used in each chapter and the research output obtained from each part

3. Challenges and opportunities for the adoption of highly energy-efficient housing concepts

This research has identified very important challenges to and opportunities for the innovation adoption of highly energy-efficient housing concepts, particularly passive houses, as observed from the supply side (Part A), the demand side (Part B) and the policy side (Part C), see Figure 3.

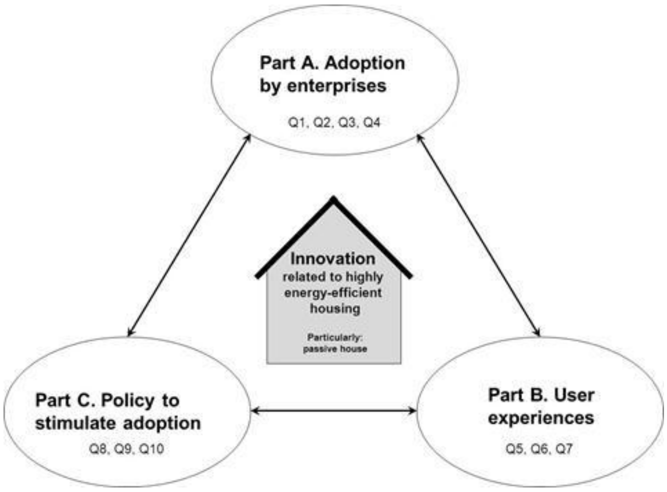

Figure 3: The research defined the 'innovation' and studied its adoption by enterprises (Part A, four studies/sub-questions), end users (Part B, three studies/sub-questions) and policy (part C, three studies/sub-questions)

The study developed many answers to the main question by studying the issue from various perspectives. When addressing the main research question from the perspective of the supply side, the main conclusion is that multi-player enterprise collaboration plays a key role in the adoption of 'concept' innovation (e.g. passive houses). From the perspective of the end user, it can be concluded that the problems and positive experiences of end users should be used to guide further innovation. From the policy perspective, it can be concluded that increasing the diffusion of highly energy-efficient housing (particularly passive houses) requires an active role on the part of government policymakers with regard to the adoption of the innovation.

3.1 Multi-player enterprise collaboration plays a key role in the adoption of 'concept' innovation

Examination of the experiences of enterprises with innovations in demonstration projects reveals that an integrated architectural 'concept' innovation diffusion approach - like experienced during the promotion of passive houses - can stimulate enterprises to adopt a multitude of innovative technologies (possibly in clusters), services and systems as well as architectural innovations. One advantage of the passive house concept is that it can be easily translated into generally recognised principles, which enterprises can relate to specific requirements.

Findings from the study indicate that, for the construction sector, suppliers can be important players for innovation adoption. The empirical research includes an investigation of a reference innovation journey for the adoption of the passive house by a supplier, thereby shedding light on the potential for systemic innovation involving various stakeholders, who supply the necessary competencies, expertise and resources. Led by the passive house ‘concept’ approach, and with the help of an innovation agent, the supplier was found to start a formal structured risk-sharing innovation journey towards modular innovation as a vehicle for incorporating architectural and system innovation. This is in sharp contrast to the usual ad hoc generation of knowledge and loose actor collaboration found in demonstration projects, which usually rather results in incremental innovation taking place during specific project phases.

Project-related fragmentation, characterised by separate small and medium-sized enterprises (SMEs), each performing a fraction of a supposedly integrated project, was found to pose an important barrier to the development of passive houses, particularly for the renovation market. To counteract this barrier, it is essential to develop and cultivate a network around the proposed and actual ‘concept’ innovations. Given the specificity of the construction sector and the ‘concept’ innovations for achieving a high level of energy performance, it would be worthwhile to cultivate and develop specific innovation agents as intermediaries between suppliers and other players in the construction chain.

One particular challenge involves increasing the flow of necessary technical information, knowledge and project management skills from the frontrunners to the many less experienced implementing actors, most of which are SMEs, which form an important target group for the market introduction of ‘concept’ innovation in the construction sector. For example, in the case of the development of the Flemish market for single-family passive houses, small enterprises played the most important role in sparking radical innovation at the regional level, while large companies were slower to adopt innovation through incremental innovation, particularly given the financial and networking incentives that were in place and that targeted a larger market. The results identify the need to characterise, cultivate and develop enterprise collaboration in various subsequent innovation phases and transitions between phases. Business-to-business collaboration was found crucial to the development of ‘concept’ innovation in both the market-introduction phase and the early-adoption phase. Such collaboration can be facilitated by multi-player enterprise networks, in which various types of actors (e.g. architects, installers, contractors and consultants, as well as clients and knowledge institutes) can network and collaborate.

In sharp contrast to the market for newly built passive houses, the renovation market still has far to go with regard to the development of improved collaboration structures. A pool of experienced actors for implementation of highly energy-efficient housing renovation has yet to be defined, and adapted quality-assurance instruments and support schemes are needed as well. A major opportunity lies in finding market-proof structures for collaboration and communication, in order to reduce the burden on homeowners, particularly with regard to alleviating financial burdens and burdens related to project management.

3.2 The needs and experiences of end users should be used to guide further innovation

On the one hand, enterprises need to innovative. On the other hand, they are more likely to find a market by responding to customer needs and expectations with their technologies, systems, services and architecture. Findings from the post-occupancy evaluation studies in this research show that potential residents have various reasons for choosing nearly zero-energy dwellings, with the energy costs associated with a dwelling being an important argument. The passive house requirements allowed clients to negotiate a well-defined target with executing parties. Nevertheless, a survey of end-user experiences in the Netherlands revealed that the choice for low-energy, passive houses or zero-energy houses was not very obvious from the perspective of the client. On the other hand, end users living in highly energy-efficient houses were quite satisfied with their dwellings, indicating a high level of comfort. These findings could be used as additional arguments in the promotion of such dwellings. One potential area for improvement involves the promotion of innovative renovation concepts towards owner-occupants. Factors that motivate owner-occupants to adopt highly energy-efficient renovation concepts include – in addition to structural improvement and increased surface area - the promise of improved comfort, a more general concern for the environment and improved health conditions.

The results of this research indicate that the demand side suffers largely from a lack of knowledge regarding available innovative concepts. With regard to the lack of knowledge, social strategies can be recommended (e.g. establishing peer-to-peer knowledge-exchange networks for owner-occupants, nurturing those networks with experiences from experienced owner-occupants, architects and contractors). In order to improve diffusion, the relative advantages and visibility of the actors involved should be addressed. The attractiveness of highly energy-efficient concepts, particularly for renovations, could still be increased by providing reference networks, suitable tools and significant economic incentives for both customers and executing parties.

One barrier to the adoption of nearly zero-energy houses involves the perception that such houses offer insufficient air quality and/or comfort in the summer, independent of energy category. Design deficiency (e.g. lack of shading or ventilation bypass) or technical deficiencies in the heating and ventilation systems could be linked to negative experiences. In addition, the simplicity and the user-friendliness of control systems were identified as being of the utmost importance. These experiences suggest opportunities for architectural and technological innovation.

Process innovation is also needed, primarily with regard to quality assurance during design and execution, combined with requiring the high level of energy performance of nearly zero-energy houses. A post-occupancy evaluation study of certified passive houses in Flanders shows that current obligatory requirements for passive house certification (like those used in Flanders) do not always lead to positive appreciation of indoor temperatures, indoor air-humidity levels and/or noise levels. There is room for improving the requirements regarding cooling demand, the design and the installation of indoor climate systems, as well as for those regarding user-friendliness and information on building services (particularly mechanical ventilation systems). These recommendations can be discussed in the development of widely supported plans that aim to improve the general quality of building services in housing, indicating adaptations to regulations and building codes. Careful design and execution, including noise protection, sufficient air humidity control and odour removal strategies, are critical points for attention in relation to possible improvements in all housing categories.

In order to avoid negative end-user experiences, it is strongly recommended that inhabitants be provided with information in addition to that provided in the standard short introduction to the house. At the very least, this information should include operation manuals, although it should ideally include detailed instructions concerning the advanced systems they will encounter in the dwelling as well. Particularly for end users who are not involved in the building process (e.g. end users in rental housing), it is advisable to provide user-oriented technical information and/or training by qualified and/or experienced sources.

3.3 Increasing the diffusion of highly energy-efficient housing requires an active role on the part of policymakers

For the future implementation of national energy policies in Belgium and the Netherlands, the findings indicate that ‘passive house’ is an important and useful term, which offers market visibility and some level of policy acceptance. One important challenge with regard to avoiding market confusion is to ensure that definitions are clearly formulated and used consistently at all political levels (i.e. national and regional) and that they are compatible with the recast European Energy Performance of Buildings Directive (EPBD). Within this framework, government policymakers who are responsible for the development of energy policy should define and reward better energy performance for highly energy-efficient housing concepts (e.g. by using fiscal tools and an associated control system).

European states could benefit from integrating available labels in their implementation of the Energy Performance of Buildings Directive. Labels for passive houses have already been introduced as an option in many European countries, in order to introduce more user influence and to encourage market differentiation amongst enterprises. The diffusion of labels has benefited from the support of governments, banks, companies or combinations of these entities. Combining existing advanced labels (e.g. passive house) with the energy certificate scheme of the EPBD is recommended, although the way in which this should be done can be highly country-specific. National, regional and municipal authorities could further facilitate the adoption of labels through such actions as increasing their visibility in knowledge-transfer activities and by recognising the expertise of label providers. In addition, educational programmes for specific target groups are needed in order to support the acceptance of related quality-assurance procedures.

In general, it is essential to nurture a high level of corporate involvement and collaboration, as well as quality assurance with regard to nearly zero-energy concepts. To achieve this goal, a broad range of potentially interlinked communication activities is needed, with high intensity of communication. This communication should be neutral, positive and peer-to-peer, addressing various customer and business segments. The availability and attractiveness of conceptual approaches to highly energy-efficient housing should be increased, particularly during the market-introduction phase. Neutral actors (e.g. passive house networks) can contribute to develop communication strategies and market infrastructure.

Very important is that customers and businesses are guided with appropriate information at each step of their innovation decision-making processes. Customer confidence should be enhanced, and perceived compromises should be eased by cultivating motivation, increasing availability, highlighting attractiveness and guaranteeing quality. To induce environmentally conscious behaviour, communication policies should focus more on exemplification (i.e. the effective use of experiences from demonstration projects), as well as on engaging, enabling and encouraging clients and businesses. In addition to targeting the development of customer demand, communication should be specifically directed towards the uptake of innovation by businesses. A set of coherent communication activities could be defined in order to realise the diffusion of innovation by focusing on behavioural change and by creating synergies to produce identifiable innovation outcomes. Specific competencies and resources are needed in order to guide companies in their innovation journeys.

4. Recommendations for further market development

To accelerate the transformation of the energy and housing market significantly, we should address all barriers to innovation diffusion and early market development simultaneously. Collaboration amongst all adopter categories in the elimination of barriers could be expected to result in successful market development for highly energy-efficient housing and renovation.

Various categories of important adopters were defined in Figure 3: enterprises (particularly groups of SMEs and suppliers), end users (noting the importance of owners and occupants) and policymakers (particularly for the development of energy policy and innovation policy). Throughout the various studies, three reoccurring important barriers for market development of highly energy-efficient housing emerged. These three barriers can be roughly summarised as ‘lack of motivation’, ‘lack of knowledge’ and ‘lack of competencies’.

The various studies illustrate that innovation adoption by enterprises for highly energy-efficient housing is not a stand-alone process in which enterprises promote and end-users adopt single technologies. Instead, this research reveals strong support for a ‘concept’ approach to innovation diffusion, in addition to drawing various connections between recommendations from the supply side, the demand side and for policy development. In general, the continued use of collaborative strategies can be highly recommended. As indicated by the findings of this study, peer-to-peer knowledge exchange networks for owner-occupiers, architects and contractors or multi-player enterprise networks can be trustworthy players who can provide neutral information, networking opportunities and a system of appraisal. Networks and policymakers should now work together to develop an integrated master plan, focusing on the further development of quality-assurance systems and enterprise collaboration towards systemic innovation. Both networks and policymakers should seriously reflect on their communication strategies and respond adequately to enterprise demand for various innovation phases, as well as to end-user demand emerging from various market segments.

The cross-reflection generated two main recommendations for increasing the adoption and diffusion of highly energy-efficient housing concepts. These recommendations are directly based on various recommendations emerging from the studies.

1. Developers of innovation and energy policy should support specific change agents.

Energy policy and innovation policy should be integrated for the construction sector. Funded innovation agents should guide committed SMEs and suppliers. Funded change agents should guide potential adopters in each step of their innovation-decision processes. In some cases, these change agents could also combine their communication activities with positions as enterprise-innovation agents. At the same time, enterprise collaboration and multi-player networking should be stimulated.

2. Quality-assurance schemes for highly energy-efficient housing should be introduced or revised.

The quality of demonstration projects should be assured since benefits that are not related to energy should be used to persuade potential adopters. Notably, indoor comfort and the adequate performance of building services should be guaranteed and end users should be provided with detailed information. A system of appraisal for nearly zero-energy housing can be defined, for example using available passive house labels or related experiences. At the same time, an educational programme should be developed, particularly for highly energy-efficient housing renovation.

These recommendations should be implemented in order to eliminate barriers to innovation and to stimulate opportunities for innovation. In turn, this could accelerate the adoption of highly energy-efficient housing and the achievement of energy-policy objectives.

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Beyond Terminology - Which Contracting Features Promote Innovation

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Abstract

Two opposing contracting forms in construction are DB (Design and build) and DBB (Design-bid-build). The first one provides the contractor degrees of freedom in design, which enables innovation. DBB is the safe and traditional contracting form, where the client is responsible for the design and the contractor build accordingly. There is a lack of empirical studies comparing these contracting forms on efficiency and innovation. A first step in comparing is to define and separate the contracts. The straightforward solution is to use the client instigated definitions at face value i.e. a contract is a DB or a DBB according to the client. This is shown to be problematic by using five road construction projects from Sweden. One of the DBB indicates more degrees of freedom in design than a DB contract and only one DB project invites new methods for construction. The paper concludes that contract labelling is not a good proxy for degrees of freedom in design, which is was theoretically drives innovation. This insight facilitates future studies to evaluate contracting forms.

Keywords: innovation contracting evaluation

1. Introduction

Two opposing contracting forms in construction are DB (Design and build) and DBB (Design-bid-build). The first one provides the contractor degrees of freedom to develop the project in order to fulfil the client's non-specified need. This contract comes with a larger risk than the DBB contract since the latter relies on earlier experiences and technics to complete a project.

Theory predicts that DB contracting has a better potential than DBB to promote innovation. The degrees of freedom to design the project enable the contractor to think in new ways of undertaking construction. There is however a lack of empirical evidence to support this theory. The only studies that shed light on the efficiency of contracting forms in construction are questionnaire based studies. But these studies have issues with biased results. Therefore there is a need for more statistical based studies. A first step toward such studies is to define contracting forms. The straightforward solution is to take the client instigated definitions at face value and use them. This might be problematic since the underlying contracts do not always conform to the theoretical definition of the contracting form.

Hence, this paper sets out to investigate if DB and DBB contracts are good proxies for degrees of freedom in design of infrastructure projects. The hypothesis is the contracts labelled DB should include more degrees freedom than DBB.

The final research question is of course the contracting forms ex post effect on efficiency and innovation. This paper will focus on the ex ante contracting documents as a way to enable for future studies to define contracting forms. Outputs of the projects will not be the focus of the study.

2. Different contracting forms in construction

The taxonomy of contracting forms in construction is overwhelming. There are an abundance of terms describing and categorising different types of contracts. A reason for this is the construction industry is very nation specific, meaning that each nation has unique traditions and legal framework. Although many features of the contracts in different countries are the same, the underlying regulations often differ or are not explicitly announced, which makes it hard to compare contracts in different nations.

This paper will focus and compare two kinds contracting types, namely the Design and build (DB) and Design-bid-build (DBB). The main difference between them is the responsibility for the design of the construction project (Eriksson and Westerberg, 2011). This difference provides both the contractor and the client with different incentives.

The following section will describe the contracts.

2.1 Design-bid-build

This contracting form can be described as the traditional and still most common way of procuring infrastructure in Sweden. Basically the client provides the design for the project and the contractors provide bids to build, and the lowest tender usually wins the contract.

When providing the design, the client also takes responsibility for the documentation and the contractor only build according to the design. If a bridge breaks down due to a under dimensioned pillar in the design, it is the clients responsibility. However, if it breaks due to a construction error i.e. forgotten rebars, it is the responsibility of the contractor.

The usual way of tendering a DBB contract is to provide the potential clients with a bill of quantities i.e. a list of the tasks to be conducted and the quantities to be used. These quantities are connected to underlying technical descriptions and manuals. Contractors then submit bids in the form of price vectors, one unit price for each quantity. The lowest vector product of prices and quantities, i.e. the lowest total price, is awarded the contract. This type of contracting is also referred to as a Unit Price Contracts (UPC) used in all kind of procurement auctions outside infrastructure (see e.g. Ewerhart and Fieseler, 2003 and Gupta et al 2012).

Payment schemes applied to this contracting form can either be fixed price or cost plus (McAfee and McMillian, 1988). The fixed price stipulates that the client pays the contractor a predetermined price regardless of the final project cost. The predetermined price *p* comes from the lowest tender *b*, accordingly

$$p_i = b_i \text{, where } b_i = \min\{B_1, B_2, ..., B_n\} \qquad (1)$$

In this setup, the contractor has a strong incentive to cut costs in order to maximize profit. Under the assumption of ex post information asymmetry (i.e. that the client cannot monitor the contractor perfectly), this can entail shirking on quality. The difference between the price and the actual cost may be negative as well as positive. This potential deviation is carried by the contractor, who bears all risk under this payment scheme.

On the other side of the scale, we have the cost-plus scheme with the client bearing all the risk. The price, *p*, that the contractor is paid coincides with his cost, *c*, accordingly

$$p_1 = c_1 \text{, for the winning contractor 1} \qquad (2)$$

Here, the incentive for the contractor to cut cost is weak.

However, the standard *McAfee and McMillian* (eq. 1-2) descriptions of the payment scheme do not coincide with how the procurements are undertaken in reality. There are no extreme versions for infrastructure contracts, at least not in Sweden (Mandell and Nyström, 2013; Nyström, 2012). The reason is that the bill of quantities consists of adjustable and non-adjustable quantities, which are defined ex ante in the procurement documents.

Hence if all of the quantities are adjustable, the contract coincides with a cost plus contract and the other way around, with a hundred percent non-adjustable for a fixed price contract.[1] In reality the contracts are mixtures of adjustable and non-adjustable quantities, making the payment scheme as a whole something in-between the cost-plus and fixed price (see Nyström, 2013 for a formal description).

2.2 Design and build

In a design and build contract, both the design and the construction is the responsibility of the contractor. The client provides an idea of what he wants in the tendering process, then it is up to the contractors to present a design fulfilling the client's expectations.

Regarding infrastructure, the idea often presented in terms of functional terms. This means that the client defines a road that he wants in terms of e.g. longitudinal unevenness, rut depth, crossfall, frost heaving, cracks and friction additional to the stretch of the road. Contractors then provide bids that fulfill these conditions and a price to undertake the project. This way of procuring a road gives the contractor degrees of freedom to find new ways of building. It enables the contractor to innovate as there is no detailed description of how to build. At the same time, it puts more risk and work on to the contractor which makes it more expensive up front than a DBB contract.

The most common payment scheme under a DB contract is some sort of fixed price, often with an incentive where deviations from a target cost are shared between client and contractor.

2.3 Comparing contracting forms

There are pros and cons with both contracting forms (Nilsson and Mandell, 2010). The ex ante simplicity of DBB is appealing in comparison to DB, meaning that it is easy to compare bids. In DBB procurement all contractors are bidding for the same product as defined by the client. Whereas in DB procurement it is not as easy to evaluate the bids as the client has to appraise both price and product. Hence, the evaluation in DBB is just one dimension (price) while the DB has two dimensions, price and suggested product.

One could argue that this is a simplistic way of describing the procurement as other quality parameters often are taken into account. However, such evaluations do not differ between the contracting forms and very seldom account for a decisive parameter.

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[1] Cost plus schemes are interpreted as a contract with all quantities being adjustable. Another definition used by Bajari et al 2012 is that all of the clients cost are forwarded to the client, i.e. just forward all invoices from the subcontractors plus the contracts own costs.

To summaries, DBB contracting has low transactions cost, has a lower price up front and a low risk contractor, while DB contracting enables contractor innovation. There are however a lack of empirical studies comparing the pros and cons (i.e. the efficiency) of these contracting forms. One hypothesis to this lack of studies is that it is hard to separate the contracting forms from each other in reality.

In trying to compare these contracting forms a first step is to define them. At first, this seems unproblematic since the projects are neatly labelled as DB and DBB. When starting to read the contracting documents, some problems arose.

The Swedish Transport Administration (Trafikverket) has chosen to focus on DB contracting, despite the lack of empirical support. An increasing proportion of their contracts are called DB at the expense of DBB contracts. Just taking DB and DBB as a proxy for degrees of freedom in design seemed problematic. Hence, the following sections will study five actual contracts with the aim of ranking them according to degrees of freedom in design.

3. Method and sample

All of the studied projects are road investments in Sweden. Trafikverket is the client and all contracts are procured according to the act on public procurement. The analysis is based on the procurement documents. These documents consist of hundreds of pages for each investment with descriptions of the project and contract. This material also refers to underlying handbooks and reference texts. The focus of the study is to compare the ex ante contracting documents although material for the outcome has been used for some of the projects.

The contracts are chosen using a convenience sample. This is due to earlier experience with getting data from Trafikverket, which has been hard. Hence, we used the data that Trafikverket could provide on short notice. This might of course be problematic since we are reviewing their organization. To minimize this problem the officials at Trafikverket were not told the purpose of our study.

4. The real contracts

The Swedish construction industry has two kinds of generic conditions facilitating contracting. These are underlying documents that are referred to in the contracts and controls how to measure things, when to renegotiate prices etc. The documents are accepted and developed by both clients and contractors. There are two types of documents, AB that supports DBB contracts and ABT that supports DB.

4.1 DBB 1: Reconstructing highway

This project is a 9 kilometer road in the south part of Sweden along the old road. It was procured in 2009 and based on AB 04. Four bids were handed in and Svevia won. The ex ante contracting sum were 197 million SEK and the final cost was 228 million SEK, which might include scope changes.

This contract can be described as a traditional DBB-contact. Trafikverket designed the road and the bids were price vectors that together with the predetermined bill of quantities made up the vector sum. The lowest bid won the contract, no soft parameters were included in the evaluation of the bids. As the project started Svevia got paid according to the quantities produced times the unit prices.

The payment scheme was referred to as a fixed price, although 80 percent of the contracting sum were made up out of adjustable quantities. A better description of such payment schemes is to see them as cost plus, where the client takes most of the risk (Nyström, 2013).

Bids with an alternative method of construction, a so called "side tender", were not allowed in the tendering process. However, Trafikverket opened up for bids with methods on how to build the road that were equivalent to their own design. Such bids needed to need to include "*technical documentation from the manufacturer, a test report from a recognized body or other relevant analysis showing that the solution to the equally meets the requirements*". Where to draw the line between a "side tender" and the equivalent solution is not clear. However, none of these bids were received.

4.2 DBB 2: Bypass Katrineholm

This project is a 20 km highway bypass outside the town of Katrineholm with three large bridges. The road is to large extent built as a green field project. It was procured in 2010 with three submitted tenders. The spread of price in the bids were low but the winning bid came from Skanska.

The contract was based on AB 04 and included that the parties should work together in a partnering setting concerning the design. No detailed design was included in the tendering documents. It was based on performance criteria such as longitudinal unevenness and rut depth etc. Hence, the contractors had to submit a design in their bids and base their price on their own design. However, there was no guarantee that this suggestion would be accepted as Trafikverket had the final saying of the design in accordance to a traditional DBB contract. The idea was that Trafikverket would finalise the design together with the winning contractor.

The cost for contractor to develop this tender was allegedly 4-5 million SEK, which was 1,5 percent of the ex ante contracting sum and about double the amount of a regular DBB-contract.

The payment scheme was based on a target cost, were deviations was split between client and contractor. There was also an option to build an additional 6,3 km of road, which was used.

The procured price was 312 million SEK and the final cost was 327 million SEK. Some of this cost overrun might have been due to scope changes. The project was finished 2,5 months ahead of schedule. As a whole the project is considered a success from both parties.

4.3 DB 1: Reconstruction of highway

This project was procured in 2010 and consists of 10 kilometer road with 4 bridges in the south part of Sweden. The contract was based on ABT 06 and the contractors were responsible for the design.

The total price in the bids were made up out of seven parts in the contract, two interchanges, three clusters of smaller roads and four bridges. These parts were described using functional terms in tendering documents, such as longitudinal unevenness, rut depth, crossfall, frost heaving, cracks and friction. Based on these descriptions the contractors had to design and price a road that fulfilled the requirements.

Strabag won the contract with a bid of 185 million SEK.

The definition of the road in functional terms gave Strabag degrees of freedom to design the road. However, the methods used to fulfill the design were stipulated in Trafikverket´s underlying handbooks, such as the handbook for asphalting (Vägverket, 2007) or for dimensioning a road (Trafikverket 2011). Suggestion that deviate from this could be accepted but required documentation that verified an equivalent quality. This was expressed in the same way as in DBB 1: "*technical documentation from the manufacturer, a test report from a recognized body or other relevant analysis showing that the solution to the equally meets the requirements*".

Apart from this, there were more aspects that bound the degrees of freedom in this contract. Some examples include that the barriers separating oncoming traffic must be of a certain brand, that exit ramps should be formed as a clover, that a certain type of grass should be used on the noise barriers etc.

The final cost of the project was approximately 240 million SEK, which might have included scope changes. There were some problems with the evenness of the road after the project was finished, which the contractor had to take care of.

4.4 DB 2: Motorway Extension

This project is an expansion of an existing highway in the south part of Sweden. It includes 8 bridges and 5,5 km of road. The tendering process started in 2010 and the road opened for traffic in December 2012, one month ahead of schedule.

The winning bid came from Strabag at 160 million SEK. The final cost was 192 million SEK, which might have included some scope changes.

The tendering document consisted of two projects, one larger and a smaller, where Trafikverket choose not to include the smaller.

In accordance to a DB contract the tendering documents were based on longitudinal unevenness, rut depth, crossfall, frost heaving, cracks and friction. The contract was regulated by ATB 06.

However, there were aspects in the contract that bound the degrees of freedom for the contractor to design the project. One was that suggestions deviating from Trafikverket´s handbooks needed support by technical documentation from a third party (the same formulation as before on DBB 1 and DB 1). The client also stipulated that certain types of bridge parapets, lighting and center beams had to be used.

4.5 DB 3: New highway

This was a big new road investment in the middle part of Sweden. The project was a green field production consisting of 22 kilometers of road and 17 bridges. The project was initially divided into three different contracts, with an option for the contractors to put in a combinatorial bid for all three contracts (see e.g. Lundberg and Lunander, 2012 for more on combinatorial auctions in Swedish road procurement). NCC won the contracts for all three parts at a price of 439 million SEK. The contract was regulated by ABT 94.

The project also included a partnering bit not directed towards any specific part of the contract but more of a declaration that both parties would work collaborative.

The description of the project in the tendering documents was very detailed. An example is that Trafikverket defined the thickness and type of asphalt to be used. The tendering documents did not use any functional descriptions of the road. However, the first paragraph of the technical description opened up for alternative solutions, without strict demand of technical documentation from a third party. In principal, this opened up for alternative design.

The final cost of the project was 540 million SEK.

5. Degrees of freedom in design

All studied projects, except DB 3, include a formal bound on the degrees of freedom to design the road. These bounds include certain brands of material e.g. barriers and asphalt, detailed design features such as the height of a noise barrier or the shapes of the exit ramps but also in the form of high transactions cost for alternative suggestion of construction. This formal requirement, that alternative suggestion deviating from Trafikverket's handbooks should be supported by technical documentation, hampers the incentive to innovate. One could argue that this is a way for the client to secure the quality of the road by sticking to what has worked in the past. However, there is always a risk involving in trying new solutions and if the contract is written in the right way, the contractor is responsible for all potential future problems with the construction.

If the analysed contracts were to be ranked using an ordinal scale in terms of degrees of freedom for design, it would be the following figure 1.

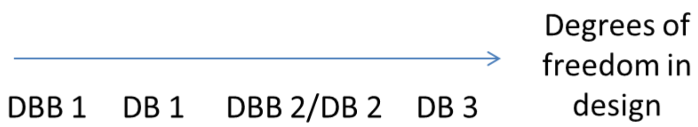

Figure 1: Ordinal ranking of project in terms of degrees of freedom in design

An interesting thing is that DBB 2 can be categorised as having more degrees of freedom than DB 1. Although the client has the responsibility for the design in DBB 2, the contract is framed in such a way that innovative ideas from contractor have a possibility of getting utilized. In DB 1 the contractor is responsible for the design but bound by the underlying handbooks of how to build the road due to the ridged demands for verifying equivalence.

DB 3 differs from the other contracts, despite a very detailed design, by the technical description inviting alternative designs.

Another interpretation of the material is that the client in the DB contract is putting the design risk on the contractor without giving them a real possibility to deviate from the handbooks. Going from the DBB to the DB is just shifting the remaining design risk of a DBB contract onto the contractor. The design risk of the DBB contract, based on the client handbooks, is small but not non-existent. Due to the restriction in the tendering documents, the possibility of innovation in a DB contract is not more likely than in the DBB setting. Moving away from all risk, without any change in expected project outcome looks favourable for the client but the remaining question is how much they have to pay for this shift in risk to the contractor. Going from DBB to DB can for example be expected to reduce competition.

6. Conclusions

The theoretical pros and cons of DB and DBB contracts are known. DB enables innovation, while DBB has lower transaction costs and risks. There is however a lack of empirical studies supporting either of these hypotheses.

One possible reason for this is the complexity in separating contracting forms from each other. The above study of five contracts indicates that just taking the contract labelling at face value do not capture the degrees of freedom for design, which is was theoretically drives innovation. In order to separate contracts from each other in terms of design freedom, one has to look beyond labelling and study the individual contracts.

The interesting final question is to study the effect of contracting form on innovation and efficiency, i.e. the outcome of the projects. When taking on this question, it has been shown that contract labelling is not a good proxy for degrees of freedom in design.

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A Pedagogical Framework for Conceptualising the Design and Delivery Of Construction Management Courses Through 'Constructive Alignment'

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Abstract

Although the application of constructivism to learning encompasses number of different ideas these are connected by the need to associate the design of learning events with the students' ability to engage with the learning in a meaningful manner. Accordingly 'instructional design' literature emphasises the need for alignment between the 'course objectives' and 'assessment practice'. 'Constructive Alignment' (CA) proposed by Biggs, represents a merger between constructivism and instructional design, which employs constructivism as a framework to underpin all stages of instructional design. CA necessitates decisions regarding the strategic selection of appropriate student-learning behaviours e.g. meaning directed (deep learning) or reproduction directed (surface learning). There is limited discourse in the literature contextualising CA in the context of construction management education. The aim of this paper is therefore to describe a CA-based conceptual framework to drive the design and delivery of a construction management programme using blended delivery mode. Using this framework it thereafter describes the role of the educator (Director, Facilitator, Assessor) and strategies associate with these roles (design, delivery, assessment strategy).

Keywords: construction management education, pedagogical design, cognitive processing, higher order learning

1. Introduction

Construction Management (CM) is relatively a young profession and has loose and fuzzy boundaries in terms of functions and knowledge base. Moreover, the CM role in project-based organisations is dominated by complexity, uncertainty and interconnectivity (Turner, 2006; Turner and Muller 2003). “The connectivity and interdependency between multiple sub-systems- organisational, technical, or social together with their positioning as part of uncertain and dynamic socio-cultural-political environments, poses considerable difficulties in understanding and predicting the overall behaviour of a construction project organisation” (Gajendran et al., (a) 2011 p 84). Such an operating environment demands CM graduates who can have KSA (Knowledge, Skills and Attitudes) to operate in turbulent environments.

The KSA’s underpinning the tertiary CM education has constantly evolved through the engagement with professional bodies and industry members. It is suggested that CM practice should be “informed, supported and challenged by an independent academic discipline” (Blake, 2010). Although high level decision making in a project based organisational environment are underpinned by objective reality (e.g. material science, engineering technology), most decision making in the realm of construction management practice are underpinned by subjective or socially constructed reality (Gajendran et al., (a) 2011; Askland, et al 2013). Therefore the nature of learning environment should provide opportunities to students to simulate and engage in complex practical problem solving tasks through the application of theory to develop appropriate KSA’s for industry practice and on-going professional development. The aim of this paper is to build a ‘Constructive Alignment’ (CA) based conceptual framework for design and delivery construction management programs could facilitate more desirable learning outcomes.

2. Conceptualising philosophical positions on pedagogy

Educational psychology literature indicates that an ‘inductive learning environment’ is more desirable, for effective teaching and learning outcomes, through ‘learning in context’ or ‘situational learning’, as the motivation to learn is driven by the ‘need to know’ (Murray et al. 2004; Prince and Felder 2006). Prince and Felder (2006) state that inductive method presents a learner (student) centred approach, and learning (of subjects) happens via “specific observations, case studies or problems, and theories are thought or the students are helped to discover them only after the need to know them has been established’ (p 123). Also they indicate that ‘Inductive teaching and learning’ can encompass number of instructional methods, which are characteristic as ‘active learning’ and ‘constructive methods’.

2.1 Constructivist pedagogical learning environment

‘Constructive methods’ (Biggs 1996; Felder and Brent 2004) of teaching and learning holds the ‘subjective reality’ view ‘that whether or not there is an objective reality …, individuals actively construct and reconstruct their won reality in an effort to make sense of their experience’ (Prince and Felder 2006). On the contrary, “positivism (‘objective reality’) model in higher education assumes that ‘absolute knowledge’ exists independently of human perception and the teachers’ duty is to lecture and transmit this knowledge to the students, while students are expected to absorb this knowledge” (Prince & Felder 2006, pp124). Felder and Brent (2004) argue that students in higher education should appreciate the notion of ‘contextual relativism’, the uncertainty and the contextual nature of knowledge (rather than to hold belief on certainty of knowledge), and should take personal responsibility for determining the truth, through gathering evidence for analysis and synthesis. Therefore, the design of a teaching and learning environment driven with ‘constructive methods’, at a conceptual level, will reflect the real world complexities during learning process, and prepare ‘life long learners’.

Anderson and Krathwohl (2001) emphasis on the concept of meta-cognition, in designing the instructional and delivery methods, which makes students more aware of and responsible for their own knowledge and thought. "Meta-cognitive knowledge is more strategic than the other types of knowledge [factual, conceptual, procedural]. At the heart of meta-cognitive knowledge lie analytic strategies, evaluative strategies, and creative strategies. Initially, these strategies may need to be imposed externally, that is, directly taught by teachers" (Anderson & Krathwohl, 2001). Crafting of the ‘cognitive processing activities’ (the thinking motion that students employ to process a subject matter) is very important in designing the learning environment, as it directly impact the learning outcomes in terms of knowledge and skill acquired by students (Brewer et al., 2007).

2.2 Constructs underpinning a pedagogical framework

Entwistle and McCune (2004) proposed four distinctive learning styles namely, ‘meaning oriented’, ‘reproduction directed’, ‘application directed’ and ‘undirected’. Felder and Brent (2004) and Prince and Felder (2006) also identified three approaches to learning by students, namely, ‘surface’, ‘deep’ or ‘strategic’, and recommend the deep approach should be the goal of instruction for higher order learning. Table 1, through fusing the above learning styles, proposes four positions, namely Meaning directed (Deep learning), Application directed, (Strategic learning), Reproduction Directed (Surface learning) and Undirected to characterises the possible learning behaviours of students (Vernunt, 1996).

Characteristics of learning behaviours are more clearly articulated through appropriate positioning of the ***Cognitive, Affective and Regulative*** aspects (Vernunt and Vermetten, 2004), reflecting the different mental models and learning orientations.

Table 1: Student learning styles and learning environment

Constructs influencing teaching and learning	*Meaning directed (Deep learning)*	*Application directed (Strategic learning)*	*Reproduction Directed (Surface learning)*	*Undirected*
Mental model	*Construction of knowledge*	*Use of knowledge*	*Intake of knowledge*	*Relying on teachers and other students*
Learning orientation	*Personal orientation*	*Vocational orientation*	*Certificate and self-test orientations*	*Lack of integration*
Cognitive process	*Deep processing*	*Concrete processing*	*Step wise processing*	*Processing not identified*
Regulation of learning	*Mostly self regulated*	*Both external and internal regulation*	*Mostly external regulation*	*Lack of regulation*
Affective processes	*Intrinsic interest*	*Practical interest*	*Fear of forgetting*	*Lost self esteem and expectation of failure*
Types of assessment supporting different types of learning	*Problem Based Scenario/ Case study based assessment*	*Writing report on specified or predetermined issues*	*Tests, quizzes*	

Source: Adopted and modified from (Entwistle and McCune 2004)

Affective activities, which are about motivational aspects of learning, involve emotions that arise during learning and lead to affective states that may positively, neutrally, or negatively influence the progress of a learning process. *Regulation activities* steer the cognitive and affective activities, (through learning task, monitoring process of learning, diagnosing the cause of the difficulties one encounters, and changing learning activities during learning) therefore indirectly lead to learning outcomes. Regulation activities can be more effectively controlled by the assessment- formative and summative- regime. That is appropriate pedagogical design should lead to grades bands (e.g. Higher Distinction to Fail) corroborating with the hierarchy of learning styles. That is the engaging 'cognitive process' at the level of 'deep processing strategy', which combines the learning activities "relating," "structuring," and "critical processing" promotes higher meta-cognitive abilities should attract higher levels of grades.

Making parallels to the Blooms Taxonomy (Bloom 1956) teaching and learning should shift from knowledge/comprehension (reproduction directed/surface learning) Application analysis (Application directed) to emphasis on synthesis and evaluation (meaning directed). Number methods can be employed in crafting an 'Inductive' learning environment for high meta-cognitive outcomes, and they are 'inquiry learning', 'problem passed learning', 'project based learning', 'case based teaching' and 'discovery learning'.

3. Operationalising a pedagogical framework

The academic programs educating for established professions (e.g. engineering, nursing, architecture, construction management) generally position their teaching philosophy on producing job-ready graduates - equipped with appropriate knowledge, skills, attitudes and strong work ethics, while becoming independent life long learners, who will make a positive difference in the industry and society as a whole. Therefore it is crucial that the associated pedagogical philosophy is appropriately operationalized to achieve the expected outcomes of the teaching philosophy.

Biggs (1996) has encouraged viewing higher educational practice from ‘constructivist learning’ theory, and ‘instructional design’ literature: that couples the philosophical position to operational practice. Although constructivism encompasses number of theories the common theme is about the learner's activities in creating meaning. While, instructional design literature emphasises on the alignment between the course objectives and the targets for assessing student performance. Biggs proposed CA, that represents a merger of these two domains, which is employ, constructivism as a framework to drive all stages in instructional design. Therefore, constructivism will steer - deriving curriculum objectives (that will set expected performances at a suitably high cognitive level), teaching/learning activities to drive to the performance and assessment (formative and summative reporting student performance).

Figure 1 describes the teaching and learning process coupling ‘constructivist learning’ approach and ‘instructional design’. The constructivist-learning environment in this case is deeply embedded and ‘Project/Problem Based Learning (PBL)’.

3.1 PBL for constructivist learning environment

In a PBL curriculum students are challenged with a real-word open ended and ill structured, problem and they are expected to work in formal or informal teams to identify what is to be learnt and develop a solution generally justified among alternatives. The process is underpinned by extensive analyses of real or hypothetical scenarios. In PBL mode instructors act merely as facilitators and not act as the fountain of knowledge or as primary source of information (Prince et al 2006). The stags of PBL design encompasses (a) naming (where main issues in the problem are identified), (b) framing (where the limits of the problem is established), (c) moving (where experimental action is taken) and reflecting (where the frame and the move are evaluated and critiqued) (Nelson, 2003).

PBL mode is embed in ‘constructivism’ and enables effective instruction characterised by (Biggs, 1996; Prince & Felder, 2006):

- Commencements of the instruction should be with the content and experiences that students can relate to, proofing an opportunity for students to make connections to their existing knowledge structure

- Presentation of learning materials should not lead to a situation where the students have to abruptly and drastically alert their cognitive models.

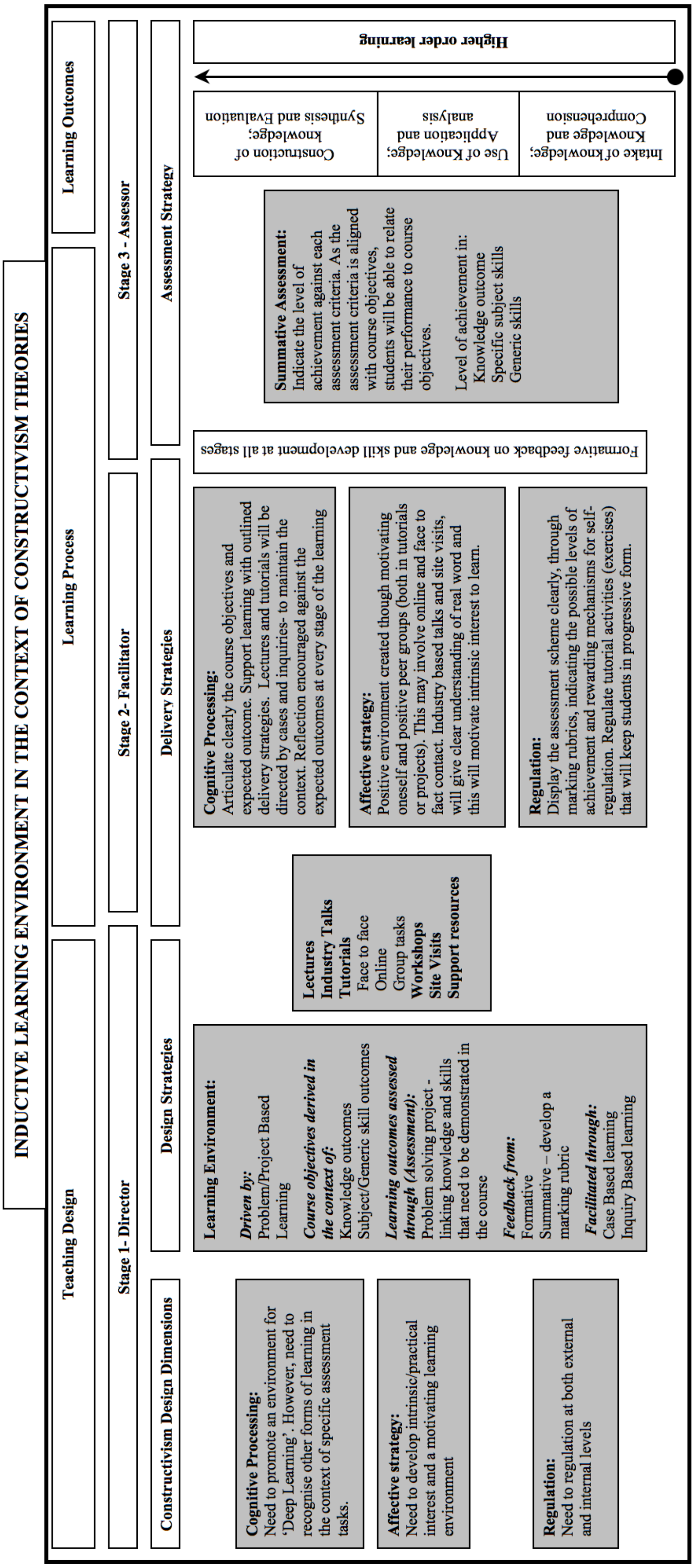

Figure 1: A model illustrating teaching and learning approach

- Instructional design should encourage students to fill in gaps in materials themselves and become self learners

- Opportunity for students to work in small groups in a collaborative and cooperative learning sprit.

The teaching approach, illustrated in Figure 1, translates the philosophical position into in three stages of operational teaching role: Stage 1- Director of Learning Environment, Stage 2- Facilitator of Learning Process and Stage 3- Assessor of the Learning Outcomes.

3.2 Stage 1- Director of learning environment

The ‘director of learning environment’ is an important role (and stage) in designing a constructive learning environment. The design and delivery of each individual CM courses (or units) and the degree as whole should consider the extent of cognitive processing, affective strategy and regulative mechanisms embedding. These three aspects drive the project/problem-based delivery, design of learning outcomes (course objectives), style of delivery facilitation, assessment instrument and feedback style.

Designing the course objectives is one of the important aspects in teaching and learning. In a constructivist learning environment course objectives are contextualised through the project/problem-based delivery and drafted in a manner to elicit required the knowledge and skills (both subject and generic) from students. The objectives (which will them be aligned to assessment) need to consider level of cognitive processing to be embedded. Thereafter, each time the course is delivered, problem/project with adequate complexity and relevance will be sourced from live projects from the industry (or simulated projects) to drive student learning to demonstrate their acquisition of skills and knowledge. The course objectives also need to be mapped with the relevant professional bodies competences (e.g. RICS, CIOB, AIB etc.) and University graduate profile. Moreover, students should be informed about the intended learning outcomes at the outset through course documentation.

The other important aspect being the ‘director of the learning environment’ is designing assessment tasks (and associated weightings) and feedback mechanisms. The assessment design is key for driving learning and assessment tasks should align with course objectives (Gore et al. 2009; Norton, 2004). Although constructivism philosophy is primarily driven by ‘meaning directed learning’ which warrants scenario-based assessments (case study or project based) and ‘reflective journals’ (Masui and Corte, 2005), assessment such as ‘reading summary blogs’, ‘essays’ (application directed) and quizzes (reproduction directed) can also be introduced with specific objectives to asses knowledge areas which are a from of scaffolding assessment towards ‘scenario based assessments’.

Moreover, the assessment tasks also should focus on developing the soft skills of students, including ability to mange group work and reflect/self assess (Boud, 1995). Group work has been widely accepted by higher education sector as an effective teaching and learning tool - allowing social interaction (promoting collaboration, communication exchange of views), and support for learners (to take more responsibility) - warrant by the constructive learning environment (Collis & Moonen, 2001).

Feedback design needs to support on going learning with formative feedback and final certification with summative feedback. The marks allocation (or marking rubric), which is also a regulation mechanism, can be based on the level of learning demonstrated by a student - and learning will range from Knowledge creation (Higher distinction/distinction), Use of knowledge (Distinction/Credit) and Intake of knowledge (Pass) (Bloom, 1956).

Facilitation in the learning environment is an important aspect in terms of taking the students from the course objectives to final assessment- through a positive and productive learning curve. Therefore, facilitation mechanism is then designed to support the student learning throughout the course taking into considering the course objectives, and assessment regime. These facilitation mechanisms are also embedded in constructive theories. Lectures, tutorials, site visits, industry based lectures are driven by case or inquiry based learning. The cases or inquiry (which will be related to the overall problem or project) will be used as a trigger to learning, therefore the need to study that particular subject or knowledge domain is reinforced to students - thus students learning occurs in the context of real world.

3.3 Stage 2- Facilitator Learning Processes

Facilitation is focused on development of the cognitive process of students, with appropriate affective strategies, based on the learning environment design developed in Stage 1. Here, students are exposed to the boundaries of relevant knowledge (basic concepts, theory and principles based on case based or inquire learning). Demonstrate the linkages between areas of knowledge and the relevance of the discipline and motivate students to develop their own knowledge gathering strategies. The facilitation will focus on students’ (a) naming (identifying the key issues in problem are identified), (b) framing (establishing limits of the problem), (c) moving (experimental actions) and reflecting (evacuate the framing and moving) (Nelson, 2003). In these process students are encouraged to think critically, establish reasoning and reflect.

Above mentioned actives are facilitated through lectures, tutorials (individual consultations and in small groups), seminars, discussion panel, games and videos. Through the facilitation process students are encouraged to work in teams and build up communities as their reference group and to be judged and critiqued by peers. Affective and regulative strategies motivate students to discover new applications of knowledge and creation of knowledge. Students are encouraged to question the information they are exposed to at any time; therefore students are not limited to the personal views, knowledge and experience of an individual lecturer.

Guest lectures expose students to distinguished persons from the industry to give the students a broad exposure in specialised topic areas, the practical application perspective and inspiration. Site visits take students learning to an application context. Students are continuously encouraged to explore and seek alternate sources. Also effective communication is maintained with students through online (Blackboard) and other ICT tools. By giving constructive formative feedback, they are given an indication of their progress on their knowledge and skill development.

The online Asynchronous Discussion, in form of online tutorial tasks, provides a good base for exploring formative assessments encourage a learning community that promotes self-regulated meaningful learning approach and instil lifelong learning capabilities (Vonderwell, et al 2007). Formative assessment is specifically intended to generate feedback on student performance to improve and accelerate learning and it is believed that it empowers students as self-regulated learners, which is the central gist of PBL philosophy (Nicol & Macfarlane-Dick p 109). Moreover, the '[o]nline discussion (as tutorial problem solving or general discussion) provides the ability to learners to respond to question and support "co-construction of knowledge through meaningful discourse' (Vonderwell et al 2007, p311). Asynchronous problem solving tutorial discussions, which are designed to be analogous to summative assessment tasks, close the feedback loop, by students using the feedback gathered in tutorials to improve the quality of summative assessment tasks. Asynchronous discussion forum is a very appropriate method to facilitate distance learning and mixed mode tutorials/formative feedback delivery. This approach allows me to be a facilitator, a mentor for life long learning and a formative feedback provider.

3.4 Stage 3- Assessor Learning Outcomes

Role of the assessor is two fold - (i) assessing the students' learning against the set targets (or rubric) and (ii) assessing the effectiveness of the course design. The first key role of the assessor is partly embedded in the facilitation process - where formative form of assessment tasks provide feedback to guide student learning and use marking rubrics provide summative assessment for specific assessment tasks to indicate the level of learning student has demonstrated. Incremental marks scale, as a regulative strategy, can reward students starting with basic learning to higher order learning and finally reflective skills (Biggs, 2003). Despite the educational merits of group work (Collis & Moonen, 2001) assessing group work, especially the group work process is challenging. Assessors need to ensure that the mechanisms to deal with freeriding are enforced in the assessment (Gajendran et al., 2003) to deal with non-engaging students.

Academic Integrity (AI) (e.g. plagiarism, falsification of data etc.) issues have a bearing on assessment tasks that are not set in an invigilated exam situation. Leask (2006) indicates that 'plagiarism is a complex, culturally loaded concept which causes much anxiety for both academics and students. Exactly what constitutes plagiarism is depended on the number of contextual factors' (p183). The universities have developed robust of policies and educational resources to training students on this issue (Gajendran et al (b), 2011). Any assessment regime should mitigate the risk of students plagiarising. All opportunities should be given to students to detect unintentional plagiarism. Students are given the opportunity pass their work through Turnitin software to unlimited time before the final submission.

The second role of the assessor is becoming very important from an institutional perspective due to the reported challenges faced in the "design of assessment tasks, namely: misalignment with the stated curricular goals; misalignment with the teaching that has been provided; lack of clarity about expectations; unreasonably high or low expectations; and tasks that hold little significance for students' career or professional aspirations" (Gore et al., 2009, p5). Therefore, second role of assessor is focused on monitoring the effectiveness of the summative (as well as formative) assessment schemes (designed in Stage 1) in explicitly and clearly assessing the learning outcomes set by the course objectives. Based on the feedback the design of the course needs to be constantly revisited (Stage 1).

4. Concluding remarks

This paper proposes a pedagogical framework for designing a learning environment for CM education through CA; merging 'constructivist learning' theory and 'instructional design' approach. It argues that the Construction Management (CM) with loose and fussy boundaries operating in a socially constructed project-based environment is dominated by complexity, uncertainty and is best educated through 'constructivist' educational philosophy. Constructivist approach enables to construct and reconstruct knowledge and social retaliates based on situational aspects, and provides a pedagogical position that aims to create a meaning associated learning environment to foster deep learning. CA, proposed by Biggs, represents a merger of constructivism and instructional design, which employs, constructivism as a framework to drive all stages of instructional design emphasises on the alignment between the 'course objectives' and 'assessment practice'. The CA is also about strategising and directing selected student-learning behaviours e.g. meaning directed (deep learning), reproduction directed (surface learning) etc. The outcomes of this paper, in the form of a conceptual framework proposes four positions, namely Meaning directed (Deep learning), Application directed, (Strategic learning), Reproduction Directed (Surface learning) and Undirected to characterises the possible learning behaviours of students. Characteristics of learning behaviours are more clearly articulated through appropriate positioning of the Cognitive, Affective and Regulative, reflecting the different mental models and learning orientations. The paper explains how the conceptual pedagogical design can be operationalised through roles of an educator (namely Director, Facilitator, Assessor) and strategies associate to the roles (design, delivery, assessment strategy).

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Old-Technology Twist To Sustainability Innovation In The Construction Industry: Case-Study of an NGO's Low-Tech Alternative for Energy Efficient Housing in Finland

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Abstract

The built environment accounts for approximately 40 % of total energy use and anthropogenic greenhouse gas emissions in many developed countries. Increasing the energy efficiency of buildings and decreasing construction phase emissions are central to mitigating climate change. Sustainability innovations are seen as an integral part of the solution. The purpose of this paper is to explore how sustainability innovations may actually come about in the construction industry. This paper presents the results of a longitudinal case study of an unlikely innovator in the construction industry, the Finnish Cultural Foundation, and its K3 houses initiative. The three K's stand for the Finnish words for beautiful, sustainable, and affordable. In practice the initiative has resulted in five complete designs for industrially manufactured detached houses that are free for private and commercial use. By proving the economic and technical feasibility of a vapour-barrierless timber-frame structure and natural ventilation in meeting the strict energy efficiency requirements of the Finnish building code, the Foundation attempts to point out an alternative path to increasing technology-dependence in low-energy building. The data consists of interviews and archival material. The data is analysed using a visual mapping strategy and the case description is analysed using a model of the structural context of the management of innovation in the construction industry. The results reveal numerous challenges regarding inter-organizational interactions, some of which are context-dependant and others with generalizable implications. Especially the interplay between vision pull and regulatory push mechanisms as drivers of innovation is of interest to both academics as well as practitioners. The contribution of the study is twofold. First, the case serves as a revelatory example of a low-technology solution to increasing energy efficiency of housing. The plans are highly innovative, but do not rely on high-technology. Second, it offers a detailed account of the complex nature of innovation processes in the construction industry. Of special interest is how an NGO as an outsider to the sector manages innovation in the construction industry.

Keywords: Innovation, Detached housing, Regulation, Ecological modernization theory, Low-technology

1. Introduction

The built environment accounts for approximately 40 % of total energy use and anthropogenic greenhouse gas emissions in many developed countries (UNEP, 2007). Increasing the energy efficiency of buildings and decreasing construction phase emissions are central to mitigating climate change. Given that the buildings sector has been estimated to have the largest climate change mitigation potential in the upcoming decades (IPCC, 2007), and that the main GHG abatement measures in the sector have been estimated to have negative cost (McKinsey, 2010), it comes as no surprise that the subject has received much attention from practitioners, regulators, and academics alike.

To realize the sector's climate change mitigation potential, sustainability-oriented innovations are called for. Hansen et al. (2009) discuss two mechanisms that drive sustainability innovation: regulatory push and vision pull. New laws and regulations increase pressure for innovativeness, but at the same time sustainability presents a new source of ideas and visions that lead to business opportunities. It is common to associate sustainability innovations with new technologies (*e.g.* Huber, 2004). Such a view is typical to so called ecological modernization (EM) theories, which have gained prominence among policy makers (Mol and Sonnenfeld, 2000). EM theories have, however, been criticized for having too much faith in technological development and for ignoring societal issues in seeking solutions to environmental problems (Bailey et al., 2011). Nevertheless it seems that technological innovations dominate the subject matter in sustainability innovation literature. Therefore this paper knowingly adheres to the Schumpeterian view that innovations are new combinations – of which new technologies can but do not need to be a part of (Schumpeter, 1961). As the title of the paper suggests, old technologies may well present innovative opportunities when considered as potential building blocks for such combinations.

The purpose of this paper is to explore how sustainability innovations actually come about in the construction industry. The paper presents the results of a longitudinal case study of an unlikely innovator in the construction industry, the Finnish Cultural Foundation, and its K3 houses initiative. The three K's stand for the Finnish words for beautiful, sustainable, and affordable. What began as an attempt to bring architects and the housing industry closer together to create beautiful yet affordable detached houses, transformed into a quest to preserve natural ventilation and other traditional building principles in order to point out an alternative, low-technology path to increasing technology-dependence in energy efficient houses. In practice the initiative has resulted in five complete designs for industrially manufactured detached houses that are free for private and commercial use. Despite demand and the high expectations of the Foundation and their company partner Fiskars Corporation no K3 houses have been built by the end of 2013. This paper examines in detail inter-organizational interactions in the project. The perspective is on the numerous challenges with a special focus on regulation.

2. Research design

This paper reports the findings of a longitudinal single case study. The case study approach is argued to be appropriate since the focus is on a contemporary phenomenon within its real-life context, and the boundaries between the phenomenon and the context are unclear (Yin, 1994). The case was selected on the grounds that it is an extreme exemplar (Eisenhardt and Graebner, 2007). The Finnish Cultural Foundation is an atypical innovator, and it is an outsider to the construction industry. As for its K3 houses initiative, it is an ambitious attempt at sustainability innovation that has targets concerning the ecological, social and economic dimensions.

The empirical data consists of interviews and archival data. Five interviews in total have been conducted. The interviewees include the Secretary General of the Foundation, both project coordinators, and two members of the steering group. The interviews were conducted in late 2013 with the exception of one interview that was conducted in 2012. They vary from 25 to 110 minutes in duration. The archival data is extensive. It consists of both publicly available as well as confidential documents. The background material that is available online includes for example technical reports, design guidelines for architects, and an assessment report on the house designs. In addition a preliminary report from 2008 on the relevance, execution and challenges of the project, and an internal report of the Foundation from 2013 were made available by two separate interviewees.

The presentation of the case is straightforward. First, a visual mapping strategy (Langley, 1999) is used to produce a timeline with the main events of the project. Second, the events are discussed in more detail using a model of innovation management in the construction industry developed by Winch (1998) to structure the narrative. The model stems from literature on innovation in complex systems industries, which highlights the interconnected and emergent nature of innovation in certain industries (Miller *et al*., 1995). Lastly, the main elements of the case are discussed in relation to literature on innovation in the construction industry.

3. K3 houses initiative

The idea for the initiative originates from discussions between a consultant living in the Billnäs area, the real estate manager of the Fiskars Corporation, and the Secretary General of the Finnish Cultural Foundation in 2007. Eight complete designs for industrially manufactured sustainable detached houses were ready by the end of 2009, five of which were selected for further development after a thorough assessment. In 2010 natural ventilation and vapour barrierless structure were added to the design requirements. The second-round designs were completed in 2011, and shortly after that the initiative was publicly announced. The main events of the project are visualized in Figure 1. The timeline shows the order and approximate timing of events, but not their running time. Solid arrows indicate causal links between events. Dashed arrows indicate an indirect link between events. The events are categorized in rows representing the background of the main actor.

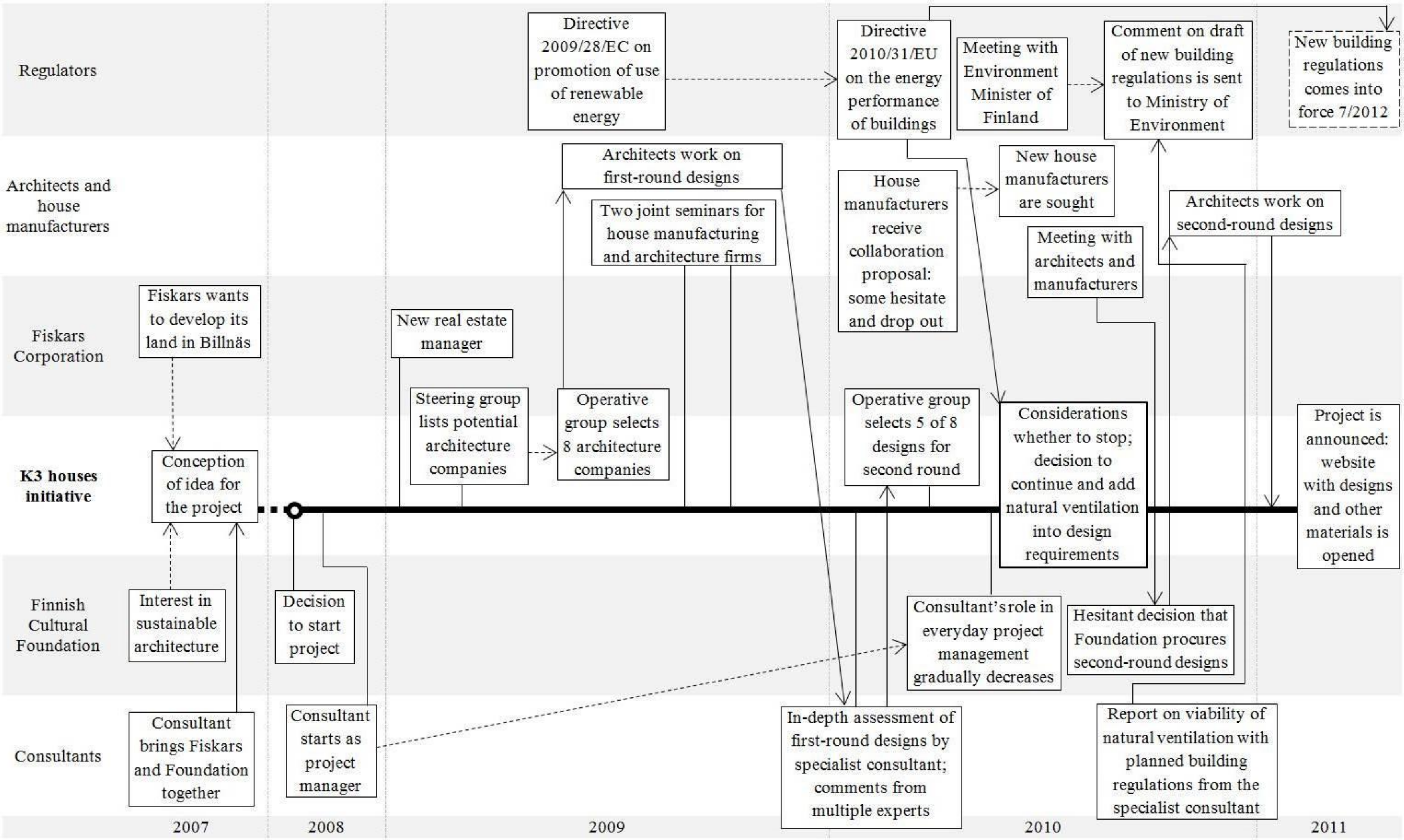

Figure 1: Timeline of the K3 houses initiative

The timeline ends in the public announcement of the initiative. The original objectives of the Finnish Cultural Foundation for the project were twofold. To make the house designs available for private and commercial use and to find house manufacturers willing to build the first K3 houses. Both objectives have been met, and the initiative has been praised by a multitude of experts, but due to various reasons by the end of 2013 not a single industrially manufactured K3 house has been built. The project is still ongoing in the Foundation, and new means to get the first houses erected are still sought. The focus of this paper, however, is mainly on the events prior to the announcement of the initiative. The model in Figure 2 is adapted from Winch (1998). It is used to structure the examination into the actions of the Foundation and various stakeholders during the project, and into possible reasons why the project is yet to be the success the Foundation had originally envisioned.

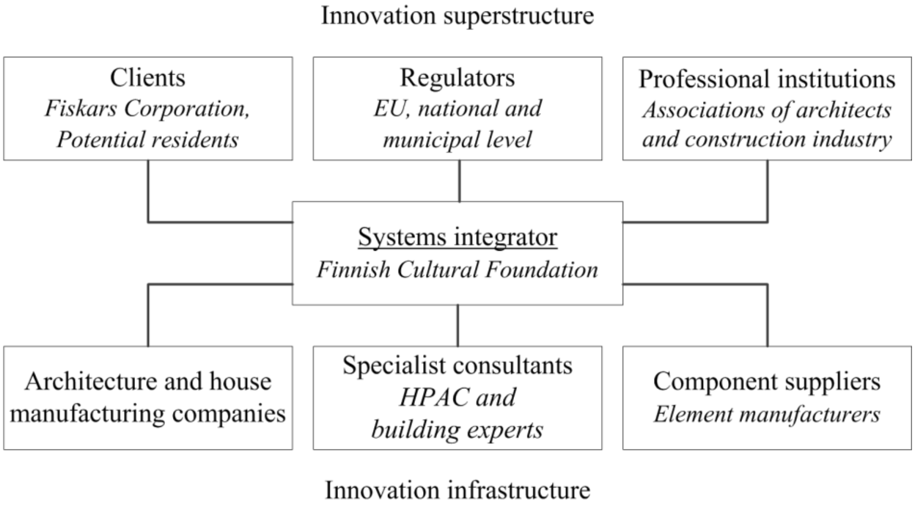

Figure 2: Structural context of the management of the K3 initiative

3.1 Systems integrator

As its name implies, the Finnish Cultural Foundation is an atypical innovator in the construction industry. It is a non-governmental organization whose main task is to award grants, but the Foundation also funds and organizes initiatives of varying scope to support its aim of promoting cultural and economic life in Finland. It has provided approximately 400 000 € for the K3 houses initiative, nearly three thirds of which for the design work of the architects. Although the Foundation’s assets stand around 1000 million euros, the project is considered a notable investment by the interviewees from the Foundation as well the other interviewees, perhaps because it is so far from its regular day-to-day activities.

The K3 initiative got its name only shortly before its public announcement. Before that it was discussed under various titles. For example in the preliminary report the initiative was called “Finnish Cultural Foundation’s and Fiskars Corporation’s single-family home initiative”. Also in many other written documents it is described as a joint effort between the Foundation and Fiskars. Nevertheless, from an innovation project perspective the Finnish Cultural Foundation is the sole systems integrator. The real estate manager of Fiskars had a crucial role in the conception of the idea and without it the initiative would have probably never begun. However, after the initiative was organized as a project it seems that the decision-making power has concentrated in the hands of the Foundation.

A steering group was appointed at the beginning of the project. Its exact composition has varied slightly, but only two of its nine members can be considered otherwise external to the project participants: an architect, and the former communications manager of a construction industry association. Other members include employees and board members of the Foundation, the real estate manager of Fiskars, and the project manager consultant. The steering group was quite active in the beginning, but it was gradually replaced by a smaller operative group mainly from the Foundation. On the individual level, the Secretary General of the Foundation has been very influential in the project, perhaps even more so towards its latter stages. In addition the project management duties were taken over by an employee of the Foundation in 2010, further contributing to the concentration of decision-making power. All in all it can be said that the position of the systems integrator in Figure 2 as the central node of a network illustrates quite accurately the role of the Foundation in the project as portrayed in the data.

3.2 Innovation superstructure

Clients. The project has two clients. The primary client is a subsidiary real estate company of the Fiskars Corporation. Fiskars is a large landowner in Billnäs, a district of the municipality of Raasepori near the historic birthplace of the corporation. Fiskars has been founded in 1649, making it the oldest company in Finland, and its history and that of the surrounding areas have always been intertwined. Therefore the interests of Fiskars in developing its land are said to go beyond economic value. The company has reserved 13 lots specifically for building sustainable houses that are designed in the project. Fiskars has been involved in the project from the offset. The secondary clients are the potential residents, the people who would buy the lot from Fiskars and a house from one of the house manufacturing companies. Attempts to identify potential residents and to include them in the design process were made at various points of the project.

The level of activity of Fiskars has varied during the project. The real estate manager of the Corporation was a central figure in the initial negotiations with the Finnish Cultural Foundation. He also occupied a position in the steering group. Later, as he retired, the position was passed to his successor in Fiskars. When the steering group ceased to meet actively the real estate manager of Fiskars continued as the only non-Foundation member of the smaller operative group. However, two issues seem to have decreased the level of involvement of Fiskars in the project. First, the personnel change in Fiskars coincided with the global financial crisis. The new real estate manager has not been as influential in Fiskars as his predecessor, and the crisis lessened the corporation’s immediate interest towards the Billnäs area. According to the interviewees these things together have decreased the enthusiasm of Fiskars towards the project. Second and perhaps related to the first issue, during the project Fiskars withdrew from its planned role as developer. As more attention was directed towards the possible risks with building new-to-the-world house types, Fiskars realized it does not want to carry the attached risks as developer.

Whereas Fiskars has been tightly involved in the project, the secondary clients have been more difficult to take into consideration. Understandably the possibility of potential home buyers to influence the house designs has been limited. The project was announced publicly only after the second-round designs had been finished. Still the Foundation wanted to hear the opinion of non-professionals. To do this, the employees of the Foundation and Fiskars were asked to comment on the first-round designs. Still it was a fear of the Foundation that there would be no demand for the houses. It was thought that Finnish home buyers are too used to house manufacturers catering to their very specific preferences, and that the K3 houses are too inflexible for their individualistic taste. In addition some of the first-round designs had elements which were thought to be contrary to the expectations of the buyers. For example one design has a roof with no eaves. An interviewee from the Foundation describes in an anecdote how the design caused a lot of headshaking among the assessment panel because although shown to work technically it is so blatantly against what home buyers had been taught in the last years about demanding large enough eaves.

In the end the fear of no demand was in vain as tens of people showed interest for the houses in Billnäs. There have also been calls from people who would have liked to build the houses in other parts of Finland, but the house manufacturers and the Foundation have wanted to start in Billnäs. Despite the demand the lots in Billnäs are still empty. One reason is the distribution of risk. Fiskars withdrew from its planned role as the developer, the Foundation shunned the idea of carrying more risk, and neither an outside party nor the house manufacturers wanted to step in. As an unintentional result the deal for the potential residents is rather forbidding. In order to buy the lot from Fiskars, the buyer agrees to purchase one of the K3 houses from the house manufacturers, but is held responsible for possible alteration work in the future if the house does not function properly. In the words of the project coordinator from the Foundation: “Out of all possible bearers of responsibility, the one who has the least capability is held liable”.

Regulators. The Finnish government’s plan to renew national standards for energy efficiency of new construction had a tremendous impact on the project. As the Finnish Cultural Foundation realized that all new construction in Finland is obliged to be energy efficient after the regulation comes into force, it felt forced to rethink its objectives. The foundation perceived no more need for it to promote low-energy solutions to detached housing, since the same problem would soon be addressed by market-based actors. At this point there was serious consideration whether the plug should be pulled on the project, but instead it was decided to refocus it. A new direction was found in natural ventilation and minimizing electric appliances, or what some interviewees call organic houses.

It was stated in the draft version of the new Finnish building regulations explicitly, that despite the increasing energy efficiency demands natural ventilation will remain an option for new construction. However, many of the experts interviewed by the Finnish Cultural Foundation saw the combination as very challenging – if not impossible – to realize at least for the do-it-yourself home builder. Some of the heard experts criticized the planned regulations for this. Thus the Finnish Cultural Foundation decided to seize on dimensions of ecological and social sustainability other than low energy consumption, *e.g.* resiliency of the building, local building materials, and indoor environmental quality. In short, whereas the original idea of the project was perceived to fall flat due to the new regulations forcing all new construction to be energy efficient, the same regulations also acted as the main driver for the project's reorientation.

The significance of this turn is underlined by all interviewees, and it is evident also in the archival material. It is talked about in two ways: as a shift in or an expansion of the objectives. Perhaps more critical voices see it as a shift, as a disengagement from the original goal of producing aesthetically pleasing low-energy detached houses. This view dominates among the interviewees from outside the Finnish Cultural Foundation. Those more favourable to the turn see the added design requirements of vapour-barrierless structure and natural ventilation as an expansion of the existing sustainability dimension of the project. This seems to be the view of the interviewees from the Foundation. Regardless, the impact of this reaction to the proposed new legislation was pervasive. Not only did it affect the commitment of for example the house manufacturers, but it led the Foundation to define for the first time what it specifically means by sustainability in detached housing.

In practice the decision regarding the goals was first made by the operative group of the project and later approved by the board of trustees of the Finnish Cultural Foundation. Before making the decision the Foundation's Secretary General and Fiskars' real estate manager arranged a meeting with the Environment Minister of Finland about the regulations and the project. And, soon after, a report on the suitability of natural ventilation with the new building regulations was procured from a specialist consultant. Encouraged by the meeting and based on the report, an official comment on the draft of the regulations was composed and sent to the Ministry. As the renewal of the building regulations was tied to the national implementation of the European Union directive on the energy performance of buildings, it was acknowledged that the project's ability to influence the content of the regulations is limited. Nevertheless, both interviewees from the Foundation and one from the steering group voice their disappointment over the status of natural ventilation in the final building regulations. This issue also extends the influence of regulators from the national to the municipal level.

Although the statement that natural ventilation will remain an option in the future was left in the final building regulations, it was not clarified how its viability should be demonstrated in practice. Instructions were not included in the regulations even though they were specifically asked for in the Foundation's comment on the draft. Why this is so was only speculated. A recurring conjecture was the perceived hegemony of the dominant design, mechanical ventilation, within the Ministry of the Environment. One of the interviewees encapsulates this viewpoint nicely: "That we don't know yet, whether [the Ministry's trust in mechanical ventilation] is too great, but big it is – nearly absolute trust". That the instructions did not make into the regulations is seen by some of the interviewees as harmful to the goals of the project. This problem was brought to the Foundation's attention by one of the house manufacturers.

Because it is easier to prove the viability of mechanical ventilation than natural ventilation in an energy efficient house on paper, the regulations are seen to favour mechanical ventilation. Moreover, in Finland municipal building officials are quite independent and able to exercise much authority. Therefore the decision over the viability of natural ventilation is left to the interpretation of the building official on a case-to-case basis. And because officials are responsible for the legality of their actions, some of the interviewees fear that the officials may discriminate against risky technologies – in this case natural ventilation in an energy efficient house. It must be made clear that there is no evidence that the officials would not approve the organic houses. On the contrary, the municipal building officials in Raasepori have already green-lighted the building of the houses in Billnäs. However, the interviewees from the Foundation repeat the concerns of the house manufacturers, who perceive it as a threat that officials in other municipalities are not as approving. This is said to affect some house manufacturing companies' willingness to invest in the project.

Professional institutions. Unlike clients and regulators, professional institutions have played only a minor indirect role in the project. One member of the steering group is a former communications manager of the Confederation of Finnish Construction Industries, who is seen by other interviewed steering group members to represent the industry's viewpoint. But the Confederation itself has had no part in the project. The Finnish Association of Architects (SAFA) was also mentioned in the interviews. The role of SAFA even led to a small dispute in the steering group. The architect member of the group would have wanted to organize an architectural competition for the first-round house designs, but the Finnish Cultural Foundation did not support this view. The ideal of the project in the beginning was the veteran house, a wooden type house built in large quantities in Finland in the 1940s and 1950s. The fear of the Foundation was that if an architectural competition would have been organized according to the rules of SAFA, it might have lost control over the outcome. Because the Foundation wanted the end result to appeal to masses, like the veteran house, it did not want the architecture profession alone to declare what is good for this purpose. Instead they asked the opinion of a variety of stakeholders from architects and building experts to potential home buyers. Although professional institutions have not been directly involved in the project, understanding the relations between the architecture profession and house manufacturing industry in general is central to understanding what has happened in the project.

3.3 Innovation infrastructure

Architecture and house manufacturing companies. This is the only actor category which needed to be labelled differently from Winch (1998), who used the label trade contractors. The label was changed because trade contractors – specialized subcontractors – have not been actively involved in the project and the participating architecture and house manufacturing companies do not really fit any other actor category. Potential architects were first listed by the steering group, but the final selection was done by the operative group led by the Foundation. Designs were procured from eight Nordic architecture companies. House manufacturers were invited to join the project after the architects had started working. After a thorough internal and external assessment five of the eight designs were selected for further development, three from Finland and two from Sweden.

The first round designs proved to be a disappointment for the Foundation especially regarding ecological sustainability. Many architects seemed to have a limited understanding on the subject, although Swedish architects fared much better than their Finnish counterparts. The decision to add natural ventilation in the design requirements was made at about the same time. At this point the house manufacturers were hesitant to continue and dropped out. As new house manufacturing companies were sought, the Foundation wanted to ensure that every house design would have a committed manufacturing company. Therefore the Foundation actively paired off architects and house manufacturers. It also included a clause to the agreements with the architects that they should work closely together with their house manufacturer partner during the design phase in order to ensure that the designs are easy to transfer to production. This did not work out as the Foundation had hoped. Nevertheless all five designs were completed more or less on schedule and according to the new design requirements.

There are two major issues regarding the architecture firms and house manufacturers to consider: 1) mistrust between architects and house manufacturers, and 2) perceived inability or unwillingness of house manufacturers to invest in development activities. The interviewees from the Foundation repeatedly brought up difficulties with the cooperation between architects and house manufacturers – or more accurately the lack of cooperation. As a worst case example the project manager told how an architect handed in the finished designs as agreed, but two weeks later the partner house manufacturer called to ask whether the project manager had heard from the architect because they would like to start with the process; “Not to even speak of designing together, the architect didn’t even bother to tell the house manufacturer that the designs are in fact finished”. Of course some company pairs did better, although none of them met the high expectations of the Foundation. The second point is one that is used by the interviewees to partially explain why no houses have been built. The house manufacturers were perceived to have much difficulty in incorporating the designs into their production processes. This in turn was seen to cause difficulties in estimating the building costs and in offering the houses for a fixed price. According to the Foundation this led to a situation in which the houses that were made available to potential residents by house manufacturers were too expensive to qualify as affordable.

Specialist consultants. The use of consultants and experts during the project has been extensive. In two phases it has even been crucial for the advancement of project. In fact, it was a consultant living near Billnäs who introduced the land development plans of Fiskars to the Finnish Cultural Foundation, and who arranged the first meeting between the two parties. At the very beginning of the project, shortly after the funding decision by the Foundation, the same consultant prepared a report on the different possibilities regarding the execution of the project. He also acted as the coordinator of the project until late 2010. It is impossible to say whether the project would have started without the consultant, but in retrospect it is clear that his role has been very influential.

The second time consultants played a crucial role in the project was around the decision to add natural ventilation into the design requirements of the houses. As the Finnish Cultural Foundation has practically no expertise in building, it had to rely on external expertise during this phase. Especially one specialist consultant was central. The in-depth assessment of the eight first round designs was procured from a Finnish architect-consultant specializing in sustainable design. The same specialist consultant was also asked to provide design guidelines for a passive house and later for an organic house. Together with two HPAC experts he also wrote a report on the viability of natural ventilation with the planned building regulations for the Foundation. This report proved to be important for the project, as it was used as basis for the comment on the draft legislation to the Ministry of Environment.

The above-mentioned consultants were highly influential in the beginning and around the organic-house-turn, but other experts were also heard during the project. In general the use of external knowledge resources in the project has been entirely up to the Finnish Cultural Foundation. It has procured statements and reports from the experts it has chosen. When the architects started working on second-round designs it was the Foundation who assigned them a technical expert to help with the ventilation calculations. This way of keeping control while relying on external resources was put into words by one of the interviewees from the Foundation: “That we wanted to keep the strings in our own hands doesn’t mean that we wouldn’t hear experts”.

Component suppliers. The Foundation has not been directly involved with the component suppliers; rather it seems that it has assumed the house manufacturers to collaborate with them as needed. This has not always been the case, which is has led to surprises in the building cost estimates. For example one of the house designs contains a large prefabricated concrete element as a heart, around which the rest of the house can be built in various ways. Although the approach was applauded for innovativeness in the initial assessment of the house design, the element turned out to be so heavy that it would require very expensive foundation work. Another house design has two chimney flues. It too suffers from costliness; suitable prefabricated elements could not be found, and building two masonry chimneys on-site would increase costs to beyond the reach of typical home buyer. It is an interesting question how much the building cost of the houses could have been reduced if the collaboration between architects, house manufacturers, and component suppliers had been tighter, and whether the Finnish Cultural Foundation as the systems integrator could have helped it.

4. Discussion

This paper set out to examine how sustainability innovations actually come about in the construction industry using the K3 houses initiative as a revelatory example. The focus is on challenges encountered in the project with a special focus on regulation. From the examination of the case at least six potential reasons for why no K3 houses have been built yet can be drawn:

1) As an unintended consequence of agreements between Fiskars and the Foundation, the risk of financing possible alteration work if the house does not work properly falls on the home buyer, the one least capable of carrying it
2) Lack of support from the regulators for natural ventilation as an option for energy efficient detached houses increased the hesitancy of the house manufacturers
3) In most cases architects did not include house manufacturers in the design process, although it was explicitly agreed upon
4) Most house manufacturers were not willing or capable of investing in development activities that are required to get the designs from paper into the production process
5) Due to various uncertainties the majority of house manufacturers were unable to offer a fixed price for their houses, which is contrary to the expectations of consumers
6) Two house manufacturers did offer their houses for a fixed price, but the houses are too expensive to qualify as affordable, possibly due to the risks and price of untested technical solutions

The first reason is one that could have perhaps been easily avoided. An interviewee from the foundation admits that when the extensive risk sharing agreement was made with Fiskars, its effect on the residents was not considered well enough. In retrospect the agreement was too good, and could have been more favourable to the home buyer. In addition, in the model by Winch (1998) there are two systems integrators, a principal architect and a principal contractor. The former is said to be in charge for the planning phase and the latter for the execution. It seems the Foundation has immersed itself in the first role, and avoided the second. Especially since Fiskars withdrew from the role of developer, an outside principal contractor could have worked out. According to the interviewees such a systems integrator was sought but not found in the latter stages of the project. None of the house manufacturers wanted the role.

Reason 2 is highly interesting. The national implementation of the EU directive on the energy performance of buildings threatened to pull the rug under the Foundation's feet as all new houses built after July 2012 are obliged to be energy efficient. Therefore the Foundation decided to change course and add natural ventilation and vapour barrierless structure into the design requirements. Two non-Foundation interviewees think that the houses would have been built already if it were not for this turn. Without it, however, the K3 initiative would lack its most unique and externally applauded features. Had the systems integrator been a commercial organization, it is likely that the regulatory changes would have supported rather than undermined the project, because of the alignment of the original goals with the new regulations. But since the Foundation has no commercial interest of its own, it was more important for it to promote something that it values and that would otherwise be neglected – even if it is against the general direction of regulatory development. Hansen et al. (2009) discuss two mechanisms that drive sustainability innovation: regulatory push and vision pull. The latter seems to explain the Foundation's actions better. On the other hand, considering the difficulties encountered by the Foundation, it seems that regulatory push is a much stronger force affecting the general direction of development of energy efficient detached houses in the future.

Reasons 3 and 4 are what the Foundation term "structural problems" in the internal report. The perceived grudge between architects and house manufacturers leads to separateness of design and construction, which in turn is detrimental for innovation because the feasibility of the designs is assessed only after they are ready (Tatum, 1989). And low expenditure on R&D is not an issue only with the house manufacturers but the whole construction industry (Miozzo and Dewick, 2004). In that sense reason 4 is in line with the observation that innovation is rarely integral to the organization culture of construction companies (Hartmann, 2006). But although the so called structural problems are significant, the interviewees state there were exceptions among architects and house manufacturers. Some of them would actually collaborate and be willing to invest in the needed development. Reasons 5 and 6 on the other hand seem have to do with the difficulty of estimating risks and costs of previously untested technologies. This kind of uncertainty has been said to hinder the adoption of innovations in organizations (Frambach, 1993). Although natural ventilation *per se* is anything but new, its viability together with other components of the energy efficient house designs is untested. This uncertainty and the related cost and price issues are important, but cannot be speculated further with the available data. Interviews with house manufacturers are the next step in the research.

Finally, what can be said about the applicability of the findings more broadly? That one cannot generalize on the basis of a single case is a popular misconception (Flyvbjerg, 2006). Although some of the issues such as the mistrust between architects and house manufacturers are context dependent, others have generalizable implications. On the practical side the case supports the contention that a supposedly technology-neutral policy can actually favour a specific technological trajectory (Azar and Sandén, 2011). The EU directive on the energy performance of buildings requires that "Member States shall ensure that by 31 December 2020 all new buildings are nearly zero-energy buildings" (Directive 2010/31/EU, Article 9), likely leading to demands for greater airtightness and increased insulation of buildings in all EU countries regardless of climate. Therefore, if there is will to retain natural ventilation as an option for detached houses in the future, regulators on the national level must resolve how its feasibility should be demonstrated to regional building officials in practice.

The main theoretical implications of the paper have to do with Winch's (1998) model. The data supports the model especially regarding the central role of the systems integrator. With only a light modification the model contains all relevant actors, making it very useful in structuring the case description. However, it seems to be overtly simplified regarding clients, and it does not pay attention to the relationships between different actors. Demanding and experienced clients have been said to be central to innovation in the construction industry (Blayse and Manley, 2004). But there is typically more than one client with differing needs and preferences, for example in this case Fiskars but also the potential residents. Considering that great emphasis is put on the role of the user in general innovation research (e.g. von Hippel, 2005), it is odd that users are not more explicitly present in innovation models of the construction industry. Thus users perhaps deserve to be more visible in the model. Secondly, the model does not take into account the mutual dynamics or hierarchy of the actors, although they may shape the context of the management of innovation in the construction industry significantly.

5. Conclusions

This paper set out to examine how sustainability innovations actually come about in the construction industry using the K3 houses initiative of the Finnish Cultural Foundation as a revelatory example. The initiative started out on a rather technology-oriented path driven by regulatory push. Mainly due to regulatory changes the project took a new direction in an attempt to point out an alternative path to increasing technology-dependence in low-energy building. The main finding is that the role of the systems integrator as the champion of the project is crucial. However, in cases where the innovation is driven by vision pull but is partially conflicting with the dominant technological trajectory fostered by regulation, it seems to be highly difficult to get the members of the project consortium to commit to the vision. This was evident in the K3 houses case. Despite demand and broad expert support for the initiative, the lack of commitment has led to numerous challenges that has delayed or even prevented the construction of the houses. Diverting from the dominant technological trajectory is seen as highly risky. In networked sustainability innovation projects that are driven more by visionary will than regulatory necessity, efforts to rally the project participants behind the vision seem to be even more important than justifying the project's cause to outsiders.

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Analysing Governance Categories Used On Project Alliances in The Construction Industry

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Abstract

In Australia, collaborative contracts, and in particular, project alliances, have been increasingly used to govern infrastructure projects. These contracts use formal and informal governance mechanisms to manage the delivery of infrastructure projects. Formal mechanisms such as financial risk sharing are specified in the contract, while informal mechanisms such as integrated teams are not. Given that the literature contains a multiplicity of often untestable definitions, this paper reports on a review of the literature to operationalize the concepts of formal and informal governance. This work is the first phase of a study that will examine the optimal balance of formal and informal governance structures.

Desk-top review of leading journals in the areas of construction management and business management, as well as recent government documents and industry guidelines, was undertaken to to conceptualise and operationalize formal and informal governance mechanisms. The study primarily draws on transaction-cost economics (e.g. Williamson 1979; Williamson 1991), relational contract theory (Feinman 2000; Macneil 2000) and social psychology theory (e.g. Gulati 1995). Content analysis of the literature was undertaken to identify key governance mechanisms. Content analysis is a commonly used methodology in the social sciences area. It provides rich data through the systematic and objective review of literature (Krippendorff 2004). NVivo 9, a qualitative data analysis software package, was used to assist in this process.

A previous study by the authors identified that formal governance mechanisms can be classified into seven measurable categories: (1) negotiated cost, (2) competitive cost, (3) commercial framework, (4) risk and reward sharing, (5) qualitative performance, (6) collaborative multi-party agreement, and (7) early contractor involvement. Similarly, informal governance mechanisms can be classified into four measureable categories: (1) leadership structure, (2) integrated team, (3) team workshops, and (4) joint management system.

This paper explores and further defines the key operational characteristics of each mechanism category, highlighting its impact on value for money in alliance project delivery. The paper's contribution is that it provides the basis for future research to compare the impact of a range of individual mechanisms within each category, as a means of improving the performance of construction projects.

Keywords: collaborative contracts, formal governance mechanisms, informal governance mechanisms, value for money, infrastructure projects, project alliances

1. Introduction

Recently published research undertaken by the authors (Chen, Manley et al. 2012) into the governance of collaborative construction projects identified categories of formal and informal governance mechanisms that are important to VfM. These categories arose from content analysis of relevant articles appearing in top journals in the construction management and general management fields. The categories were refined through triangulation and represent clearly defined and mutually exclusive groupings. This process resulted in identification of the categories shown in Table 1.

Table 1: Categories of formal and informal governance for collaborative contracts

Formal Governance Categories	Informal Categories
1. Negotiated cost	1. Leadership structure
2. Competitive cost	2. Integrated team
3. Commercial framework	3. Team workshops
4. Risk and reward sharing	4. Joint management system
5. Qualitative performance	
6. Collaborative multi-party agreement	
7. Early contractor involvement	

The categories shown in Table 1 facilitated the design of a rigorous questionnaire to uncover the optimal balance of such mechanisms in the Australian infrastructure context. Formal mechanisms are grouped according to seven categories, comprising negotiated cost, competitive cost, commercial framework, risk and reward sharing, qualitative performance, collaborative multi-party agreement and early contractor involvement (Australian Constructors Association 1999; Morwood, Scott et al. 2008; Rahman and Kumaraswamy 2008; Ross 2008; Lahdenperä 2009; Lahdenperä 2010; Love, Mistry et al. 2010; Department of Infrastructure and Transport 2011; Lahdenperä 2012). Informal mechanisms are grouped according to four categories: leadership structure, integrated team, team workshops and joint management system (Yeung, Chan et al. 2007; Rahman and Kumaraswamy 2008). The aim of the current paper is to describe the operation of each governance category and its potential impact on value-for-money from constrution projects.

The previous study by the authors indentified the key governance mechanisms outlined above and described their operation on two primary infrastructure delivery systems – project alliances and Early Contractor Involvement Contracts (Chen, Manley et al. 2012). A limitation of that paper was that it did not describe each mechanism in detail. The current paper remedies that shortcoming.

2. Research Methods

The research question driving the current study was ‘How do the different governance mechanisms on project alliances contribute to performance outcomes?’ As background to an empirical study of this question, the results presented here are based on a literature review that was undertaken to achieve two primary objectives. The first objective was to identify the essential features of both formal and informal mechanisms which have been applied on project alliances. Special attention was paid to the mechanisms which are associated with industry practices in Australia. The second objective was to seek evidence for the mechanisms’ influence on VfM. The findings of the literature review will be used to operationally define the mechanisms, and to propose hypotheses for further deductive investigation in the second phase of this study.

The approach used to review the literature was directed content analysis (Krippendorff 2004). This approach uses well established theories and findings of prior research to identify key concepts and variables as initial coding categories (Krippendorff 2004). Nvivo, a qualitative data analysis software, was used to support the systematic process of coding and identifying themes (Dyer and Singh 1998). The literature review involved three steps, as detailed below.

The first step of the review drew on transaction-cost economics theory (Williamson 1979; Williamson 1991), relational contract theory (Feinman 2000; Macneil 2000), social psychology theory (e.g. Gulati 1995) and strategic alliances literature (e.g. Gulati and Singh 1998; Krishnan and Martin 2006; Luo 2007; Hoetker and Mellewigt 2009) to provide an understanding of the nature and governance structures of collabrative contracts. These four areas were targeted because they emerged as the most promising given the topic. They were identified through a high-level content analysis sweep of a broad range of likely academic areas. The understandings they yielded subsequently led to the conceptualisation of ‘formal mechanisms’ and ‘informal mechanisms’. Coding categories and performance measures defined in the strategic alliancing literature (Gulati and Singh 1998; Ferguson, Paulin et al. 2005; Luo 2007; Hoetker and Mellewigt 2009) were used as a benchmark to help define the two types of governance arrangements of relevance in the collaborative contracting context.

The second step of the review focused on construction managment literature, to disaggregate the governance arrangements into more specific categories. The review targeted papers published between 2000 to 2012 by construction management journals reporting studies related to alliances, cooperative procurement, relational contract and partnering. Following the methods used by key published conceptual and literature review studies (e.g. Gupta, Smith et al. 2006; Yeung, Chan et al. 2007) the review canvassed papers published in *Journal of Construction Engineering and Management; Journal of Management in Engineering; Construction Management and Economics; Engineering, Construction and Architectural Management; International Journal of Project Management; and The Engineering Economist.* The review especially paid attention to the studies, both conceptual (e.g. Eriksson and Westerberg 2011; Lahdenperä 2012) and empirical (e.g. Rahman and Kumaraswamy 2008; Love, Mistry et al. 2010), about the essential factors that affect the success of collaborative procurement approaches. Some success factors such as trust, attitude, win-win philosophy, cooperative culture and open communication are latent cognitive elements which need to be activated by governance mechanisms (Lahdenperä 2012).

The third step of the review is yet to be undertaken. That will involve identifying individual mechanisms associated with each governance category that have the potential to influence VfM. In addition to the literature reviewed in steps one and two, this step will consider government publications (e.g. Department of Treasury and Finance 2006; Department of Treasury and Finance 2009; Department of Infrastructure and Transport 2011) and industry guidelines and reports (e.g. Australian Constructors Association 1999; Morwood, Scott et al. 2008) to identify fine-grained governance mechanisms that impact VfM in the Australia infrastructure industry.

The governance categories on which the current paper is based where identified by a coding process cross-referenced between three senior researchers, which continued until the number of new catgories found, and the new descriptions found, substantially diminished with further reading or cross referencing. The content analysis covered assessment of hundreds of relevant journal papers, books, government documents, and industry reports.

3. Analysing Governance Categories

This paper describes the operation of each governance category and its potential impact on value-for-money from constrution projects.

3.1 Formal Governance Mechanisms of Collaborative Contracts

The content analysis identified that formal governance mechanisms can be grouped according to the following seven categories: negotiated cost, competitive cost, commercial framework, risk and reward sharing regime, qualitative performance measurement, collaborative multi-party agreement and early contractor involvement (Australian Constructors Association 1999; Morwood, Scott et al. 2008; Rahman and Kumaraswamy 2008; Ross 2008; Lahdenperä 2009; Lahdenperä 2010; Love, Mistry et al. 2010; Department of Infrastructure and Transport 2011; Lahdenperä 2012). These categories represent depersonalised exchanges, sharing of financial risk and reward, and performance measurement, as well as the development and implementation of formal contracts (Ferguson, Paulin et al. 2005; Luo 2007; Hoetker and Mellewigt 2009). These seven categories are considered to be the essential pillars of formal governance that have the most potential to impact on VfM (Yeung, Chan et al. 2007; Morwood, Scott et al. 2008; Rahman and Kumaraswamy 2008; Chan, Chan et al. 2010; Lahdenperä 2010; Love, Mistry et al. 2010; Lahdenperä 2012). The key characteristics of each category are outlined below.

3.1.1 Negotiated cost

Negotiated costs are a feature of alliance projects. The contracting parties agree on a cost level prior to commencing construction (Lahdenperä 2010; Lahdenperä 2012). The project cost is collectively estimated by an integrated team formed by the client, designers, contractors and other service providers during the Target Cost Estimate (TCE) phase of an alliance (Morwood, Scott et al. 2008; Rahman and Kumaraswamy 2008; Lahdenperä 2009; Department of Infrastructure and Transport

2011). During the TCE process the parties come together to develop the scope of work, define the time schedule, and agree on cost-reimbursable principles, in particular, the project break-even point (Morwood, Scott et al. 2008; Lahdenperä 2009; Department of Infrastructure and Transport 2011). This approach encourages cooperative behaviours and motivates the parties to strive for efficiency (Love, Mistry et al. 2010), which in turn helps to achieve a successful alignment of the engineering, construction and management solutions to the client's VfM at a fair price (Department of Infrastructure and Transport 2011). As an output of the TCE, the TOC is developed to represent the expected cost of the project's scope at completion, including project specific costs and overheads, as well as service providers' profit margin and non-project related corporate overheads (Morwood, Scott et al. 2008; Department of Infrastructure and Transport 2011). The TOC is used as the benchmark to assess performance and to determine how risk and rewards are shared by the parties (Morwood, Scott et al. 2008; Lahdenperä 2010; Department of Infrastructure and Transport 2011). Therefore, TCE's are designed in conjunction with other essential formal mechanisms that aim to increase the certainty of successful project delivery and achieving the client's VfM (Morwood, Scott et al. 2008; Lahdenperä 2010; Department of Infrastructure and Transport 2011).

3.1.2 Competitive cost

Competitive project costs can be ensured under alliances with either single or multiple TOCs. Single and multiple TOC approaches, as well as various hybrids between these two approaches, can be employed to ensure competitive costs under collaborative contracts (Morwood, Scott et al. 2008; Department of Treasury and Finance 2009; Lahdenperä 2010; Love, Mistry et al. 2010). There has been an ongoing debate about the advantages and the disadvantages of the alternative approaches (Ross 2008; Lahdenperä 2009; Department of Infrastructure and Transport 2011).

In the single TOC approach, the client determines the TOC with only one preferred proponent team, which is selected primarily on the basis of experience, capability and attitude (Lahdenperä 2010). The primary advantage of this approach lies in its capacity to support the development of a trustful and cooperative relationship between the client and the proponent, which has a positive impact on the project (Ross 2008). Some argue that this approach lacks sufficient incentive to achieve cost-effective pricing that benefits the client (Department of Infrastructure and Transport 2011). This is despite the fact that transparent financials are employed to ensure competitive costs. Transparent financials enable the participants in a collaborative contract to understand the nature of fair cost and to reach an agreement on a risk and reward formula (Lahdenperä 2012). An open-book accounting approach, where the costs of one party are known to all other key parties, is adopted during the TCE, and third party financial auditing is involved to ensure the transparency and openness of the commercial arrangement (Hauck, Walker et al. 2004; Morwood, Scott et al. 2008; Lahdenperä 2012). This goes some way to ensuring competitive costs, while, for alliances, multiple TOC approaches go even further.

Under the governance of the multiple TOC mechanisms, at least two independent proponent teams are selected in the first instance based on their experience, capability and attitude, with limited or no regard for price (Love, Mistry et al. 2010). The client supports the proponent teams to develop their respective designs, execution strategies and associated TOCs, and selects the winning team with an emphasis on the price (Lahdenperä 2010; Department of Infrastructure and Transport 2011). It has been argued that the multiple/ dual TOC approach builds competitive tension between the proponent teams, hence has the advantages of overcoming misalignment during the TCE, enhancing innovation, and enabling proponents to differentiate their value proposition (Morwood, Scott et al. 2008; Department of Infrastructure and Transport 2011). This approach also provides flexibility in terms of choosing the level of competition between proponents on alliances: both full price competition (involving the development of a full TOC) and partial price competition (developing TOC elements) are used according to the project nature and circumstances (Department of Infrastructure and Transport 2011). In addition, some case study evidence also supports that the total cost to establish a TOC using a dual TOC approach was less (of the order of 2% of TOC) than when a single TOC was used (Department of Treasury and Finance 2009). However, given the similarities between the dual TOC approach and conventional price-based selection, this approach may compromise the closeness and intimacy which assure the development of a collaborative culture at the early stages (Ross 2008).

Given that between 60% and 70% of the project cost is typically procured in a market tested competitive environment, the potential savings by employing the multiple TOC approach can only be found in 30% to 40% of the project cost. Hence, these cost savings might not adequately offset the cost associated with the multiple TOC development process, if the process is only motivated by cost minimisation (Morwood, Scott et al. 2008). The literature confirms that the different TOC approaches are important mechanisms that enable competitive cooperation, whilst acknowledging that there is ambivalence amongst practitioners and theorists with regard to the merit of the different levels of price competition that may be employed on alliances (Ross 2008; Lahdenperä 2010; Love, Mistry et al. 2010; Department of Infrastructure and Transport 2011).

In non-alliancing environments, collaborative contracting in the form of conventional contracts with partnership agreements, or early contractor involvement contracts, has a stronger emphasis on cost. This may be good for one side of the VfM equation, but the arguments above indicate the potential for loss of value stemming from weaker relationships.

3.1.3 Commercial framework

The commercial framework of collaborative contracts is typically comprised of three components: direct costs and project specific overheads; fee for the service providers, including normal profit and non-project specific corporate overheads; and risk and reward amount, as determined by the gain-share and pain-share mechanisms, which measure the project performance against the TOC and non-cost related Key Result Areas (KRAs) (Morwood, Scott et al. 2008; Lahdenperä 2009; Department of Infrastructure and Transport 2011). The KRAs are measured through Key Performance Indicators (KPIs) (Evans & Peck 2010). Service providers are guaranteed the recovery of project specific costs (Lahdenperä 2010), however monies associated with pain share, gain share and risk/ reward are recouped through adjustments to the service provider's fee (Morwood, Scott et al. 2008; Lahdenperä 2009; Department of Infrastructure and Transport 2011).

Two primary fee payment methods have been used in collaborative contracting, each encourages either cost saving and/ or design innovation (Morwood, Scott et al. 2008). In the fixed payment approach, the client fixes the payment as a lump sum based on the TCE, irrespective of the actual direct costs for the project, and makes progressive payments on the basis of the pro rata lump sum during the project delivery period (Morwood, Scott et al. 2008; Department of Infrastructure and Transport 2011). This approach offers an incentive for service providers, especially the constructor, to minimise construction costs, but may restrict the potential for further design development and innovation, which could offset additional design fees the client otherwise needs to pay (Morwood, Scott et al. 2008). The variable payment approach, on the other hand, sets the fee payment as a fixed percentage of the actual direct cost, irrespective of where the actual cost ends up relative to the TOC. This approach supports the integrated design and construction teams to enhance project outcomes through innovation, however, may not provide a strong incentive to drive cost reduction (Morwood, Scott et al. 2008).

3.1.4 Risk and reward sharing regimes

The pain-share and gain-share regime constitutes the foundation of the collaborative contract's commercial framework (Yeung, Chan et al. 2007; Lahdenperä 2010). This regime enables the parties (including the client) to share savings and overruns according to the set TOC, i.e., any cost under- or over-run against this TOC is split in pre-agreed, specified proportions. The governance mechanisms of the regime are designed specifically to spur the parties to invest and cooperate in joint design during the development phase, which is critical for innovation and project success (Hauck, Walker et al. 2004; Love, Mistry et al. 2010; Lahdenperä 2012).

The fundamental principle of the collaborative contracting commercial framework is collective risk sharing. This principle is supported by gain-share and pain-share mechanisms, whereby a win/win and lose/lose rule is applied (Chan, Chan et al. 2010; Lahdenperä 2012). Both cost and non-cost performance measures are used to achieve VfM for the client (Yeung, Chan et al. 2007; Morwood, Scott et al. 2008). The cost performance measures assess the actual outturn costs (AOC) to deliver the work against the agreed TOC. If the project is completed at less than the TOC, the client and service providers share additional profits (Morwood, Scott et al. 2008; Lahdenperä 2009; Department of Infrastructure and Transport 2011). Normally, the client takes 50% of both the gain (profit due to cost underruns) and pain (loss due to cost overruns), and the remaining 50% is available to be split between the service providers (Morwood, Scott et al. 2008; Department of Infrastructure and Transport 2011). Some collaborative contracts uncap the cost gain share to give the service provider greater incentive to drive cost saving (Morwood, Scott et al. 2008). In recent years, client organisations have become increasingly concerned over VfM, and have placed a cap on cost gain share to reduce the likelihood of over-pricing during the TCE (i.e., a soft TCE) (Morwood, Scott et al. 2008; Department of Infrastructure and Transport 2011).

In terms of the pain share, both the client and service providers are liable for the loss if the project overruns the TOC (Morwood, Scott et al. 2008; Lahdenperä 2009; Department of Infrastructure and Transport 2011). This mechanism puts the fee payment at 100% risk depending on the project outcomes. Historically, most collaborative contracts cap the overall risk for each service provider at the loss of the service provision fee (Hauck, Walker et al. 2004; Lahdenperä 2010). Hence, even in the worst scenario, the service providers will still be reimbursed for the direct costs of the project

(Morwood, Scott et al. 2008). It has been argued that this mechanism leaves the client to carry the entire project overrun if the project becomes distressed, which may undermine the concept of risk and opportunity sharing, and 'best-for-project' decision making (Department of Infrastructure and Transport 2011).

3.1.5 Qualitative performance measurement

In addition to the actual target-cost arrangement, collaborative contracts may also include various qualitative key performance indicators in the reward system (Lahdenperä 2012). The owner's non-price objectives are represented by Key Result Areas (KRAs) such as facility performance, disturbance avoidance, good safety, and timely completion. KRA's are pre-agreed between the client and service providers, and are measured through Key Performance Indicators (KPIs) (Morwood, Scott et al. 2008; Lahdenperä 2009; Department of Infrastructure and Transport 2011). The client may provide separate funding, that sits outside the agreed TCE, to incentivise the service provider's performance against non-cost KRAs, when exceptional performance exceeding minimum condition of satisfaction (MCOS) is required (Morwood, Scott et al. 2008; Department of Infrastructure and Transport 2011). The service providers may also be liable to pay for non-cost performance that does not meet MCOS (Morwood, Scott et al. 2008; Department of Infrastructure and Transport 2011). However, without linking the reward mechanism with the pain share the client may end up funding exceptional performance against non-cost KRAs even though the project is over budget (Department of Infrastructure and Transport 2011). Conversely, if non-cost positive performance is self-fund, i.e. taken from the non-project related component of the TCE (Morwood, Scott et al. 2008; Department of Infrastructure and Transport 2011), and is only rewarded if cost underruns occur, the incentive for the service providers to achieve the required performance level for non-cost KRAs may diminish if there is a cost overrun (Department of Infrastructure and Transport 2011). Therefore, it has been suggested that the commercial framework only includes the most important KRAs, where the performance measures of other KRAs are not incentivised in a commercial sense (Morwood, Scott et al. 2008). In addition, the split between the service providers' share of gain share/pain share for the KRA performance pool depends on the degree to which each participant can influence the outcome (Morwood, Scott et al. 2008).

3.1.6 Collaborative multi-party agreement

In alliance projects, the collaborative contract is established as a project delivery vehicle. This is a multi-party agreement that can be executed by all parties, through which they jointly define their respective objectives, establish the commercial arrangement, design the organisational structure and decision making processes, and agree on behavioural commitments (Australian Constructors Association 1999; Morwood, Scott et al. 2008; Lahdenperä 2009; Department of Infrastructure and Transport 2011). Following the principles of relational contracting (Feinman 2000; Macneil 2000), collaborative contracts focus on the necessity of trust and mutual responsibility and prioritise the values of fairness and cooperation (Chan, Chan et al. 2010; Lahdenperä 2012). Moreover, the parties' collective responsibility for the project is underpinned by mutual liability waivers (Lahdenperä 2012) through 'no dispute' and 'no blame' commitments, which rule out the possibility that any participant can be held legally liable for poor performance or negligence (Morwood, Scott et al. 2008).

3.1.7 Early contractor involvement

Early Contractor Involvement (ECI) is a collaborative project delivery method that brings in contractor's experience and knowledge into the planning and design (Australian Constructors Association 1999). In comparison with the traditional contract approach (e.g. design and construct contract), the primary advantage of ECI lies in its capacity to enable constructability to be built in from the beginning of the project, thereby saving time and cost, and encouraging innovation (Edwards 2009). Compared to project alliances, which provide better risk management when a high degree of uncertainty is involved in both the development and delivery phases, and therefore requires an ongoing collaboration between the owner and service providers, ECI helps to remove initial risk uncertainties to a certain degree, and achieves a realistic risk adjusted price (Edwards 2009). Hence ECI is more appropriate for managing medium design completion and confidence when less time is available (projectmanager.com.au 2011).

ECI minimises resource requirements during the tendering stage, and uses non-price selection criteria and some input cost related criteria at the predetermined stages to select a contractor (Department of Main Roads 2009). ECI covers two stages (Department of Main Roads 2009; Edwards 2009). In Stage 1 the owner bears most of the project risk and the contractor's obligations are limited to design preparation (Edwards 2009). In the collaborative stage, the contractors, designer and owner work together to develop the design, program, budget and risk allocation model. This arrangement not only allows the service providers to focus on their skills and experience, but also encourages knowledge assimilation and innovation (Edwards 2009). As a result, the owner benefits from a range of design scenarios, sensible risk management and appropriate contract development (Department of Main Roads 2009). During this stage, transparent cost and documentation enable in-depth discussion and understanding of the project requirement (Department of Main Roads 2009). Through risk analysis and investigation, the contractor has the opportunity to prepare a price based on reasonable understanding of the project, even if certain risks cannot be designed out or otherwise mitigated through planning (Edwards 2009). This approach is essential for VfM, since a secured margin increases financial certainty for contractors, thereby reducing the likelihood of margin recovery strategies such as claims in Stage 2 (projectmanager.com.au 2011). In addition, price competition may be created in Stage 1 to ensure VfM, particularly by public sector clients, through selecting multiple bidders (usually up to three) to participate in the scoping and pricing. On the contrary, private sector clients tend to use a sole source or single tenderer to increase collaboration through design and construction (projectmanager.com.au 2011).

In Stage 2, the contractor carries out detailed design and documentation, construction of project works, provides materials, labour, plant and equipment, and fulfils other obligations under the contract. The method of payment for the contractor can be the agreed Risk Adjusted Price (RAP), in a lump sum, a schedule of rates with provisional sums, or a combination of both. The offer can also be a Risk Adjusted Maximum Price (RAMP) for the agreed risk allocation and design. Work subject to an RAMP is performed as day work and on an open-book basis. The payment to the contractor is based on actual cost and at an agreed rate, plus an agreed amount for profit and overheads. The opportunity to share in savings and rewards encourages the contractor and the owner to work together to reduce project time and cost (projectmanager.com.au 2011). Similarly to project alliances, the contractor is financially rewarded for success in some KRAs (e.g. environmental performance and early construction completion) from a performance pool (Edwards 2009). Under the circumstance that certain risks are out of control of either party, the performance pool is reduced to encourage a cooperative approach to deal with the challenges (Edwards 2009). The formal mechanisms adopted by the ECI process to increase VfM include: open-book arrangements in Stage 1; selection of contractors and designers with a proven track record; an independent estimator to analyse and review target costs to validate the Stage 1 output; the rate is decided based on the contractor's benchmark projects; and competitive pricing of supplier and sub-contractor components (Department of Main Roads 2009; Edwards 2009).

3.2 Informal Governance Mechanisms of Collaborative Contracts

In line with the conceptualisation of informal mechanisms (Gulati and Singh 1998; Luo 2007; Hoetker and Mellewigt 2009), the literature review found that informal governance mechanisms can be usefully grouped according to four categories: leadership structure, integrated team, team workshops and joint management system (Yeung, Chan et al. 2007; Rahman and Kumaraswamy 2008). These informal governance categories help ensure mutual trust, a win-win philosophy, open communication and a collaborative culture (Eriksson and Pesämaa 2007; Yeung, Chan et al. 2007; Rahman and Kumaraswamy 2008; Pesämaa, Eriksson et al. 2009; Love, Mistry et al. 2010). Effective informal governance creates a social condition conducive to sustaining these latent cognitive factors during project delivery (Chan, Chan et al. 2010; Lahdenperä 2012). The four identified categories of informal governance are outlined below.

3.2.1 Leadership structure

A collaborative contract framework adopts a special leadership structure, where: the project board provides vision, governance and leadership; the project management team drives the operational project delivery under the leadership of a project manager; and the wider project team implement the project (Morwood, Scott et al. 2008; Edwards 2009; Department of Infrastructure and Transport 2011). Unlike a conventional project delivery approach, each level within the leadership structure is formed by an integrated team (Chan, Chan et al. 2010). The project board and project management team are formed by representatives from both the client organisation and the service providers (Hauck, Walker et al. 2004; Edwards 2009). The representatives are selected based on project specific experience, leadership and communication capabilities, cultural alignment to the collaborative contracting framework, and their capacity to influence resource available to the project (Love, Mistry et al. 2010). In order to build mutual understanding and ultimately sustain the client-service provider relationship, the client's representatives on the panel for selecting service providers are often people who will continue to work within the project (Morwood, Scott et al. 2008; Edwards 2009). The project team integrates the resources and capabilities of service providers from wider functional areas including design, construction, systems and controls, community and stakeholders, environmental, as well as culture and relationships (Chan, Chan et al. 2010). In particular, when service providers select partners to form a proponent team, the existing relationship that exists between a potential partner and the client, and those among the potential partners themselves, are also taken into consideration, along with concerns about complementary resources and capabilities to form a project mix (Morwood, Scott et al. 2008).

3.2.2 Integrated team

The governance structure of collaborative contracts adopts a wide range of informal mechanisms to develop an integrated project team. First of all, culture management is not left to chance (Rahman and Kumaraswamy 2004). The management of relationships and culture needs to be included in the high performance plan at the beginning of the project (Morwood, Scott et al. 2008). Symbols such as team branding, awards, office layout, display of project targets and objectives, and meeting protocols, are used to create a culture of cooperation and high performance; the project charter defines the requisite behavioural characteristics for this culture to evolve (Morwood, Scott et al. 2008). Newsletters about emerging innovations are distributed to keep people engaged in innovative project activities (Love, Mistry et al. 2010). Specific communication tools, such as an expectation matrix, are also developed for the team members to align their commitments to each other (Love, Mistry et al. 2010). It has been suggested that high performance project plans need to be specified with powerful meeting architecture (Morwood, Scott et al. 2008). Both focused, integrated workshops and meetings are needed to integrate design and construction to ensure that project solutions are cost effective and innovative (Rahman and Kumaraswamy 2008). The client organisations often introduce relationship managers to the project team to align the expectations of and maintain the relationships amongst all team members (Rahman and Kumaraswamy 2008). The integrated team formed by staff members of all parties is co-located in a common office to facilitate joint problem solving, learning and cooperation (Hauck, Walker et al. 2004; Love, Mistry et al. 2010).

3.2.3 Team workshops

Relationship workshops are widely used in collaborative projects to facilitate open communication and build relationships and mutual understanding (Chan, Chan et al. 2010). Independent facilitators are also commonly engaged for team development activities and cultural alignment in workshops (Bresnen and Marshall 2000; Morwood, Scott et al. 2008; Lahdenperä 2012). Such workshops are used intensively in alliance projects and in more conventional projects with arrangements such as ‘partnering’ or ‘early contractor involvement’ attached. The remainder of the discussion refers mainly to an alliance project context.

During the team formation stage, workshops such as selection workshops and commercial alignment workshops are used to tease out technical issues and build relationships between parties (Chan, Chan et al. 2010). Through these workshops the client and service providers collectively generate the vision for project delivery, develop the principles for the commercial arrangement, and design an innovation program (Yeung, Chan et al. 2007; Love, Mistry et al. 2010). The workshops enable the parties to discuss and agree on the definition of the elements that make up the direct costs, the corporate overheads and normal profit, and to review and agree on the gain share/pain share regime including the performance measures for KRAs (Morwood, Scott et al. 2008; Love, Mistry et al. 2010). Relationship and team building activities are often intended for key personnel representing the contracting parties to strengthen the team spirit (Kumaraswamy, Ling et al. 2005). During project operation, workshops are carried out to promote effective coordination of the duties assigned to partner members, and to discuss innovations and share knowledge. These workshops can involve client and service provider representatives at all levels, including contractors, designers and key sub-contractors and suppliers (Australian Constructors Association 1999; Bresnen and Marshall 2000; Love, Mistry et al. 2010). In the project evaluation phase post-project-delivery, review workshops are usually carried out to enable learning, to identify opportunities for improvement of team processes, (Love, Mistry et al. 2010) and to reinforce relationships for future projects (Morwood, Scott et al. 2008).

3.2.4 Joint management systems

Collaborative contract governance emphasises the principle of co-operative joint decision making, which is realised through mechanisms that integrate people, systems and processes into a joint management system (Hauck, Walker et al. 2004; Eriksson and Pesämaa 2007; Love, Mistry et al. 2010). At the early stages of project delivery, the joint decision making system is established through integrating the best management systems from each participant organisation, including components such as cost control, safety and quality, and information management (Morwood, Scott et al. 2008; Love, Mistry et al. 2010). Successful integration enables a mutual understanding of participants' culture and procedures, and ultimately facilitates organisational alignment (Love, Mistry et al. 2010). Co-operative joint decision making is required at various levels (Lahdenperä 2012). The project board and project management team need to make unanimous decisions on a 'best for project' basis (Morwood, Scott et al. 2008; Department of Infrastructure and Transport 2011; Lahdenperä 2012). Complex structural and managerial problems are resolved at the project team level to advance the goals of the project ahead of those of individual participant organisations (Hauck, Walker et al. 2004). For example, on-site construction change orders are managed by the project team at the project level (Hauck, Walker et al. 2004). Project delivery under the governance of collaborative contracts especially demands an effective use of shared information technology (IT) systems and information processing integration to support open communication and information sharing (Bresnen and Marshall 2000; Hauck, Walker et al. 2004; Eriksson and Pesämaa 2007). An integrated web-based IT system incorporating building information modelling (BIM) is needed to facilitate information flow within the joint management system (Lahdenperä 2012). Commission and training needs for the IT system need to be addressed at project commencement (Morwood, Scott et al. 2008).

4. Conclusions

According to relational contract theory (Macneil 2000), transactions occur only within relations, hence the investigation into collaborative contract governance structure needs to engage in combined contextual analysis of relations and transactions. The literature review describes a draft framework that conceptualises the governance structures of collaborative contracts. The framework asserts that: a) the governance structures are supported by seven categories of formal governance mechanisms and four categories of informal governance mechanisms; and b) the governance structures have significant implications in achieving VfM, which is reflected in project performance. Future more refined analysis will enable the construction of measurement scales which will be used by the authors in a questionnaire about both types of governance mechanisms in collaborative contracts.

Future research planned by the authors will test the validity of the proposed measurement scales, at the same time providing generalisable statistical evidence concerning the relative value of individual governance strategies for VfM in collaborative contracting. There is currently no evidence of this type available in academic literature, government reports or industry studies. Such research will further extend our conceptual understanding of governance mechanisms in procurement contracts, and provide practical outcomes as to the means of maximising value for money on infrastructure projects. Future research planned by the authors will study the degree to which the implementation of formal and informal mechanisms impacts on project performance, guided by the model shown at Figure 1.

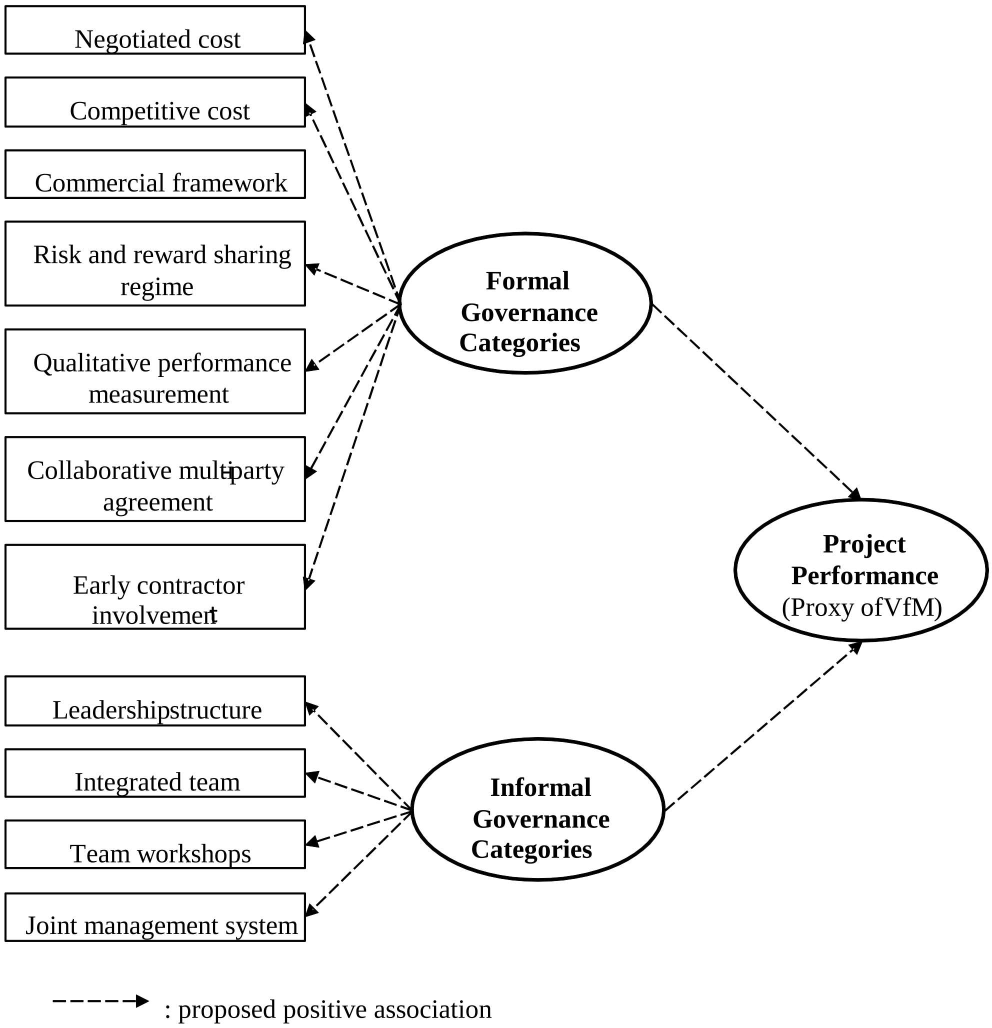

Figure 1: Conceptual model of governance categories that enhance VfM of collaborative projects

The current paper has examined the nature of each of the eleven governance categories. The findings of the future study will show which specific governance strategies or combinations of strategies sitting within each mechanism are most important in providing value for money on collaborative contracts in the infrastructure industry.

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Learning Routines Used By Firms During Construction of Infrastructure Projects Using The Alliance Procurement Method

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Abstract

Collaborative contracting has emerged over the past 15 years as an innovative project delivery framework that is particularly suited to infrastructure projects. Australia leads the world in the development of project and program alliance approaches to collaborative delivery. These approaches are considered to promise superior project results. However, very little is known about the learning routines that are most widely used in support of collaborative projects in general and alliance projects in particular. The literature on absorptive capacity and dynamic capabilities indicates that such learning enhances project performance. The learning routines employed at corporate level during the operation of collaborative infrastructure projects in Australia were examined through a large survey conducted in 2013. This paper presents a descriptive summary of the preliminary findings.

The survey captured the experiences of 320 practitioners of collaborative construction projects, including public and private sector clients, contractors, consultants and suppliers (three per cent of projects were located in New Zealand, but for brevity's sake the sample is referred to as Australian). The majority of projects identified used alliances (78.6%); whilst 9% used Early Contractor Involvement (ECI) contracts and 2.7% used Early Tender Involvement contracts, which are 'slimmer' types of collaborative contract. The remaining 9.7% of respondents used traditional contracts that employed some collaborative elements. The majority of projects were delivered for public sector clients (86.3%), and/or clients experienced with asset procurement (89.6%). All of the projects delivered infrastructure assets; one third in the road sector, one third in the water sector, one fifth in the rail sector, and the rest spread across energy, building and mining.

Learning routines were explored within three interconnected phases: knowledge exploration, transformation and exploitation. The results show that explorative and exploitative learning routines

were applied to a similar extent. Transformative routines were applied to a relatively low extent. It was also found that the most highly applied routine is ‘regularly applying new knowledge to collaborative projects’; and the least popular routine was ‘staff incentives to encourage information sharing about collaborative projects’.

Future research planned by the authors will examine the impact of these routines on project performance.

Keywords: project alliances, collaborative contracting, Australia, New Zealand, project performance, project outcomes, learning, absorptive capacity.

1. Introduction

Collaborative procurement models have emerged over the past 15 years as a means of managing large complex infrastructure projects (Morwood, Scott et al. 2008, Kelly 2011). Collaborative procurement aims to manage the high degree of risk and uncertainty associated with these projects by implementing mechanisms that enable and sustain interdependence and cooperative social behaviour between clients and service providers (Williamson 1991, Rahman and Kumaraswamy 2004, Davis and Love 2011, Scheepbouwer and Humphries 2011). Collaborative procurement is also more suited to facilitating high levels of stakeholder engagement, along with community and environmental outcomes (Morwood, Scott et al. 2008).

Pure project alliancing for infrastructure delivery has been mostly developed in Australia, and was used there to deliver approximately 500 public infrastructure projects during a period of labour and resource shortages from the late 1990’s to 2007 (Morwood, Scott et al. 2008, Kelly 2011). Changing market conditions over this time have stimulated the continual evolution of new models of collaborative procurement, such as partnering, early contractor involvement and early tender involvement (Chan, Chan et al. 2010, Kelly 2011, Lahdenperä 2012, Mignot 2012). Similarly, recently difficult economic conditions, coupled with an increasing demand for infrastructure development, have prompted an expectation of more efficient and sophisticated collaborative project performance outcomes in this sector (Morwood, Scott et al. 2008, Ross 2008, Leiringer, Green et al. 2009). Practitioners seek ways to achieve these improvements, against a backdrop of performance heterogeneity between collaborative projects in the infrastructure sector (Department of Treasury and Finance 2009).

The theory of evolutionary economics and dynamic capability theory assert that the learning capability of organisations is associated with project performance (Wernerfelt 1984, Barney 1991, Teece, Pisano et al. 1997, Eisenhart and Martin 2000, Zollo and Winter 2002, Helfat, Finkelstein et al. 2007). This paper draws from these theories to define learning capability as a knowledge-based dynamic capability that is comprised of higher order learning routines distributed throughout three sequential phases of learning: knowledge exploration, transformation and exploitation (Lane, Koka et al. 2006, Lichtenthaler 2009, Lewin, Massini et al. 2011). These routines enable an organisation to configure its knowledge base and lower order operational routines to optimise project performance and continually evolve its capabilities in response to changing market conditions (Cohen and Levinthal 1990, Nonaka 1994, Zahra and George 2002, Leiringer, Green et al. 2009, Nonaka and von Krogh 2009, Nooteboom 2009, Hartmann, Davies et al. 2010, Lewin, Massini et al. 2011).

Learning capability is strongly aligned with the principles of collaborative procurement, which aim to encourage knowledge creation and sharing between participant organisations, through formal and informal networks and relationships (Love, Tse et al. 2002, Carrillo, Robinson et al. 2006) . Hence, organisations with better learning routines are more likely to both achieve and benefit from successful collaborative project delivery because they are better able to absorb and apply knowledge generated or held by other organisations (Love, Tse et al. 2002, Hartmann, Davies et al. 2010). Learning capability is organisation-specific, and hence could be inferred to be an important source of organisational competitive advantage and project performance heterogeneity between organisations (Nelson and Winter 1982, Barney 1991).

To date, studies exploring the cause of performance differences between collaborative projects has focused on the impact of governance mechanisms, such as target cost arrangements, financial risk and reward sharing regimes, team and leadership structures etc (Hauck, Walker et al. 2004, Eriksson 2008, Rahman and Kumaraswamy 2008, Chan, Chan et al. 2010, Love, Mistry et al. 2010, Lahdenperä 2012). Whilst there has been an increase in recent years in studies regarding the resources of construction organisations (Leiringer, Green et al. 2009, Hartmann, Davies et al. 2010, Jin 2010, Rose and Manley 2012), investigation of the learning capability concept remains at an exploratory level with regard to the Australian infrastructure sector. There is little statistically rigorous empirical evidence confirming which learning routines are applied by participant organisations in this context, nor the impact these routines have on project performance. Given the growth of projects delivered through alliances, it is important to understand the learning capability of organisations that work on them.

In response to this knowledge gap, this paper reports the results of a large scale quantitative survey undertaken in 2013 on collaborative infrastructure projects in Australia. Preliminary analysis of the survey data is undertaken to explore the following research objectives: 1) to identify which learning routines are being applied in collaborative infrastructure projects in Australia, and 2) the extent to which these routines are being applied.

The paper very briefly introduces the concept of learning capability and then summarises the survey procedure and data analysis methodology that was used. The demographic profile of the survey respondents is presented to characterise the nature of recent projects and their participants. The results identify the relative extent to which various learning routines were applied in these projects, highlighting those that are most and least prevalent.

2. Learning Capability

Learning capability is underpinned by internal and external learning routines that explore, retain and exploit knowledge both inside and outside of organisational boundaries (Lichtenthaler and Lichtenthaler 2009, Lewin, Massini et al. 2011). Learning routines are defined by Zollo and Winter (2002p.340) as “stable patterns of behaviour that characterise organisational reactions to variegated, internal or external stimuli”. Internal learning routines facilitate variation and new idea generation, dissemination and combination of internally generated knowledge, and use of the knowledge to update old routines (Nonaka 1994, Zollo and Winter 2002). Lewin, Massini et al. (2011) define external learning routines as those that integrate external knowledge into internal knowledge creation and application processes. Lewin, Massini et al. (2011) propose that internal and external routines are interdependent and complimentary, whereby internal routines are required to ensure the knowledge gained through external routines is implemented.

Lane, Koka et al. (2006p.856) defined 3 phases of external learning routines: "(1) recognising and understanding potentially valuable new knowledge outside the organisation through *exploratory learning*; (2) assimilating valuable new knowledge through *transformative learning*, and (3) using the assimilated knowledge to create new knowledge and commercial outputs through *exploitative learning*". Lichtenthaler (2009) later found through empirical study that these phases also apply to internal routines. Scholars agree that these phases most likely occur within a continuous knowledge cycle, where the development of new operational routines in the exploitation phase is likely to generate further external knowledge acquisition and internal knowledge creation in the exploration phase (Zollo and Winter 2002, Lewin, Massini et al. 2011). Further to this, Lewin, Massini et al. (2011) suggest that internal and external learning routines may become integrated and not easily distinguished. Therefore, the study did not try to separate them.

An organisation can only build its collaborative project management capability by deliberately employing learning routines that enable the exploration, transformation and exploitation of knowledge they have gathered through their prior collaborative project experience; experience alone will not improve their capability without utilisation of the appropriate learning routines (Jin and Doloi 2008).

3. Method

3.1 Data sampling procedures

Data for this study was gathered through a quantitative survey that sought to characterise the learning capability and collaborative project performance of organisations engaged in recent or soon to be completed collaborative infrastructure projects in Australia. The survey was distributed to the contact database of the Alliancing Association of Australasia (AAA), a total sampling frame of 1688 prospective respondents, including construction sector practitioners representing public and private sector clients, contractors, consultants and suppliers. Following a pilot testing process, as recommended by Neuman (2003), the survey was distributed by email as a link to an online form, and was open for response over a period of 12 weeks from November 2012 to February 2013.

At closure of the survey, 357 responses had been received, of which 37 responses were eliminated during analysis of outliers and missing values. In total, 320 valid responses were utilised, providing an overall response rate of 19%. Applying the sample size estimation formula recommended by Bartlett, Kotrlik et al. (2001), this response rate will ensure the statistical rigour of data at an alpha level of 0.05 with a 3% margin of error.

3.2 Participant and project characteristics

The survey posed a series of questions to characterise the demographics of the survey respondents. Respondents were also asked to identify a recently, or soon to be, completed collaborative project with which they had been involved, to which their subsequent responses on learning routines pertained. Table 1 illustrates the characteristics of the respondents and their projects.

The majority of projects used alliance delivery systems (78.6%); whilst 9% used Early Contractor Involvement (ECI) contracts and 2.7% used Early Tender Involvement contracts, which are ‘slimmer’ types of collaborative contract. The remaining 9.7% of respondents used traditional contracts that employed some collaborative elements. The majority of projects identified were delivered for public sector clients (86.3%), and/or clients experienced with asset procurement (89.6%). All projects identified delivered infrastructure assets; approximately one third each in the road and water sectors, one fifth in the rail sector, the remainder capturing assets across the energy, building, mining, oil and gas, waste management and defence industries. Of these projects, 80.3% were completed between 2010 and 2013. Responses were approximately equally distributed between representatives of client (34%), contractor (34%) and consultant (31%) organisations, while sub-contractor and supplier organisations were infrequently represented.

Table 1 shows that the responses gathered represent a broad cross section of participant organisations across a range of sectors, locations and project values.

Table 1: Respondent demographics and project characteristics

Project characteristics	n	%		n	%
Type of client			**Experience of client in asset procurement**		
Public sector	276	86.3	Experienced	285	89.6
Private sector	44	13.8	Inexperienced	33	10.4
Type of contract			**Project Sector**		
Project alliance	155	51.8	Road	113	38.0
Program alliance	80	26.8	Water	89	30.0
Early contractor involvement	27	9.0	Rail	52	17.5
Design and construct with collaboration	16	5.4	Energy	14	4.7
Cost plus incentive fee with collaboration	8	2.7	Building	10	3.4
Early tender involvement	8	2.7	Mining	10	3.4
Lump sum with collaboration	4	1.3	Oil & gas	4	1.3
Other contracts with collaboration	1	0.3	Waste management	3	1.0
			Defence	2	0.7
Value of contract held by respondent organisation (m = AUD million)			**Project Location**		
< $500,000	30	9.5	NSW	98	30.7
$500,000 < $2m	25	7.9	Qld	85	26.6
$2m < $5m	15	4.8	WA	71	22.3
$5m < $10m	13	4.1	Vic	43	13.5
$10m < $50m	61	19.4	NZ	9	2.8
$50m < $100m	45	14.3	SA	8	2.5
$100m < $500m	82	26.0	ACT	2	0.6
> $500m	32	10.2	NT	2	0.6
Other	12	3.8	Tas	1	0.3
Total Project Value (m = AUD million)			**Year of project completion**		
< $5m	7	2.3	2008 and before	12	4.4
$5m to < $10m	3	1.0	2009	16	5.8
$10m to < $50m	18	5.9	2010	44	16.0
$50m to < $100m	41	13.5	2011	35	12.7
$100m to < $500m	142	46.9	2012	113	41.1
> $500m	92	30.4	2013	29	10.5
			2014 and after	26	9.5
Respondent characteristics					
Number of collaborative projects the respondent had previously worked on prior to the project reported in survey:			**Type of organisation you worked for during the project:**		
0	35	10.9	Client	108	34.3
1	38	11.9	Contractor	106	33.7
2	60	18.8	Consultant	98	31.1
3	42	13.1	Supplier	2	0.6
4	28	8.8	Subcontractor	1	0.3
5	29	9.1			
6	22	6.9	**Type of position you held during project:**		
7	5	1.6	Project leadership team	142	48.1
8	5	1.6	Operational management team	103	34.9
9	1	0.3	Advisor/ facilitator	50	16.9
> 10	55	17.2			

3.3 Data measures

Respondents were asked to consider the learning processes applied by their parent organisation during the collaborative project they had described. The survey presented 19 potential learning routines for consideration across the three learning phases of knowledge exploration, transformation and exploitation. The routines were based on findings in the literature about current practice. In addition to the conceptual literature, the measurement scales published by Kale and Singh (2007) and Lichtenthaler (2009) proved particularly useful in defining the 19 routines used in the present survey. These routines were independently identified by each of the authors and triangulated to arrive at the final set which represents the most important routines without overlap or omission. Respondents were asked to use a 7 point Likert scale to identify the degree to which they perceived that each learning routine was implemented by their organisation, where 1 = strongly disagree, 7 = strongly agree.

3.4 Data analysis

The paper presents descriptive charts showing the percentage of respondents that agreed, to some extent, that each routine was applied by their parent organisation during the project they identified. The presentation of data will rank the routines from most applied to least applied.

The results presented will not be differentiated according to respondent or project characteristics; further analysis in subsequent papers will assess the extent to which these contextual factors influence application of learning routines. However, given that 78.6% of the respondent population were involved with project or program alliances, it can be inferred that the results will closely align with routines applied during the use of project alliances.

4. Results and Discussion

Figure 1 shows the percentage of survey respondents that agreed, to varying extents, that each organisational learning routine was applied by their organisation during their collaborative project. The routines are ranked in order from most to least applied.

Figure 1 shows that of the 19 learning routines tested, the most popular was ‘regularly applying new knowledge to collaborative projects’; which was implemented by 86% of the survey respondents. The least popular was ‘staff incentives to encourage information sharing about collaborative projects’, which was implemented by 18% of respondents. While the majority of learning routines that were canvassed (16/19) were applied by at least 50% of respondents, only a relatively smaller proportion of learning routines (7/19) were applied by a large proportion (≥ 70%) of the respondent group.

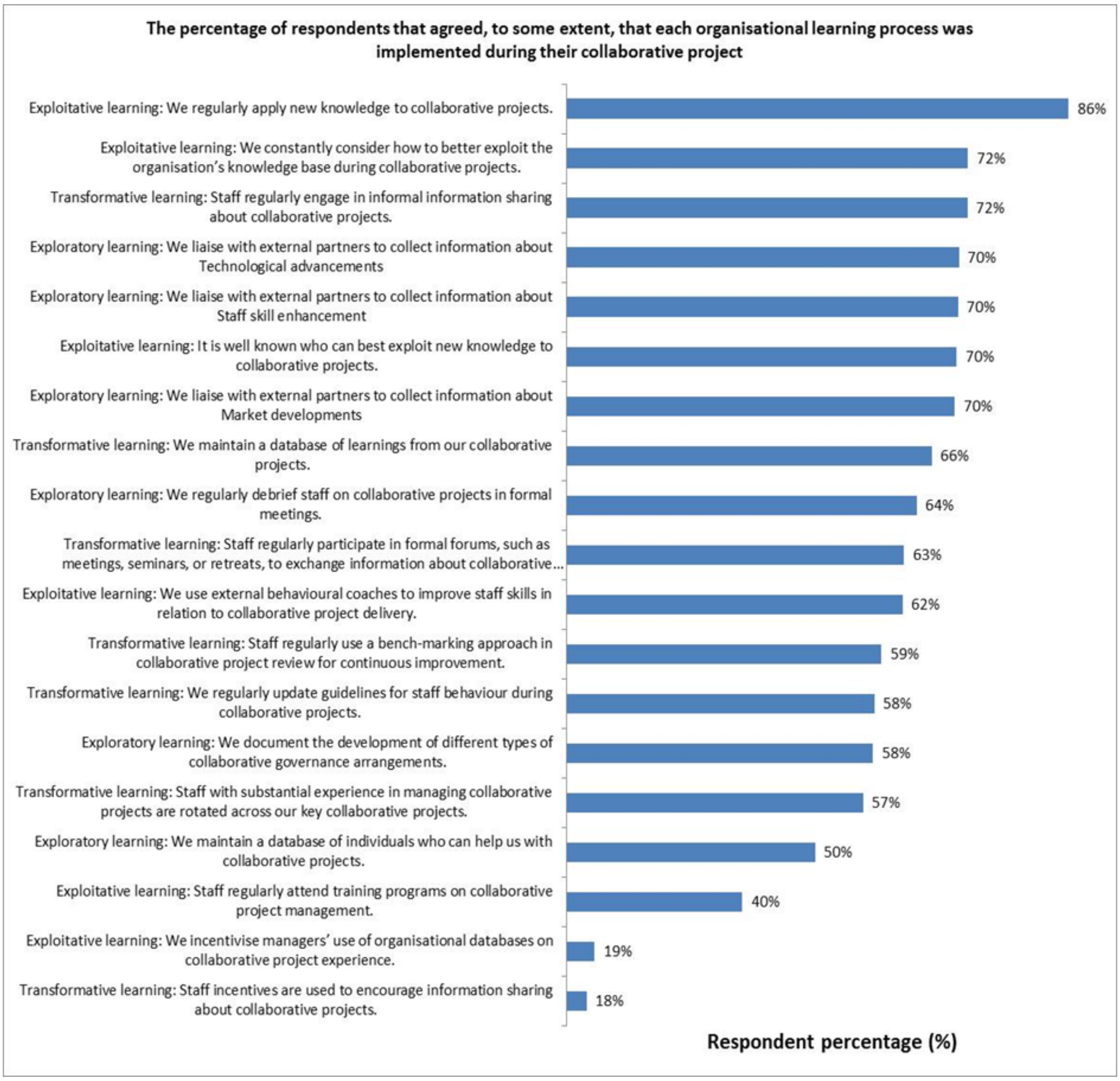

Figure 1: The percentage of respondents that agreed, to varying degrees, that each organisational learning routine was implemented during their collaborative project

4.1 Exploratory, transformative and exploitative learning routines

Figures 2, 3 and 4 illustrate the survey responses relating to each routine, with the routines segregated according to the learning phase to which they belong.

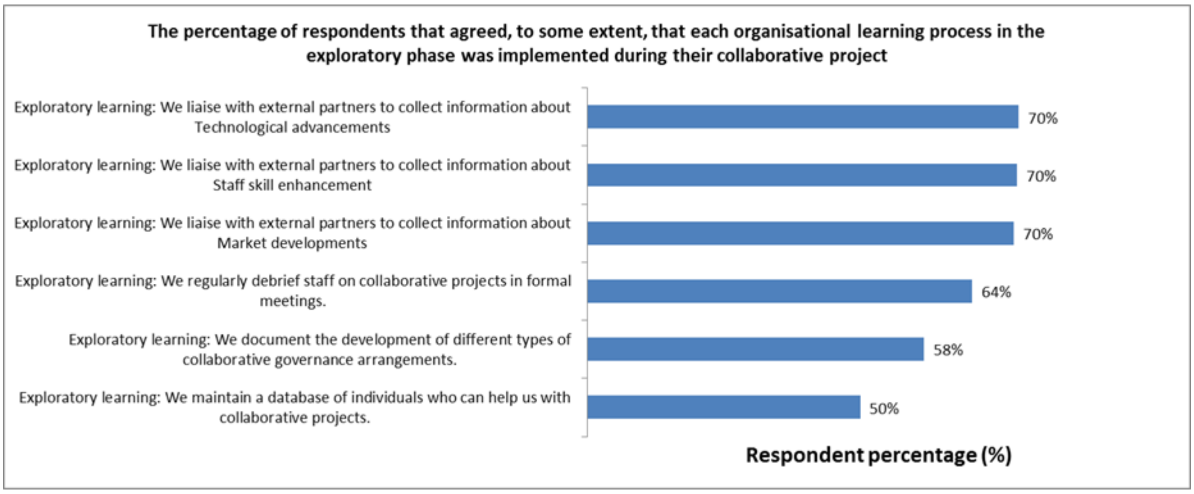

Figure 2: The percentage of respondents that agreed, to varying degrees, that each organisational learning routine in the exploratory phase was implemented during their collaborative project

Figure 3: The percentage of respondents that agreed, to varying degrees, that each organisational learning routine in the transformative phase was implemented during their collaborative project

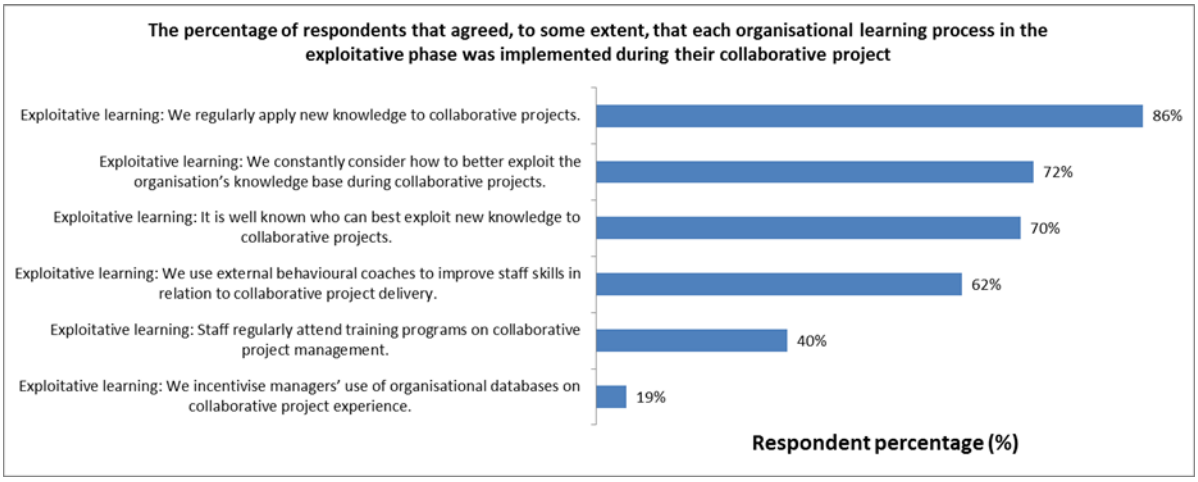

Figure 4: The percentage of respondents that agreed, to varying degrees, that each organisational learning routine in the exploitative phase was implemented during their collaborative project

Figures 2, 3 and 4 show that three each of the six exploratory and six exploitative routines were applied by at least 70% of the respondents, while only one of the seven transformation routines were applied by this proportion of respondents. This indicates that exploratory and exploitative routines are valued most highly, and at a comparable level, by the survey respondents. It is to be expected that participant organisations in collaborative projects would value and apply exploratory routines that enable the external knowledge sharing and relationship building that is characteristic of collaborative procurement (Morwood, Scott et al. 2008, Edwards 2009, Love, Mistry et al. 2010, Ruana, Ochiengb et al. 2012). Similarly, it is also expected that infrastructure organisations would focus on exploitative routines that enable them to achieve a competitive market advantage and increasingly efficient and sophisticated stakeholder expectations in a challenging infrastructure market (Manley 2006, Department of Treasury and Finance 2009, Department of Infrastructure and Transport 2011). This includes enhancing their capability to modify and reconfigure collaborative contracts and procurement models to suit fluctuating project and market needs (Morwood, Scott et al. 2008, Leiringer, Green et al. 2009, Miller, Furneaux et al. 2009, Love, Niedzweicki et al. 2012). The comparable degree to which exploratory and exploitative routines are applied is consistent with the finding in the literature that these learning phases are closely linked in a continuous knowledge cycle (Zollo and Winter 2002).

The distribution of the exploitative routines shows that four of the six routines were applied extensively, while the remaining two routines were applied to a relatively low extent. This indicates that there is a large degree of variation in the perceived value of the exploitative routines tested, and may indicate that the least applied exploitative routines are not perceived to be as relevant or valuable to collaborative infrastructure organisations. Conversely, the distribution of all six of the exploratory routines tested seems closely clustered, suggesting that they are applied very similarly by infrastructure organisations, and/or that the respondents interpreted the meaning of these routines very similarly.

Transformative routines were the least strongly applied learning phase. This probably reflects the role of such routines in providing the bridge between explorative and exploitative learning phases. It might be hard for respondents to identify with the subtle activities that bridge these two important functions. Also, the value and importance of transformative learning routines may not be as tangibly understood as the other two phases. Transformation routines involve assimilating new knowledge through conversion of tacit knowledge to explicit knowledge. It might be that this phase is not conceptually distinct and that the routines involved are better located within the other two phases. The distribution of all seven of the transformative routines tested was strongly clustered, suggesting that as per the exploratory routines, these routines are interpreted and/or applied similarly by the respondents.

4.2 Utilisation of specific routines

The results support the expectation from the literature that the use of external advisors and behavioural coaches for both provision of external knowledge and staff training would be prevalent (Morwood, Scott et al. 2008, Hartmann, Davies et al. 2010, Love, Mistry et al. 2010, Department of Infrastructure and Transport 2011). However, the results show that there is relatively minimal investment in formal internal training programs, in contradiction with expectations reported in this same literature. Similarly, the use of experienced staff to coach new staff on new projects was less applied than might have been expected.

The literature asserts that both formal and informal communication mechanisms are applied across the three learning phases to facilitate knowledge generation and transfer within organisations. The results suggest that organisations in the Australian infrastructure sector may favour informal routines to a higher degree than formal routines in their internal communications (Abdul-Rahman, Yahya et al. 2008, Morwood, Scott et al. 2008, Hartmann, Davies et al. 2010, Love, Mistry et al. 2010). For example, the routine "staff regularly engage in informal information sharing about collaborative projects" was applied by 72% of the respondents, whereas the routine "staff regularly participate in formal forums, such as meetings, seminars or retreats, to exchange information about collaborative project implementation" was applied by 63% of respondents, comparatively. The results also suggest that there is little emphasis on the formal documentation of knowledge and development of prescriptive guidelines associated with transformative routines, although transformative routines associated with face to face dissemination of knowledge occur to a moderate-high extent, for informal and formal mechanisms, respectively. Similarly, the use of transformative routines to periodically benchmark and audit project performance for continuous improvement were not as highly applied as might be expected (Love, Tse et al. 2002, Robinson, Anumba et al. 2005, Bresnen 2007). Knowledge sharing and application incentives were the routines that were applied the least.

5. Conclusion

Organisational learning capability is considered to be a knowledge-based dynamic capability, comprised of internal and external learning routines that are positively associated with collaborative project performance. These learning routines can be categorised into 3 interconnected phases of learning: knowledge exploration, transformation and exploitation. A large scale quantitative survey was conducted to explore the specific learning capability of collaborative infrastructure projects in Australia, of which little empirical data has been gathered to date. The survey captured data on both the performance of recently completed collaborative infrastructure projects and the learning routines applied by the participant organisations during these projects. In particular, the survey was dominated by the alliance procurement method. This paper reports on the preliminary findings of this survey, presenting a descriptive summary of the learning routines that were applied. It was found that the most highly applied routine is 'regularly applying new knowledge to collaborative projects'; and the least popular routine was 'staff incentives to encourage information sharing about collaborative projects'.

The results in this paper are preliminary only and a limitation is the lack of statistical analysis. Future research is planned by the authors to: a) statistically confirm the descriptive patterns observed in this paper, b) establish whether there is a relationship between these learning routines and project performance, c) highlight which learning routines are most influential on project performance' and d) undertake factor analysis which will provide more information about the role of the transformative learning phase in this context. Additional empirical studies exploring the application of learning routines within collaborative infrastructure projects in other nations and within other sectors within Australia would be beneficial. It is intended that this research will inform guidelines to be used by practitioners to enhance organisational capability, and thus support improvements in the efficient delivery of collaborative infrastructure projects, and the optimal evolution of collaborative procurement models.

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The Distribution of Absorptive Capacity Among Construction Supply Chain Participants

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Abstract

The absorptive capacity of organisations is one of the key drivers of innovation performance in any industry. This research seeks to refine our understanding of the relationship between absorptive capacity and innovation performance, with a focus on characterising the absorptive capacity of the different participant groups within the Australian road industry supply chain. One of the largest and most comprehensive surveys ever undertaken of innovation in road construction was completed in 2011 by the Queensland University of Technology (QUT), based on the Australian road industry. The survey of over 200 construction industry participants covered four sectors, comprising suppliers (manufacturers and distributors), consultants (engineering consultants), contractors (head and subcontractors) and clients (state government road agencies). The survey measured the absorptive capacity and innovation activity exhibited by organisations within each of these participant groups, using the perceived importance of addressing innovation obstacles as a proxy for innovation activity. One of the key findings of the survey is about the impact of participant competency on product innovation activity. The survey found that the absorptive capacity of industry participants had a significant and positive relationship with innovation activity. Regarding the distribution of absorptive capacity, the results indicate that suppliers are more likely to have high levels of absorptive capacity than the other participant groups, with 32% of suppliers showing high absorptive capacity, ahead of contractors (18%), consultants (11%), and clients (7%). These results support the findings of previous studies in the literature and suggest the importance of policies to enhance organisational learning, particularly in relation to openness to new product ideas.

Keywords: Australian road industry, absorptive capacity, learning capacity, innovation activity, suppliers

1. Introduction

This paper is about the innovation process and the competence of participants, particularly their absorptive capacity. The research examines the relative capacities held by different participants in the construction industry – comprising clients, contractors, consultants and suppliers. Hence the topic covers both demand-pull ideas and supply-push ideas. Such a distinction represents end-points in old linear models of the innovation process. Today, innovation is usually conceptualised to have occurred within a product *system* involving many feedback loops between participants (Manley 2003). A good example in the construction context is Gann's seminal framework (Gann and Salter 2000).

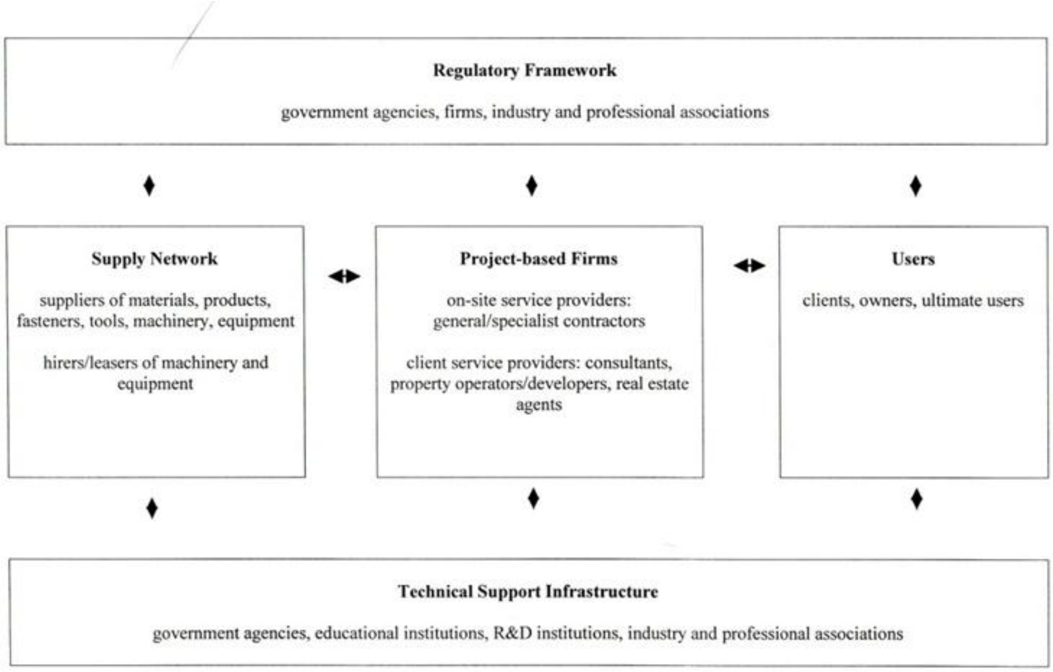

Figure 1: Participants in the building and construction project system, based on Gann and Salter (1998)

This paper addresses construction innovation by the main actors in Figure 1. As well as looking at the relationship between absorptive capacity and innovation activity (proxied by the perception of innovation difficulty), the research examined the distribution of absorptive capacity amongst industry participants.

In examining construction innovation, the boundaries of the construction industry and innovation activity need to be clearly defined. In defining the construction industry, the authors take a broad view of construction activity. Rather than considering the narrow statistical boundaries often applied to the industry, the product system view reflected in Figure 1 is adopted. The system view of construction activity provides a contribution to GDP that can be more than double that of the industry more narrowly defined (Department of Industry Science and Resources 1999: 7). This is because the traditional definition used in national accounting typically only comprises four sectors: engineering construction, construction trades, residential building and non-residential building. These sectors cover only the act of construction. They do not cover the means of construction. A system view of the industry takes into account other critical sectors which supply materials, components, products and services. Once the indirect income generated by dependent industries is taken into account, the contribution of construction activity to national economies increases significantly (Sedighi and Loosemore 2012). Our examination of innovation competency in the construction industry accounts for participants in this broadly defined system.

In defining innovation, the authors are persuaded by the highly authoritative view of the OECD (2005: 46): “An innovation is the implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organisational method in business practices, workplace organisation or external relations.”

A product innovation, which is the concern of this paper, is further defined as the “introduction of a good or service that is new or significantly improved with respect to its characteristics or intended uses. This includes significant improvements in technical specifications, components and materials, incorporated software, user friendliness or other functional characteristics.” (Organisation for Economic Cooperation and Development 2005: 48). Product innovation in road construction often comprises new material development, such as high performance concretes and asphalts, geo-synthetics, or fibre-reinforced polymer composites. Other examples include advances in intelligent network technologies, lighting, or damping and energy dissipation devices.

This paper addresses the following two research questions “What is the distribution of absorptive capacity among industry participants?” and ‘What is the relationship between absorptive capacity and construction product innovation?”.

2. Background

Organisational performance is thought to be underpinned by core competencies and the methods the organisation uses to build and exploit them (Prahalad and Hamel 1990). Core competencies are valuable, rare, inimitable and non-substitutable (Barney, Wright et al. 2001). The paper focuses on absorptive capacity, which is one of the core competencies that is considered important in the support of innovation performance (Cohen and Levinthal 1990, Zahra and George 2002, Lewin, Massini et al. 2011).

Absorptive capacity is a key driver of innovation within organisations (Cohen and Levinthal 1990). Absorptive capacity refers to the fundamental learning process of an organisation and its ability to identify, assimilate and exploit knowledge from its external environment (Cohen and Levinthal 1990). Absorptive capacity is an essential survival trait for an organisation because it allows the organisation to complement, reinforce and refocus its knowledge base (Lane, Koka et al. 2006). A recent study has verified the existence of four phases that constitute absorptive capacity in two dimensions (Jiménez-Barrionuevo, Garcia-Morales et al. 2010). The same study developed and validated a set of survey questions to measure these components. The current study used the same robust measures. Such measures assess ‘the organisation’s relative ability to develop a set of organisational routines and strategic processes through which it acquires, assimilates, transforms and exploits knowledge acquired from outside the organisation in order to create value’ (Jiménez-Barrionuevo, Garcia-Morales et al. 2010). This definition is based on the seminal work by (Zahra and George 2002).

The current study examined the four phases constituting absorptive capacity: acquisition, assimilation, transformation and exploitation. Acquisition and assimilation comprise the “potential” absorptive capacity dimension, and transformation and exploitation comprise the “realised” absorptive capacity dimension. Acquisition refers to an organisation’s ability to locate, identify, evaluate and acquire relevant external knowledge to aid in the internal development of its operations (Lane and Lubatkin 1998, Zahra and George 2002). Assimilation refers to an organisation’s ability to understand external knowledge, for instance the ability to classify and process external knowledge for internal use (Cohen and Levinthal 1990, Szulanski 1996). Transformation refers to an organisation’s ability to combine newly acquired or assimilated knowledge with existing knowledge and adapt existing knowledge for new purposes (Jansen, Van Den Bosch et al. 2005, Todorova and Durisin 2007). Exploitation refers to an organisation’s capacity to take the knowledge that has been acquired, assimilated and transformed and incorporate it into its operations for use in the external improvement of goods, systems, and processes (Jiménez-Barrionuevo, Garcia-Morales et al. 2010).

3. Methods

3.1 Sampling strategy and response rate

One of the largest and most comprehensive surveys ever undertaken of innovation in road construction was completed in 2011 by Queensland University of Technology (QUT), based on the Australian industry. The survey covered four sectors, comprising suppliers (manufacturers and distributors), consultants (engineering consultants), contractors (head and subcontractors) and clients (state government road agencies). The survey was sent to industry participants in the three largest Australian states: Queensland, New South Wales and Victoria.

The research population was defined as key organisations involved in Australian road construction projects, defined as those that were 1) prequalified by government road agencies, 2) members of selected industry associations; and 3) managing government roads. The research population comprised 865 organisations and the survey was sent by mail to one senior manager in each organisation, thus undertaking a census of the population. In total, 212 usable responses were received, resulting in a response rate of approximately 25%. Margin of error was calculated to give the researchers an indication of how precise the survey estimates were in relation to the response rate. The survey response rate of 25% yielded a margin of error of around 5%, which is considered acceptable for a survey of this type (Bartlett, Kotrlik et al. 2001). All sectors were well represented allowing comparative analysis across sector data.

3.2 Survey content development

The survey explored the four absorptive capacity phases using validated questions developed by Jiménez-Barrionuevo, Garcia-Morales et al. (2010). It contained questions about the 'measured items' associated with each phase; respondents were asked to rate the degree to which each measure of absorptive capacity applied in their organisation. The acquisition phase questions were about interaction, trust, respect and reciprocity. The assimilation phase questions were about common language, complementarity, similarity and compatibility. The transformation phase questions covered communication, meetings, documentation, transmission, time and flow. Lastly, the exploitation phase comprised questions about responsibility and application.

4. Results

4.1 Absorptive capacity by sector

In the current study, the measure of an organisation's absorptive capacity was based on the average response to each phase, based on the questions around each of the items contained in that phase, aggregated across the four phases. Organisations were then arranged into 'low', 'medium' and 'high' groups by ranking them from highest to lowest based on their total learning capacity value, then dividing this range by three to arrive at the cut-off interval between groups. The highest value across the 212 respondents was 25 and the lowest value was 13. The total range in values was 12 and the interval separating the three groups was 4. Thus, the 'low' group had scores less than 17, the 'medium' group had scores between 17 and 21, and the 'high' group scored over 21.

The distribution pie-chart in Figure 2 shows that 18% of the organisations surveyed had low absorptive capacity, 65% had medium absorptive capacity and 17% had high absorptive capacity.

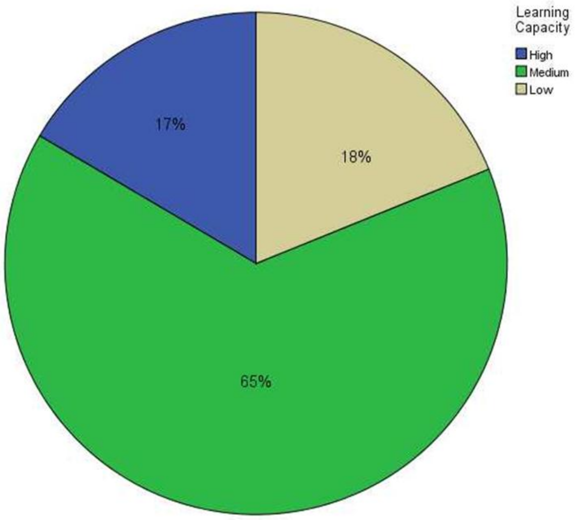

Figure 2: Distribution of Absorptive Capacity, All Sectors, Australian Road and Bridge Industry, 2011

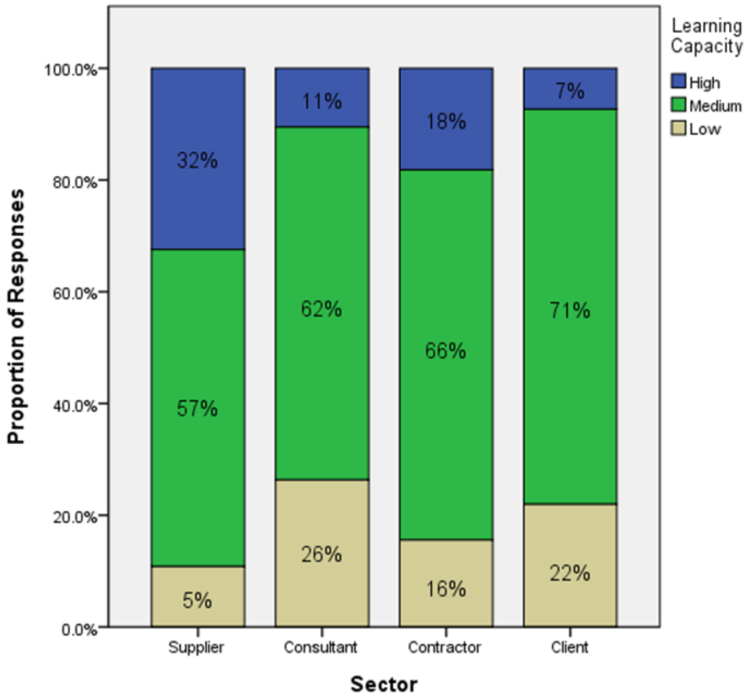

Figure 3: Distribution of Absorptive Capacity (learning capacity), by Sectors, Australian Road and Bridge Industry, 2011

Figure 3 shows that the supplier sector had the largest proportion of organisations with high absorptive capacity at 32%, while clients had the lowest proportion at 7% (closely followed by consultants at 11%). Similarly, suppliers also exhibited the lowest proportion of organisations with low absorptive capacity, at 5%, whilst consultants had the largest proportion at 26% (closely followed by clients at 22%). Hence, Figure 3 suggests that suppliers exhibit the highest overall absorptive capacity, followed by contractors, with clients and consultants exhibiting relatively poorer overall absorptive capacity. It seems that the sectors take significantly different approaches to the reception of ideas generated outside individual organisations. The results suggest supplier organisations are more open to external ideas than clients.

Table 1 shows the performance of each sector in terms of the four phases of absorptive capacity. Absorptive capacity was measured on a 7 point scale, where a 7 shows high application of absorptive capacity routines within each phase, and a 1 shows low application thereof.

Table 1: Average Absorptive Capacity, by the four phases, based on a 7 point scale, all sectors, Australian Road and Bridge Industry, 2011

Sector	Acquisition	Assimilation	Transformation	Exploitation
All Sectors	5.12	4.57	5.00	4.92
Suppliers	5.14	4.77	5.30	5.04
Consultants	4.85	4.48	4.78	4.96
Contractors	5.27	4.57	4.97	5.05
Clients	5.19	4.51	5.09	4.51

Although there are no significant differences between the data in Table 1, the results suggest some interesting trends in the relative performance of each sector within the absorptive capacity phases. Notably, suppliers exhibit high assimilation, transformation and exploitation capacity. Similarly, contractors exhibit high acquisition, assimilation and exploitation capacities. Conversely, clients exhibit low assimilation and exploitation capacities, although show moderate levels of acquisition and transformation. Consultants exhibit relatively poor capacity across all phases.

4.2 Relationship between absorptive capacity and innovation activity

In addition to examining the distribution of absorptive capacity amongst major types of industry participants, the relationship between absorptive capacity and innovation activity was examined. Due to data limitations, innovation activity was proxied by measuring the importance respondents placed on addressing innovation obstacles. A single measure of the importance each respondent placed on addressing the 22 obstacles listed in the survey was developed. The list of obstacles was derived from previous research undertaken by the authors, subsequently reported in (Rose and Manley 2012). The single measure facilitated the correlation of innovation obstacles with absorptive capacity. The single measure was obtained by taking the average of all the innovation obstacle questions for each respondent. This value is representative of the overall importance a respondent placed on addressing the obstacles hindering innovation. The survey analysis identified a significant positive correlation (99% confidence level) using a Spearman’s rho test between absorptive capacity and innovation obstacles (i.e. importance placed addressing obstacles by respondent).

5. Discussion

5.1 Relationship between innovation activity and absorptive capacity

It is widely believed that absorptive capacity is strongly positively associated with the innovative output of organisations. Cohen and Levinthal (1990) argued that knowledge of innovation potential is based on cumulative absorptive capacity. Organisations that do not invest in their absorptive capacity in a fast-moving field face the prospect of being unable to assimilate and exploit new innovation information. Tu, Vonderembse et al. (2006) agree, suggesting that the development of absorptive capacity can influence a firm’s ability to innovate in response to challenging business conditions, where “as the environment becomes increasingly dynamic, the pursuit of competitive advantage (such as innovative product development) depends on the organisation’s ability to acquire, process and share knowledge”. Further to this, Lane, Koka et al. (2006) propose that the innovative output resulting from absorptive capacity development will also create new knowledge for an organisation and its individuals, thus contributing to the evolution of further absorptive capacity in a cyclic manner.

The results of this study support the expected positive relationship between absorptive capacity and innovation activity in the context of the Australian road infrastructure industry. It was expected in this study that organisations with greater absorptive capacity would rank the resolution of innovation obstacles as being more important. This was on the assumption that highly innovative organisations would encounter obstacles more frequently, be more inconvenienced by them, and would consider it more important to address these obstacles than less innovative organisations. The results showed that organisations with higher absorptive capacity were more likely than organisations with lower absorptive capacity to rank the resolution of innovation obstacles as being very important. Similarly, this relationship has been corroborated by other empirical studies such as those reported by Murovec and Prodan (2009) and Tavani, Sharifi et al. (2013), which particularly highlight the positive relationship between high absorptive capacity and innovative product development.

5.2 Absorptive capacity by sector

The ensuing discussion focuses on exploring what differentiates levels of absorptive capacity between supply chain participants (sectors) within the Australian road infrastructure industry. In particular the discussion identifies factors that may have enhanced the high absorptive capacity exhibited by suppliers. By contrast, factors that may have influenced the low absorptive capacity exhibited by clients is also considered. This discussion draws insight from literature that canvass influences on both absorptive capacity and/ or innovative activity, on the assumption that there is a positive relationship between the two, and that what influences one may also influence the other.

Zahra and George (2002) propose that organisations build absorptive capacity differentially within each of the four phases outlined earlier. In particular, they propose that potential absorptive capacity enables an organisation to be receptive to acquiring and assimilating external knowledge, but does not guarantee the transformation and exploitation of this knowledge; enhanced innovative performance requires all components of absorptive capacity to be in balance. This variation between the phases of absorptive capacity may help explain the variation in overall absorptive capacity between organisations.

The literature widely acknowledges that the variation that organisations exhibit in absorptive capacity is likely to be influenced by the range of internal and external factors and environmental conditions to which they are exposed (Zahra and George 2002, Lane, Koka et al. 2006, Rose and Manley 2012). External influences may constitute positive triggers that enable potential capacity to be realised, thus optimising performance and innovative output; absorptive capacity can also be used as a tool to enable organisations to respond opportunistically to manage external influences that would otherwise inhibit performance (Rose and Manley 2012). Internal influences characterise the nature of an organisation’s absorptive capacity. Zahra and George (2002) suggest that external and internal factors influence the development of different components of absorptive capacity differentially. It could be inferred that each sector in the road infrastructure supply chain is exposed to different internal and external factors depending on the role the sector plays in the supply chain, and that this variation in exposure may differentially influence their impetus and capacity to develop and apply absorptive capacity (Rose and Manley 2012). Hence, the discussion will consider the impact of key external and internal influences that have been highlighted in the literature.

5.3 External factors influencing absorptive capacity

5.3.1 Fragmentation and complexity in the road industry

Construction supply chains such as the road infrastructure industry are more complex than most other manufacturing industries. They are more fragmented, as construction activity tends to be discrete, project-based, site built, tailored to unique customer needs, and based on temporary collaborations between large clusters of specialised organisations across the boundaries between design and construction (Nam and Tatum 1989, Winch 1989, Vrijhoef and Koskela 2000, Nordin, Oberg et al. 2010). The high risk of failure and the requirement for durability lead to conservatism towards trial and error approaches (Rose and Manley 2012). The complexities of this environment result in discontinuities in knowledge transfer within and between organisations (Gann 2001, Dubois and Gadde 2002), which in turn can have a significant impact on a construction organisation's capacity to identify, integrate and exploit innovative product knowledge (Manley and McFallan 2006, Rose and Manley 2012).

Manley (2008) asserts that these complexities impact less on the manufacturers (suppliers) of road products than on clients, contractors and consultants, due to suppliers being less directly influenced by discrete project work schedules. This may contribute to higher supplier absorptive capacity. Notwithstanding any additional flexibility that suppliers may experience in the innovation process, the adoption of their products is inhibited by the constraints experienced by the other actors in the supply chain (Manley 2008). There may be an emerging trend towards greater collaboration between suppliers and other actors in the supply chain, potentially resulting in greater innovative output from the supply chain, and enhanced absorptive capacity for all supply chain participants (Manley 2008, Tavani, Sharifi et al. 2013).

5.3.2 Exposure to competitive pressure

Tu, Vonderembse et al. (2006) suggest that different sectors of a supply chain are differentially exposed to competitive pressures, and are therefore differentially motivated to innovate to achieve competitive advantage. Competitive pressure is important for stimulating transformation and exploitation of potential absorptive capacity to achieve innovative performance outcomes (Zahra and George 2002). Given their core business is the manufacture of products that are applicable in a road construction context, it follows that suppliers face a high imperative to see their product innovations realised. Hence, it is to be expected that suppliers would exhibit high transformational and exploitative absorptive capacity. The study results concur with this expectation. Conversely, the client group exhibited low exploitation capacity. Given that road industry clients in Australia are public entities, it could be inferred that as clients are not exposed to same competitive pressure as participants further down the supply chain, they are less motivated to realise their potential absorptive capacity, despite their powerful market position and access to knowledge acquisition resources (Manley and McFallan 2006).

5.3.3 Influence of client demand on acquisition capacity

Caerteling, Halman et al. (2009) emphasise that government client dominance in the road infrastructure industry influences the competitive environment and the flexibility of other supply chain participants in the innovative process. Todorova and Durisin (2007) suggest that the often narrowly focused product demand stipulated by clients in this industry constrains the knowledge acquisition of other supply chain participants. Product manufacturers and suppliers would be particularly vulnerable to this influence compared to sectors that are more focused on the management of infrastructure establishment. This may explain why the supplier group exhibited a relatively low acquisition capacity compared to the other sectors.

5.4 Internal drivers of absorptive capacity

Lane, Koka et al. (2006) define internal drivers of absorptive capacity as those that focus on structure, policies, and processes within an organisation that affect knowledge transfer, sharing, integration and creation. In their study of Queensland road industry participants, Manley and McFallan (2006) found that internal business strategies were more important than external business conditions in determining highly innovative behaviour (and by association, high absorptive capacity). They suggested that firms that developed high absorptive capacity by investment in relevant internal strategies were more likely to respond robustly and innovatively to challenging business conditions than those that had not developed the appropriate enabling strategies.

5.4.1 Investment in internal research and development drives high absorptive capacity

Murovec and Prodan (2009) highlight that absorptive capacity captures both demand-pull and science-push (technical opportunity) knowledge. Nelson and Wolff (1997) propose that the acquisition and exploitation of science based technical opportunity (science-push knowledge) requires a higher level of absorptive capacity than other types of knowledge, such as that generated by market demand (demand-pull knowledge). Further to this, Murovec and Prodan (2009) find that internal investment in research and development is a critical factor influencing both types of absorptive capacity development. This is supported by the findings of Manley and McFallan (2006); that business strategies that are strongly associated with innovative capacity in the Queensland road industry include employment of new graduates, investment in technology, technical knowledge and skills, which in turn are supported by a high investment in internal research and development. Notably, Murovec and Prodan (2009) find that the purchase of externally provided research and development rather than investment in internal research and development, is ineffective in supporting either science-push or demand-pull absorptive capacity levels.

It could be inferred that suppliers, whose core business is the manufacture of technical road infrastructure products, are more likely to concentrate on the development of science-push rather than demand-pull knowledge. If science-push capacity is of proportionately greater value than demand-pull capacity, it would follow that suppliers exhibit a high overall absorptive capacity. Further to this, Manley and McFallan (2006), and Reichstein, Salter et al. (2005), assert that suppliers in the Australian road industry are less influenced by the inconsistency of project related schedules than are contractors, clients and consultants. They suggest that suppliers therefore have a greater continuity of work, and are in a better position to invest in long term research and development programs. Similarly, Gann (1997) acknowledges that manufacturers are recognised as key drivers of technical innovation in the broader construction industry, and invest more in research and development than do contractors or consultants. It would then be expected that suppliers would exhibit higher absorptive capacity than other supply chain participants, which is consistent with the results of this study.

Conversely, it could be inferred that clients, whose core business is the management of road infrastructure establishment, concentrate on acquisition of demand-pull knowledge, resulting in a lesser overall absorptive capacity than suppliers, for example. Clients are also becoming increasingly more likely to purchase externally provided research and development, rather than generating it in-house, thus potentially further reducing their overall absorptive capacity. Interestingly, the results of this study show that clients exhibit relatively high acquisition capacity compared to the other participant groups, which is contrary to the above proposed expectations. This may be due to public policy in Australia up until recently driving the ongoing maintenance of in-house research competencies of public sector clients, where other countries have downsized their comparable internal resources (Manley and McFallan 2006).

5.4.2 Influence of organisational size, structure, culture

Tu, Vonderembse et al. (2006) propose and test a series of organisational mechanisms that are critical to high absorptive capacity, which are to an extent a function of an organisation's size, structure and culture. Communication networks are identified as being essential, where the use of interdisciplinary teams, formal and informal information flows, and internal and external knowledge sharing networks build capacity. Networks that are dominated by one way communication or rigid functional boundaries inhibit effective knowledge flow. Organisations that value open knowledge sharing enhance learning, and thus capacity building. Innovative organisations conduct regular, broad knowledge scanning; the monitoring of their internal and external environment. Worker and manager knowledge were found to be less important than having a communication and knowledge network that enables efficient access to information stores. This emphasises the need for staff training that focuses on skills for accessing and processing information, and working in a cooperative, knowledge sharing environment. Todorova and Durisin (2007) concur with this assessment, suggesting that power relationships that constrain internal resource allocation may constrain the acquisition and exploitation of absorptive capacity, and that organisations with a hierarchical structure and prescriptive communication channels are more likely to experience this than organisations with smaller, more informal open communication systems.

Australian road infrastructure client organisations are typically large, hierarchical, heavily structured, mature public bureaucracies, with a historical focus on investing in knowledgeable staff, rather than knowledge sharing processes. These organisations also embody a highly regulatory and risk averse culture, with little flexibility for experimentation for innovative product development. It could be argued that these institutions have inherited a profile that exhibits some constraining communication and attitudinal characteristics, hence potentially reducing their absorptive capacity. On the other hand, supplier organisations could arguably be considered to be smaller, less mature, less structured organisations that exhibit more opportunistic, flexible and open information sharing culture and processes that would enhance absorptive capacity. Caerteling, Halman et al. (2009) explored the hypothesis that large organisations would have greater access to research resources, and that this in turn would be positively correlated with innovative output, and absorptive capacity; he found that there was no significant correlation between organisational size and innovative output, or the associated absorptive capacity.

6. Conclusions

6.1 Theoretical implications

This study extends the position adopted in the literature that there is a positive association between absorptive capacity and innovative activity, by confirming that this relationship also applies within the context of the Australian road infrastructure industry. The study confirms that organisations do build capacity differentially within each of the four phases defined by Zahra and George (2002), and that these differences can be observed between phases within each sector of the Australian road infrastructure supply chain, and between the sectors. Finally, the study provides some preliminary analysis of the potential factors influencing the absorptive capacity phase differentials between sectors of the road infrastructure supply chain, through a review of internal and external factors reported in the literature that are expected to influence the different components of absorptive capacity development differentially.

6.2 Managerial implications

The Australian construction industry has a history of slow innovation (Rose and Manley 2012). However, the conservative economic climate, coupled with a growing demand for public infrastructure in Australia and a recent supportive federal infrastructure establishment policy, requires ingenuity from the infrastructure supply chain. This study informs our understanding of the innovation capacity of the sectors in the Australian road infrastructure supply chain, highlighting that suppliers currently exhibit the strongest capacity, whereas clients and consultants exhibit the least capacity. A preliminary review of potential factors influencing these differentials suggests that factors that encourage an organisation’s capacity to innovate (absorptive capacity) include exposure to competitive pressure, high investment in internal research and development programs, and development of an open knowledge sharing environment. Specific challenges that inhibit innovative capacity for road infrastructure participants include the complexity and resource fragmentation associated with discrete, project based work flows, and the constraining effects of narrow client demand profiles. Specific influencing factors vary between the supply chain sectors depending on the role of each sector in the innovation process, thus accounting for the variation in innovative capacity between the sectors. These results can be used to inform the development of strategies and public policy that will improve the capacity for product innovation in the Australian road infrastructure industry.

6.3 Limitations and future research priorities

The results of this study could be supported by future data analysis that confirms the statistical significance or otherwise of the descriptive trends reported here. The relationship reported between innovation activity and absorptive capacity could be clarified by applying a more strongly validated measure of innovation activity in a survey of similar respondent scope. Although there is no reason to believe that the results of this study would not apply in similar contexts elsewhere, it would be valuable to replicate this study in road infrastructure and similar industries in other developed countries. A replication of this study for comparable industries within Australia would provide additional insight into potential innovation behaviours that could be applied in the Australian road industry. A more fulsome literature review and follow up empirical investigation, including qualitative data capture, that clarifies the factors that influence absorptive capacity differentials between phases and supply chain sectors, is planned by the authors. This future research will provide further guidance to improve the innovation capacity of the construction industry in general and the Australian road infrastructure sector in particular.

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Shared Value Creation in A Construction Project – A Case Study

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Abstract

The concern about climate change and the impact it will have on our living environments is driving built environment towards energy efficiency and sustainability. Built environment has significant direct and indirect impacts on social well-being, livelihood as well as affluence of local communities and individuals. Fast changing world, economic uncertainty and urbanisation call for new sustainable solutions. Built environment has a substantial role in sustainable development and noteworthy potential in shared value creation in changing world.

The focus in this research is to find out how shared value is created in built environment. Shared value creation can be defined as policies and operating practices that enhance the competitiveness of a company while simultaneously advancing the economic and social conditions in the communities it operates in. The aim of this paper is to examine shared value creation in a construction project and whether shared value creation improves quality, cost-effectiveness, sustainability and collaboration.

The research is based on case study and interviews. In order to understand actors' involvement and ambitions in a construction project semi-structured interviews were conducted. Interviewees were identified as persons who influenced design and execution of the construction project including authorities, designers, a developer, a contractor and users.

This paper is the first step in larger scale research that aims to construct a theoretical model for shared value creation in built environment. This paper describes the roles of different actors and the shared value creation process and the results in an office project. It is expected that later on the theoretical model will also have a boosting effect and applicability in other industries and business in general.

Keywords: Shared value creation, construction project, case study, collaboration, sustainability

1. Introduction

In recent years, there has been an increasing interest in corporate responsibility and sustainability. Achieving environmental and social sustainability stands out as some of the major challenges that current business leaders have to deal with (Jackson & Nelson, 2004). Corporate responsibility (CR) programmes and reports are widely used in companies today. The more business has begun to embrace CR, the more it has been blamed for society's failures. The legitimacy of business has fallen to levels not seen in recent history. (Porter & Kramer, 2011). Yet most managers frame sustainable development not as a multidimensional opportunity, but rather as a one-dimensional nuisance, involving regulations, added cost, and liability (Hart & Milstein, 2003).

It seems that the problem is that companies are trapped in the outdated approach to value creation and continue to view value creation narrowly, optimising for short-term financial performance while missing the most important customer needs and ignoring the broader influences that determine their longer-term success. (Porter & Kramer, 2011). Elkington & Hartigan (2008) found that social entrepreneurs are often ahead of established corporations in discovering shared value opportunities because they are not locked into the narrow traditional business thinking.

Sustainable development is partly social justice, and debate about what constitutes a fair and just distribution of wealth, rights and opportunities is not new (Holliday Jr, Schidheiny & Philip, 2002). The purpose of a company must be redefined as creating shared value, not just profit per se (Porter & Kramer, 2011). Creating shared value presumes compliance with the law and ethical standards, as well as mitigating any harm caused by the business, but goes far beyond that (Porter & Kramer, 2011). Elkington and Hartigan (2008) defined that shared value is created when a company generates value for both society and shareholders, while it is conducting its own. Acknowledging how to create shared value can be seen as a chance to legitimise business and make it sustainable.

According to Porter and Kramer (2011) shared value can be created in three key ways:

1. By reconceiving products and markets

   Society has different needs: Lately financial security and sustainability have been the most exposed topics. In this sense shared value creation is about meeting the changing needs of customers and finding new products or services to complement the old products. To reconceive products and markets, a company should identify the societal needs, benefits and challenges that are or could be embodied in the company's products (Porter & Kramer, 2011). It can be assumed that with these means the company will identify new markets in addition to opportunities for differentiation and repositioning in the current markets.

2. By redefining productivity in the value chain

   A company's value chain is affected by material resources, education, working conditions and connections. Redefining productivity in the value chain includes new approaches to resources use, procurement, distribution, location and employee productivity (Porter & Kramer 2011). For example greenhouse emissions are not just costly to the environment but costly to the business as well. Pollution can be seen as a form of economic waste as it is a sign that resources have been used incompletely, inefficiently or ineffectively. More over waste creates additional activities and costs that are not creating value for the company or the customer (Porter & Van der Linde, 1995).

   Today there is a growing consensus that major improvements in environmental performance can often be achieved with better technology at nominal incremental cost and can even yield net cost savings through enhanced resource utilisation, process efficiency, and quality (Porter & Kramer, 2011).

3. By enabling local cluster development

   No company is self-contained. The success of every company is affected by the supporting companies and infrastructure around it. Productivity and innovation are strongly influenced by "clusters," or geographic concentrations of companies, related businesses, suppliers, service providers, and logistical infrastructure in a particular field (Porter & Kramer, 2011). Clusters include institutions, trade associations, competition laws, quality standards and market transparency as well.

   According to Porter & Kramer (2011) clusters have a crucial role in driving productivity, innovation and competitiveness and vice versa without a supporting cluster, productivity suffers. Companies create shared value by building clusters to improve productivity while addressing gaps in the framework conditions surrounding the cluster (Porter & Kramer, 2011).

Although social entrepreneurs usually start with small initiatives, they often target problems that have a local expression but global relevance such as access to resources, education or waste management (Santos, 2012). Shared value creation is about expanding the total pool of economic and social value. The competitiveness of a company is interconnected with communities around it. A company needs a community not only to create demand for its products but as assets such as employees and suppliers. The result is a positive cycle of company and community prosperity, which leads to profits that endure (Porter & Kramer, 2011). Porter and Kramer (2006) also noted that companies cannot tackle every CR dimension and issue; instead they ought to carefully choose few CR issues that will have the greatest shared value and then apply them throughout the value chain.

Based on earlier studies buildings consume 40% of the world's materials, use 55% of the wood cut for nonfuel use, use 12.2% of the total water consumed, consume 40% of the world's energy and create 36% of the carbon dioxide emissions that cause global warming (Lenssen & Roodman, 1995, Perez-Lombard, Ortiz & Pout, 2008, UNEP, 2006). Furthermore buildings are exceedingly complex industrial products with a lifetime of decades (Airaksinen & Matilainen 2011). Therefore it can be considered that construction and building sector has potential to legitimise its' operation with shared value creation principles.

2. Research Method

Research began with a critical review of the literature focusing on sustainability and shared value creation in construction and property business. After that a case study approach applied to gather empirical evidence. Eisenhardt (1989) defines a case study as "a research strategy which focuses on understanding the dynamics present within single settings." In other words case study research consists of a detailed investigation that attempts to provide an analysis of the context and processes involved in the phenomenon under study (Yin, 2009). Case study can also be justified as "In general, case studies are the preferred strategy when "how" or "why" questions are being posed, when the investigator has little control over events, and then the focus is on a contemporary phenomenon within some real-life context" (Yin, 2009).

The case study included a case company with a case project that was selected to conduct in-depth investigation. The selected company and the project can be described as a forerunner in sustainability and it is presented in more detail later on in this paper. The data were collected with semi-structural interviews. The structure of the interview consisted of three themes of shared value creation. All together five key stakeholders were interviewed. Interviewed persons took part in the case project representing different stakeholders. The interviewees were selected to cover the main stakeholder of the case project: developer, contractor, mechanical engineering design manager and user. A general structure of the interview and the main questions were decided in advance. The detailed structure of the interview was left to be worked out in the interview situation. The interviews were recorded and transcripts were written. The outputs were analysed qualitatively. Secondary data was collected from company documents such as project sustainability case study, company web site and project material. The data were used in conducting testing of the shared value creation framework.

3. Empirical Findings

3.1 Case company

The case company is a global construction and development company with a sustainability agenda that includes social, environmental and economic aspects. These sustainability actions are coordinated firstly at group level and secondly each business unit has established a sustainability management structure appropriate to its needs. The company has acknowledged business opportunities in green business including sustainable buildings, living areas and Public Private Partnership projects.

The case company defines itself as a city builder and it has noted that sustainable development is not only about green agenda or environmental efficiency but also about social progress and economic certainty. The company sees sustainability as a good business practice and the company has a profitable growth business plan that aims to be leader in safety, role model in ethics, best in class in people development, recognised market leader in green and forerunner in risk management. As a contractor and developer the company aims to respond to society's needs. This holistic approach contributes to value creation, sustainable development and economic progress.

Targets analysed according to triple bottom line can be described as:

- The social agenda includes caring about the employees, building communities and proactive stance on business ethics. Actions for these include employee education, community education in safety, green and technology know-how as well as fighting against corruption.

- The environmental agenda consist of using natural resources efficiently and striving to minimise the footprint to leave a positive legacy.

- Part of the economic agenda is choosing projects with care. Projects with notable social and environmental risks are turned down as the risks will not be accepted. As the company sees their role as integrator, it chooses like-minded partners. The company has also acknowledged creating shared value as it is one of the largest employers and it can be stated that most of its revenue is generated and spent locally and for example the taxes paid by the company, its employees and business partners are contributing to well-being of the communities where they operate.

Having both Construction and Project Development operations, the company has a powerful business model that generates financial synergies. The revenues generated by the construction units are not only distributed to company shareholders, but also invested in company's project development streams (Residential Development, Commercial Property Development and Infrastructure Development). These generate high returns and they also bring new projects back to the construction units. Belonging to a financially strong group makes it possible to bid for, and take on, projects that no single company or business unit could handle alone.

3.2 Case project

The case project is a joint venture of the company's different business units including the developer, contractor, mechanical engineering consultant and civil works contractor. As the building was designed to be the head office for company's operations in Finland, all the above mentioned business units occupied the building after it was finished.

The project was part of company's green initiative and the building was designed to achieve LEED Core & Shell Platinum certification. The project was constructed on a brownfield site, which was previously used as a depot. The site was decontaminated prior to construction. The building is situated in a built up urban area in Helsinki, and has easy access to various services and amenities. The building has a total leasable area of 9,100 m2, consisting of eight above ground floors and three basement garage levels. The office spaces are designed to promote healthy working environments and a long useful lifespan through functional and flexible design. The office floors are open planned to allow future users to easily customise their office spaces to suit their requirements.

Property Development unit was responsible for initiating and developing the project until the building permit was valid. After that production and execution responsibilities were transferred to construction unit. Contractor is responsible for construction works, scheduling and procurement. Construction unit's subunit mechanical engineering was responsible for plumbing, air conditioning and electrical installation and systems. Energy savings and functionality of the building is highly affected by these mechanical engineering solutions. The building consumes approximately thirty percent less energy than the local building code requires, which leads to financial savings for the building's owner and tenants. Energy efficient solutions include demand-based ventilation, airtight envelope, occupancy and daylight sensors for lighting and building management system and agreement. Other energy efficiency features include optimal window placement, sunshades to avoid excessive solar heat gain and the need for additional cooling. The building is connected to a city scale district heating and cooling network.

As an innovation the project team used pioneering four dimensional (4D) Building Information Modelling (BIM) to plan the construction of the project with a delivery timeline. The BIM model incorporated construction scheduling, safety and site logistics information, existing underground utility lines and the site's terrain, which was laser-scanned prior to the project. The BIM model helped to improve productivity, reduce waste, enhance safety and reduce disturbance during construction.

3.3 Interview results

The interview focused on identifying the three main ways of creating shared value and whether these can be recognised in the case project. These key concepts included: reconceiving products and markets, redefining productivity in value chain and enabling local cluster development. Interviews were recorded and interviewer made notes during the interview. Later on responses were grouped and analysed. Using this approach allowed themes, issues and concerns to be easily identified and quantified. The interviewed persons were chosen from different stakeholder parties of the project. All of them had taken part in the project either from the design phase or at latest from the construction phase.

Interviewees	A	B	C	D	E
Stakeholder party	Contractor, User	Mechanical engineering	Mechanical engineering	User	Developer
Role/ Title	Sustainability manager	Project engineer production and product management	Design manager	Administrative manager	Project manager

All of the interviewees stated that the target for the project was to be a reference or flagship project promoting know-how of the company. Each party also had their own ambitions for developing and testing new solutions and functionality to gain experience to offer these solutions to external clients. For example mechanical engineering unit tested prefabrication possibilities and demand-based ventilation solutions, contractor tested 4D building information modelling to gain efficiency, user and developer tested workplace and environmental efficiency solutions.

Interviewees stated that brand value was gained as the project had good coverage in media during the process. This can be considered as a part of differentiation and competitiveness actions. Interviewees stated that this coverage led to interest from potential customers and partners as well as competitors. The local community in the surroundings of the project was also regularly informed about ongoing stage of the project.

Developer's target in the case project was to be the most demanding customer of the construction unit. This was described as pushing forward safety, environmental and cost efficiency issues. All the interviewees mentioned environmental certification LEED (Leadership in Energy & Environmental Design) having a guiding role in the project. It was seen as a good tool for communication (both internal and external), setting targets and ensuring that every aspect of sustainability was considered during the project. Yet it was also stated that every solution was not implemented just because of gaining the certification but the choices had to be justified based on functionality and other benefits. Interviewees stated that LEED was affecting on procurement by focusing on purchasing local services and supplies.

Energy efficiency was a focus area that each interviewee brought up. The developer has ambitious targets toward low energy buildings. M&E was interested in developing and testing new intelligent systems and services to minimise energy consumption and user was interested in optimal work conditions and low energy costs. New solutions implemented in the project included prefabrication of corridor ventilation modules, energy follow-up and optimisation service, rainwater harvesting system and testing ways to engage and involve employees to workplace design.

Interviewees also stated that there are weaknesses in the process. Most often it was mentioned that life cycle calculations should be utilised more in decision making and in comparing different solutions. One interviewee stated that there could have been more open co-operation with different stakeholders for achieving the optimal result. Interviewee mentioned that solution to this could be integrated project delivery where the risks and revenues are jointly managed by the stakeholders. In addition interviewees found that there is business and shared value creation potential on rationalising solutions and services. For example commissioning and adjusting is important after the building is completed and taken into use as by commissioning it is assured that building functions as it is designed.

4. Discussion

The purpose of this paper was to explore how shared value is created in built environment. The primary aim was to examine shared value creation in construction project and secondary aim was to find evidence on possible improvements in quality, cost-effectiveness, sustainability and collaboration.

The case company sustainability statements and strategic intentions match with shared value creation principles. For example case company's profitable growth strategy aims to reconceiving products and markets as the company aims to build buildings, infrastructure and services that society need. Image and brand building are vital to a company, yet the corporate image is not created by the marketing messages. The whole value chain and process need to be transparent to meet the desired image. Previous studies have reported that many leaders have realised that there is little growth potential in using same strategies of the same past years. As they search for new strategies, they find that sustainable development thinking opens new ways to grow (Holliday Jr, Schidheiny & Philip 2002). Furthermore shared value creation as inclusive business strategy offers new possibilities to address society needs and profitability to company.

The case project examination shows that solutions carried out in project and different stakeholders' targets can be identified as ways of creating shared value. Porter and Kramer state that shared value by reconceiving products and markets, redefining productivity in value chain and by enabling local cluster development, all these aspects can be found in the case project as follows. Productivity is redefined in value chain by procurement and logistical solutions, material selection principles, new production management solutions such as BIM and minimising waste. The case company enables local cluster development by having a focus on business ethics, diversity and training and educating its employees. In the case project the surroundings were regularly informed about ongoing stage of the project and local services and supplies were procured. It seems also that the case project was used as test-bed to different units to test new solutions and gain experience before they are offered to external customer. This can be seen as good knowledge of experimenting new solutions that are in the future offered to meet customer needs, environmental efficiency and new business opportunities. For example having the knowledge and the information of the commissioning and optimising the building systems in operational phase gives credibility and expresses liability to assure that final product meet design targets. These actions can be seen as reconceiving products and markets. Furthermore environment also benefits from conserving energy as this reduces primary energy use and greenhouse gas emissions from fossil fuels (Airaksinen & Matilainen, 2011).

5. Conclusions

The results of this research support the idea that sustainability and shared value creation components can be identified in case company's strategy and actions. The case company defines itself as a city builder and it has noted that sustainable development is not only about green agenda or environmental efficiency but also about social progress and economic certainty which is in line with shared value creation principles.

Based on case project material and interviews shared value creation has potential to create new business opportunities, improve quality, cost-effectiveness, sustainability and collaboration in a construction project. Yet new kinds of methods and contracts regarding responsibility and revenue distribution to include surrounding community and people to value creation are needed.

Several articles link shared value creation with developing societies and serving the poor, but shared value can be created in advanced economies as well. Opportunities differ, but every company and every community has them. So far, far too little attention has been paid to this opportunity.

This research raised up many questions in need of further investigation. The current investigation was limited to one project within the same company. Further studies of multiple case studies are recommended. Furthermore case studies with stakeholders representing different companies and parties concerned would establish deeper understanding of shared value creation process and its benefits. In addition investigating authority views and targets in a construction projects would provide a wider understanding of social effects.

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Significance of Change Management to Enable Sustainable Outsourcing of Building Operations And Maintenance

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Abstract

In this present globalised era, outsourcing has become a very popular and much sought after procurement strategy for building operations and maintenance. Where competitive business environment is concerned, outsourcing contributes towards reaping supplier specialisation that would either be unavailable or too costly for the organisations to procure. Generally, a sustainable procurement system should be capable enough to deliver the services free of disruptions. However, outsourcing can bring about changes in working patterns, organisational culture and management styles which can possibly disrupt the activities of an organisation. In order to circumvent such incongruities that may result from outsourcing, organisations need to adopt a measured approach towards this change. Accordingly, this research aims to investigate the importance of change management to enable sustainable outsourcing of building operations and maintenance.

Case study was selected as the most suitable research method for this study. The reasons being, the study needed to focus on in-depth decisions and behavioural attitudes of individuals and groups within and between organisations. The study was conducted through a multiple case study that included eight cases which had obtained the services by partial or full outsourcing. Furthermore, the primary source of data was collected through semi-structured interviews and content analysis was used to interpret and analyse significant findings from the interview transcripts. Case study findings revealed that, organisations prefer outsourcing in order to achieve cost benefits and to acquire external expertise. Moreover, if the changes emanating from outsourcing are not managed satisfactorily, it would result in possible disruptions. However, to make changes happen successfully is one of the most challenging tasks faced by the leadership and corporate management of the organisations.

Key words: Outsourcing, Change Management, Building operations, Sri Lanka

1. Introduction

In the last ten to fifteen years outsourcing of building operations has experienced a surge of popularity as many organisations decided to focus on their core business activities (Kadefors, 2008). This trend has been driven by changes in the business environment and the pursuit of lean operations (Hui and Tsang, 2004). According to Willcocks (2010) the sheer size of spending on outsourcing and active involvement of top management executives make outsourcing decisions more strategic in an organisation today than ever.

No organisation can stay competitive in today's rapidly changing global economy by relying solely on its own resources. Outsourcing is a necessary response to today's hyper-competitive environment (Corbett, 2004). However, outsourcing involves redrawing the organisational boundaries and changing the organisational structure. These changes often lead to reductions in the number of employees and changes in the roles and responsibilities of many of the staff remaining in the organisation (McIvor, 2005). Coping with changes caused by outsourcing to both processes and personnel can be one of the most daunting challenges facing by the manager of an outsourcing initiative (Brown and Wilson, 2005). In order to refrain from such conflicts that may result from outsourcing, organisations need to adopt an intelligent approach towards this change (Sridarran and Fernando, 2013). Accordingly, this research aims to investigate the significance of change management to enable sustainable outsourcing of building operations and maintenance.

2. Literature review

2.1 Drivers for outsourcing

Organisations select outsourcing as a building procurement option due to several reasons. Researchers (Borisova, 2011; Brown and Wilson, 2005; Usher, 2003) have identified following reasons as shown in Figure 1.

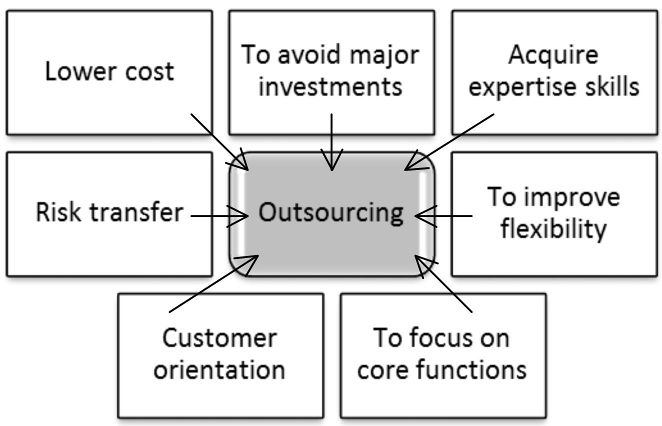

Figure 1: Reasons for outsourcing (Borisova, 2011; Brown and Wilson, 2005; Usher, 2003)

2.2 Types of outsourcing

Over the last two decades, organisations have undertaken different forms of outsourcing, based on what they felt would work best for their circumstances (Gandhi *et al*., 2012). Various authors categorised outsourcing based on different aspects. Researchers (Atkin and Brooks, 2009; De Toni *et al*., 2012) categorised building outsourcing into three categories according to the contract terms and the nature of activities performed. They are;

- Managing agent
- Managing contractor
- Total Facility Management

2.2.1 Managing agent

Organisations can opt to engage an external consultant or specialist who is capable of performing building operations in order to act as a client representative (De Toni *et al.,* 2012). This person (or organisation) is expected to arrange for the nomination of service providers (Atkin and Brooks, 2009). Figure 2 shows the contractual relationship between the organisation and the managing agent. Under this arrangement, contracts with service providers will be with the client organisation.

2.2.2 Managing contractor

In this situation there is one contract between the client organisation and the external consultant (De Toni *et al*., 2012). Subcontractors will be under the managing contractor and will not have a contractual relationship with the client organisation (Atkin and Brooks, 2009). Figure 2 shows the contractual relationship between the organisation and the managing contractor. This shows that the organisation has a single point of contact with the contractor on all matters pertaining to service provision. Thus, if a service falls below the required performance for work carried out by a subcontractor, the organisation need only direct its complaint to the managing contractor (Atkin and Brooks, 2009).

2.2.3 Total Facility Management (Total FM)

The Total FM strategy outsources all support for non-core processes/ services to large Facility Management companies (De Toni *et al*., 2012). While Total Facility Management might appear to provide an ideal solution, because it provides a single purchasing point for the organisation, the reality can be that the contractor actually subcontracts all or most of the work (Atkin and Brooks, 2009). The Total Facility Management contractor may be better able to offer a more complete and competitive solution to an organisation's needs than in the case of the managing agent or managing contractor (Atkin and Brooks, 2009).

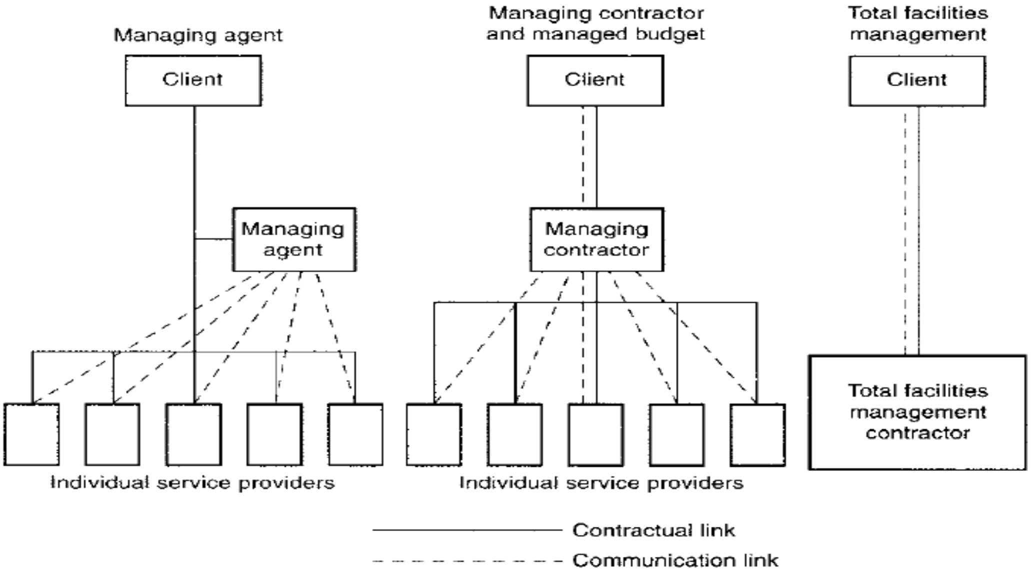

Figure 2: Types of outsourcing and their contractual links (Atkin and Brooks, 2009)

2.3 Impact of change in outsourcing practices

This apparent paradox serves to make organisations realise that, in order to progress in the competitive environment they have to do things better. Outsourcing releases a company to focus on its core business. The point is that change has always been present; it is simply that the rate of change nowadays is so great as to be visible to all (Atkin and Brooks, 2009). Ramanathan (2008) defined change as a movement from the present state of the organisation to a desired future state.

Lacity (2002) on the basis of long term research experience in outsourcing suggests that, the ability to commit to what was agreed, to fairly adapt to change, and to identify value-added services are critical to success. It is well known that people are, for the most part, resistant to change of any sort (Almaraz, 1994). Reasons for such resistance are; fear of the unknown, habit, the possibility of economic insecurity, threats to social relationships, and failure to recognise the need for change (Nadler, 1988). However, to make a successful change is one of the most challenging tasks faced by the administrative force and the corporate management of the organisation. Therefore, if the results of the unmanaged change are to be kept at the minimum, organisations should follow a methodical approach. The usual problems that may arise from the unmanaged change when outsourcing practices are resorted to are discussed below.

2.3.1 Cultural clashes between client and service provider

Rao (2004) defined culture as an integrated system of learned behaviour patterns that are characteristic of the members of any society. It includes all that a group thinks, says, does and makes, customs, language, material artefacts and shared systems of attributes and feelings. The significance of understanding culture for outsourcers is that patterns of thought and behaviour that seem so natural and ingrained in their employees may be quite alien and incomprehensible to the employees of the vendors that they hire. Culture could impact the way individuals interact with supervisors, perceive the importance of group harmony, respond to gender issues and handle quality of life concerns (Gandhi et al., 2012).

In terms of corporate culture, the client and the service provider may have different norms in terms of speed, style, decision making and organisational structure. The fact that outsourcing represents a commercial relationship between two separate entities that can hold on to extreme and inflexible positions also serves as another potential flash point (McCray, 2008; Power, Desouza, and Bonifazi, 2006).

2.3.2 Conflicts of interest when dealing with in-house tenders

Because of the different processes followed by the outsourcing provider while handling the services, the in-house staff may not be very willing to co-operate and take part in the activities carried out by the outside providers (Ikediashi et al., 2012). This can result in active or passive resistance against the entire outsourcing model. Due to lack of co-operation the vendor too may not be able to execute the functions in a way that he feels is best. Later on it may give rise to dissatisfaction of top management and that would finally affect the industrial peace.

2.3.3 Poor mutual understanding

Kern and Willcocks (2000) stated “Outsourcing seemingly is only successful when relations are effective and functioning”. Concerning this, Kishore, Rao, Nam, and Rajagopalan (2003) suggest that mutual understanding between clients and vendors should be developed by adequate mechanisms for information sharing. Once the first contract is signed, the client as well as the service provider will have team members from either side, who would be responsible to manage the initial activities regarding the implementation and the on-going activities. The client’s staffs will be emotionally affected after the changes in the organisation. Then the staffs begin to learn the details of the agreement. Therefore, they may tend to dictate terms to the outsourced party regarding what should be performed and what should be avoided (McCray, 2008). This state of conflict may lead to disturbances in operation.

2.3.4 Poor accountability

The organisation and its outsourcing partner(s) have accountability for obtaining bottom line business results. The organisation is responsible for providing guidance, prioritisation and support to the outsourcer (Sinha and Sinha, 2008). In cases where both the in-house and the outsource providers are expected to work in co-operation and accept the sharing of responsibilities, in order to complete the given task, none of them would be prepared to accept accountability for any downtime or productivity loss (Ikediashi et al., 2012).

2.4 Current outsourcing practices of Sri Lanka

The Facility Management (FM) industry in Sri Lanka too uses outsourcing as one of their procurement strategies. As stated by Nadeeshani (2006), Sri Lankan FM industry is commonly practicing the in-house option. Although, results shows that in-house option is not the best suited method in most of the situations. Furthermore Nadeeshani's (2006) research reveals that outsourcing option fulfils the requirement by reducing the management burden on noncore business activities of the organisation. The satisfaction of the requirement of Sri Lankan FM industry is steadily dropping from the Total Facilities Management, Management Contractor, Managing Agent and the In-house option respectively. It can be perceived that the in-house procurement option do not contribute significantly in reducing the management burden on noncore business activities of the organisation. Nadeeshani (2006) found that during the decision making process of procurement strategy in the FM industry in Sri Lanka, change management issues such as employee reactions, ethical and cultural impacts, willingness to manage possible discords that could arise out of contract in the future, were neglected or received the least of attention. These arguments imply that, there is a gap and a lack of knowledge of the impacts of change that occur during FM outsourcing.

3. Research Method

Case study was chosen as the most suitable research method as the study needed to focus on in-depth decisions and behavioural attitudes of individuals and groups within and between organisations (Woodside, 2010). As stated by Woodside and Wilson (2003), multiple sources are needed to increase the comprehensiveness and understanding of the same event. Therefore, this study selected multiple cases, as it offers multiple sources of evidence and possible replication of findings. Case study boundary is commercial buildings as they are the frequent practitioners of outsourcing. Eight cases were selected for this study in order to achieve data saturation and to get a broader picture of the data sources. Table 1 furnishes the list of cases. Organisations obtaining building operations and maintenance services by partial and full outsourcing have equipped equally in the selection in order to achieve a non-discriminatory solution.

Interview is the most appropriate data collection method for case study researches (Yin, 2009). For this study, semi-structured interviews were deliberated as ideal because it allows the researcher to ask additional questions to follow up on any interesting or unexpected answers to the standard questions (Mitchell and Jolley, 2009). Being so, the interviews were carried out among professionals in the respective industry and content analysis was used to analyse the interviews. The QSR.NVivo; version 7 was used to analyse the data.

Table 1: Profile of the cases

Case	Type of the Organisation/ Core business	Mode of FM outsourcing	Respondent	Profile of the respondent
A	Private Sector – Banking Industry	Fully	A1	Facilities Manager
B	Private Sector - Banking Industry	Fully	B1	Senior Manager - Operations and Maintenance
C	Private Sector – Leasing Industry	Fully	C1	Premises Manager
D	Private Sector – Office Complex	Fully	D1	Maintenance Engineer
E	Private Sector - Manufacturing	Partially	E1	Manager - Infrastructure solutions
F	Private Sector – Manufacturing Industry	Partially	F1	Human Resources Manager
G	Private Sector – Interior Solutions Industry	Partially	G1	Facilities Manager
H	Private Sector – Manufacturing Industry	Partially	H1	Administration Manager

4. Data Analysis and Findings

Collected data were divided into several themes and cross case analysis was carried out separately for fully outsourcing organisations and partially outsourcing organisations. Figure 3 illustrates the structure of the themes. The factors identified from the collected data under each theme were categorised as current outsourcing practices, current change management practices and barriers of integrating change management.

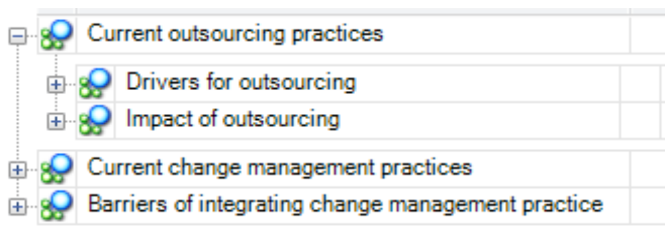

Figure 3: Structure of the themes

4.1 Current outsourcing practices

In order to explore the current outsourcing practices data were collected under two predetermined categories which were; drivers for outsourcing and impact of outsourcing.

4.1.1 Drivers for outsourcing

In the Sri Lankan context, outsourcing is a common procurement practice in commercial building sector. Interview results demonstrated that, organisations undertake outsourcing for diversified reasons depending on the determination of their functions. Table 2 shows the responses of the respondents are subject to the reasons for which they selected outsourcing as their procurement option.

Table 2: Responses on drivers for outsourcing

Reasons	Cases							
	Full outsource				Partial outsource			
	A	B	C	D	E	F	G	H
Cost saving		✔	✔	✔	✔	✔	✔	
Expertise	✔		✔		✔		✔	
Risk transfer	✔				✔	✔		
Top management policy			✔		✔			✔
Manufacturer's agent			✔		✔			
Time saving	✔						✔	
Faster replacement						✔		
Flexibility		✔						
Lack of internal resources				✔				
Single point responsibility							✔	
Avoid major investments					✔			
Concentrate on core business							✔	

Most commonly, organisations go in for outsourcing, in order to have a cost leadership and to acquire external expertise. Responses revealed, the major reasons for selecting outsourcing do not decide the mode of outsourcing (i.e. full outsourcing or partial outsourcing). In order to achieve cost leadership, the organisations have opted for outsourcing and have chosen both full and partial outsourcing. In contrast 'Respondent A1' asserted that, *"outsourcing cost is slightly high compared to in-house but efficiency wise it is beneficial"*. The plausible explanation for such a statement from 'Respondent A1' is presumed to be his non-consideration of the compulsory contributory costs such as EPF, ETF, gratuity and other grants which are borne by the organisation towards its in-house personnel, may not be pertinent to the outsourced employees. Henceforth, the lump sum imbursement made to the outsourced providers may appear to be more. Therefore, outsourcing is undeniably advantageous cost wise.

Risk transfer is another key motive for outsourcing. Though, only three respondents have directly declared risk transfer as another reason, the replies from other respondents too obliquely fell in line. The presumptive reason for the outsourcing approach selection (i.e. full outsourcing or partial outsourcing), will be the top managements' decisions and availability of organisational resources. Other reasons listed by the respondents were related to their corresponding fields of expertise.

4.1.2 Impact of change in outsourcing practices

The outcomes from the interviews imply that, the change due to the entry of another organisation makes an impact on the efficiency of outsourcing. Table 3 shows the issues as encountered by the respondents.

Table 3: Responses on issues of outsourcing

Issues	Cases							
	Full outsource				Partial outsource			
	A	B	C	D	E	F	G	H
Poor understanding of scope of the work		✔		✔	✔		✔	✔
Works may be performed in different ways	✔			✔	✔			
Poor communication			✔	✔		✔		
Cultural clashes		✔			✔			✔
Conflict of interest				✔	✔			
Poor mutual understanding		✔			✔			
Comparisons		✔						
In-house staff resistance	✔							

All the respondents agreed that, there will be an impact because of change due to outsourcing. As well as, they have listed multiform of issues arising out of full outsourcing. Conventionally, the vendor organisations lack an understanding of the requirements of the client organisation. Endorsing this, 'Respondent B1' stated that, *"They will not feel the pulse of our organisation"*. The effect of this issue will be high on the organisations which outsource FM services fully, than the organisations which outsource partially. Because, fully outsourced organisations are totally dependent on the outsourcing organisation. According to 'Respondent G1' poor understanding of the scope of the work, affects organisations which have a partially outsourcing model in a distinct way. Due to the inadequate understanding of the scope of their work at the beginning by both in-house and outsourcing parties, one party may compete to keep ahead at the expense of the other. This may possibly reduce the efficiency of the outsourcing process. The impacts of cultural clashes also are high compared to fully outsourced model, as the involvement of in-house staff is high in this model. Comparatively other issues are lesser, since they are not totally dependent on the outsourced party and they can back up with their in-house staff in an event of urgency.

Based on the respondents' views, another collision arising from full outsourcing is that the performance will vary. Basically outsourcing is a strategy to reap supplier specialisation that would either be unavailable or too costly for the organisation to procure, within the limited time. The impact can be high in cases where the outsourcing organisation proposes a replacement of specific machinery or a change of work procedure which cannot be borne by the client organisation. Furthermore, the discrepancy in the organisational culture of the client and vendor organisation can bring about interruptions. 'Respondent B1' avowed that, *"The outsourcing company is having a relax kind of discipline and times whereas the bank is very strict on timing"*. It emphases the disruptions originating from the cultural differences. Another reason is based on 'Respondent A1's statement. That is, the effect can be high, if an organisation has been an in-house model for a long time and then changed suddenly to an outsource model. They may have to select some of their in-house staff and retire them. Consequently, they may face problems from employees who resist the change and problems about labour law which restricts such retirements.

On the contrary, 'Respondent F1' stated that, *"If the management is vigilant and proactive they can avoid such conflicts before they arise"*. Nevertheless, Respondent F1 is also agrees that there are possibilities for conflicts. Based on all the respondents' responses it can be concluded that there is an impact caused by change which can affect the effectiveness of the outsourcing and it should be mitigated. Figure 4 illustrates the cognitive map showing the relationships between outsourcing and its issues. This shows the relationships of factors which decide the reasons for outsourcing and the impacts of outsourcing.

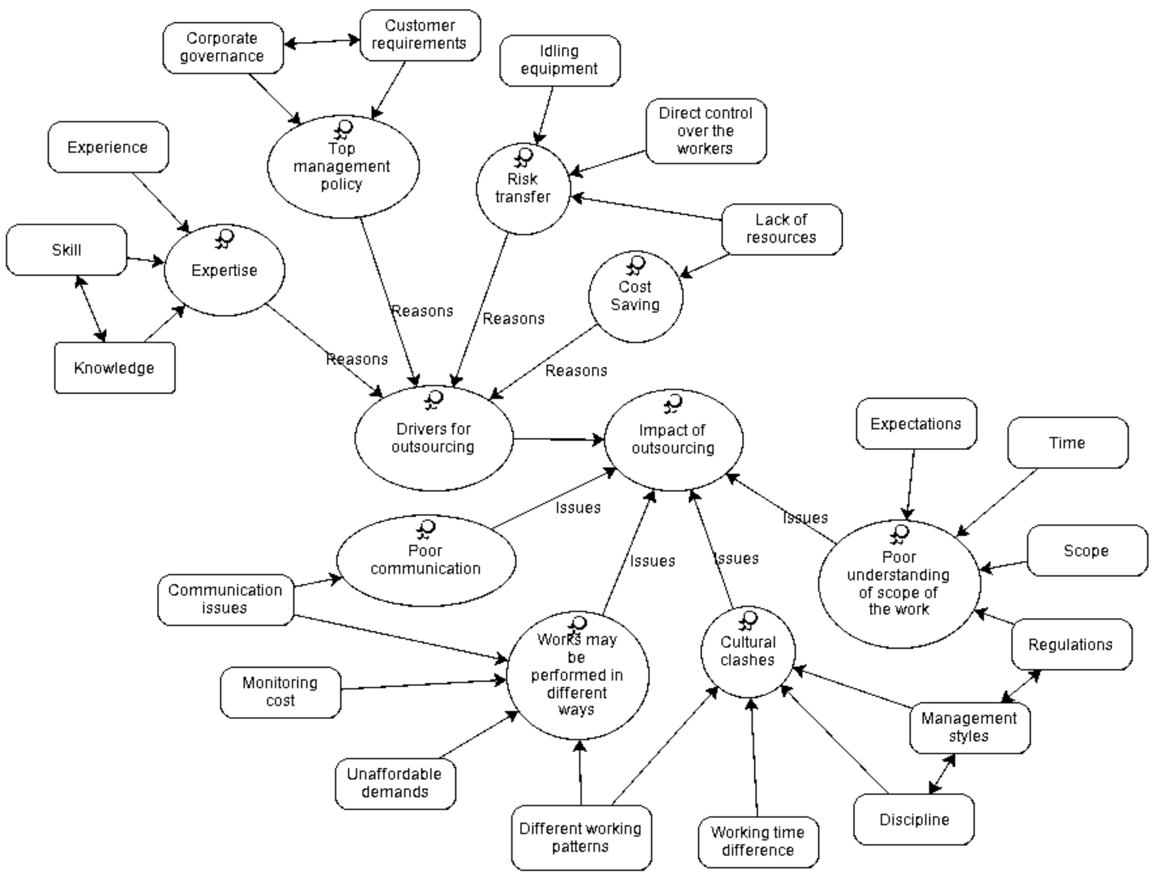

Figure 4: Cognitive map for outsourcing and its impacts

4.2 Current change management practices within the commercial building sector

Organisations have encountered manifold disagreements due to inadequate management of outsourcing change. Besides, restorative actions are taken by them to eradicate such problems, being incognizant of the root causes. Although some of those restorative actions can resolve the problems permanently, most of them are provisional. This may lead to the same problems all over again. In the Sri Lankan context, managing changes associated with outsourcing is yet in its inceptive level. Almost all the selected organisations attempt to communicate the scope and commitments as soon as a problem arises. Nevertheless, this should be done during signing of the contract. Another method of handling these issues is, training the in-house staff continuously in order to cope with the outsource parties who are experts in the given field. By encouraging team work between both the parties is also another approach which would avoid conflicts. Apart from the aforementioned practices, constant monitoring of employees, informing both the positive and the negative stake-holders prior to change, maintaining loyal relationships with outside providers, offering better packages, are also practiced by the FM practitioners in order to gloss over conflicts.

4.3 Barriers in integrating change management practices

In general, organisations conceived the impression of following a proper process, to manage the outsourcing change, to ensure the result. On the other hand, organisations found themselves confronted by various barriers to execute such strategy subject to their form of outsourcing. One of the significant barriers encountered by the Sri Lankan commercial building sector, regarding integrating change management with FM outsourcing is unawareness. Because of the lack of attention on the part of the organisations about discovering the root cause of the conflicts, they cannot adopt the appropriate process for the solution. The results of the analysis substantiated that a pre-planned decision support process can be beneficial for the organisations, to execute their outsourcing process more efficiently.

5. Discussion

The Sri Lankan commercial sector organisations are outsourcing their FM services in order to achieve cost control and to curtail the encumbrance to the management. Literature (Borisova, 2011; Brown and Wilson, 2005; Usher, 2003) also explains the same, as the reasons. Since the outsourcing is involved with third party providers, it brings changes along with it. As specified in the literature (McCray, 2008; Power, Desouza, and Bonifazi, 2006), in the Sri Lankan context also, all the organisations have experienced issues such as poor understanding of scope of the work, poor communication, cultural clashes and difference in working patterns without realising the root cause for the issues. As Nadeeshani (2006) stated, the organisations are paying less attention to the employee reactions, ethical and cultural impacts, and willingness to manage possible discords that could arise out of contract in the future during outsourcing decision making. If the organisation is not prompt to accept changes, disruptions arising are a possibility.

The evidences proved such issues can affect the efficiency of the outsourcing. Besides, restorative actions are taken by them to eradicate such problems, being incognizant of the root causes. Although some of those restorative actions can resolve the problems permanently, most of them are provisional. This may lead to the same problems all over again. In the Sri Lankan context, managing changes associated with outsourcing is yet in its inceptive level. Exercising some of the practices as an instant remedy will not eradicate the root cause of the problem. Therefore a need to adapt a systematic process is essential for the organisations.

However, the organisations found themselves confronted by some barriers on implementing such systematic processes. The main barrier encountered by most of the organisations is unawareness. The organisations' management and staff are not acquainted with change management practices. And the organisations also cannot afford to obligate change management teams or agents. As a result, the importance of adapting such systematic processes and the benefits they may bring into the organisation remain unidentified by the organisations. Furthermore, without a pre-planned procedure, organisations cannot implement such processes. Therefore the facility managers should identify and understand the significance of change management during outsourcing practices and implement it in an effective manner.

6. Conclusion

Outsourcing is one of the widely adapted procurement practices by building management practitioners. Sri Lankan commercial building sector organisations prefer outsourcing in order to achieve cost leadership, and to acquire external expertise. Hence, organisations' key intentions have been curtailed to reduce the cost. As such, concern over the soft aspects such as the ability to coordinate, organisational culture is presumed to be neglected during the selection of the vendors. In addition, occasionally manufacturers appoint their agents as outsource providers to service and maintain the plant and machinery manufactured by them. In such instances, organisations are not given an opportunity to consider outside providers' compatibility with the organisation. Successively, the efficiency of the outsourcing can get affected and attributed to the aforementioned facts. Furthermore, analysis substantiated that, if the organisations were not willing to admit changes arising out of outsourcing, disruptions can originate. In order to avoid the disagreements that may result from outsourcing, organisations need to adopt a measured approach towards this change to ensure the sustainability of the outsourcing practices. Ultimately Facility Managers should recognise the contributory element of change management and implement it to ensure the effective operation of buildings.

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Improving Life Cycle Management by employing BIM in Real Estate Management – Case Study

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Abstract

BIM – Building Information Modelling (and Management) is generally used during the design and construction phase of the buildings life cycle. The applicability and added value of BIM in real estate management (REM) has received little attention and interest from investors and operators – implying the question; how can BIM be better utilized to create value for stakeholders in the maintenance phase and thus improve life cycle management?

The purpose of this research is to identify opportunities and challenges when employing BIM into REM. In particular this paper aims to identify the benefits of BIM for different stakeholders within REM in order to demonstrate added value and improved life cycle management within the building sector.

The reported findings are primarily based on a qualitative case study of a hospital PPP-project in the construction phase where BIM has been set high on the agenda. By conducting interviews with different stakeholders the results are analysed using a theoretical lens of technological frames in order to understand the underlying opportunities, challenges and benefits that stakeholders perceive regarding BIM.

The results indicate that in this particular case study life cycle management can be improved through employing BIM. The perceived benefits gained through improved information management are related to cost-, time- and resource efficiency in the buildings operational phase.

There are feasible opportunities to be considered and developed for FM operators and investors now and in the future. Findings suggest that by comprehensively extending and employing BIM into Real Estate Management, more value can be attained from a life cycle perspective.

Keywords: Building Information Modelling, Life Cycle Management, Real Estate Management

1. Introduction

Building Information Modelling (and Management) (BIM) tools and applications are intended for use across the building project lifecycle, but so far the BIM processes and usage are more developed to support the design and construction phase. Accordingly, BIM has been a significant game changer within architecture, engineering and construction (AEC) industry. By using BIM tools and applications, projects can be achieved with lower costs, reduced delivery time, and increased productivity and quality (Azhar et al. 2008). The BIM model includes data set consisting of spatial relationships, geographic information, quantities and attributes of building elements and components, cost data, material data and project timetable, all relevant data to portray the buildings life cycle (Bazjanac 2006). It has previously been shown that a significant return on investment can be achieved by employing BIM in design & construction activities (Azhar 2011). Effective BIM management and usage can support integrated project development, the approach of integrating people, systems and practice into a collaborative process, thus enabling optimization possibilities from a project life cycle perspective (Glick & Guggemos 2009).

While BIM usage is continuously growing within the design and construction phases, there are fewer convincing examples or indication of benefits of BIM in the operation and maintenance phase of the project life cycle (Becerik-Gerber et al. 2011). Holmström et al (Forthcoming) suggest that even the evolution of BIM tools and applications for the operations and maintenance phase have been relatively slower than the development of BIM tools for design and construction phases, because the demands from the markets and stakeholders for BIM have been focussed around design and construction. Since BIM is seen as a significant investment in the design and construction phase, it appears logical, as also argued by others (e.g. Kiviniemi 2013), that the investment should be further exploited and utilized for the next phase of the buildings life cycle to obtain a better return on investment. Thus, there has to be value to capture for stakeholders who operate in the real estate management (REM) sector. However, given that BIM usage in REM is negligible, it is reasonable to say that either the investors and operators are not aware of the potential benefits of BIM to REM, or they do not agree with the potential benefits, or they do not know how to go about extracting the potential benefits, or they are simply not interested in the claimed benefits. Therefore, as a starting point, we need to investigate the prevalent perception of the potential benefits of BIM to REM across the relevant stakeholders.

Perhaps, current use of BIM is too focused on delivering the projects, rather than adding value to the project from a life cycle perspective. Andersson and Jonsson (2013) identified that value can be captured by BIM in Facility Management (FM); especially increased control of assets was identified as the greatest value. Eastman et al. (2011) emphasize that significant benefits such as higher quality and better performing buildings for owners can be achieved by utilizing BIM processes and tools in projects.

Within the design & construction sector BIM technology adds value by reducing costs and delivery time. Although, in REM the value created is not only in cost reduction, but in a more holistic value concept were stakeholders are the main focus (Jensen et al. 2012). Jylhä (2013) claims that one identified source of waste (counterpart to value) within real estate services is poor information management. Thus, by implementing BIM to the REM phase of the buildings life cycle, it should be possible to reduce waste and add value for various stakeholders through improved information management. By advancing BIM into the REM phase, a life cycle perspective is established, suggesting that information created within the design and construction phase can be used in Asset Management (AM), Property Management (PM) and Facility Management (FM). Through efficient use of this information, life cycle management can be improved and benefits for different stakeholders can be identified and delivered.

Therefore, this paper focusses on the opportunities and challenges when employing BIM into REM. In particular, we investigate how the different stakeholders within REM perceive the benefits of BIM for improved life cycle management within the building sector.

This paper begins with a background and literature review (section 2) where the management practices of REM are reviewed along with stakeholder interests. In section 3 the research design and methodology is explained. The results are presented in section 4, followed by a discussion in section 5. Section 6 concludes with a review of the key contributions of this paper.

2. Background and Literature Review

The background study was conducted in two parts. Initial information and perception of BIM in REM were also obtained during a two-day workshop/seminar on BIM for Facilities and operations management (Singh 2013). The workshop included four invited expert presentations on the workshop theme, one panel discussion, and one break away session in smaller groups. There were forty participants altogether, with nearly one-third industry representatives, while the rest of the participants were from research and academia. While a detailed review of the workshop discussions is out of scope for this paper, following are the key observations from the workshop that also guided the literature review: (1) Despite a general acknowledgement that BIM can potentially improve later lifecycle management, including REM, very little effort has been made to use BIM in REM; (2) There is a lack of clarity on the purpose and scope of BIM with respect to later lifecycle management, that is, there is a mix-up between concepts such as asset management (AM), corporate real estate management (CREM), facility management (FM), and property management (PM); (3) The lack of BIM usage in REM is more of a social and perceptual issue than a technical challenge.

Following the workshop observations, a literature review is carried out through the management aspects (AM, CREM, FM and PM) and stakeholders interests within real estate management. Applying these aspects, we seek to understand feasible BIM benefits for stakeholders for whom buildings and facilities are developed.

2.1 Real Estate Management

As the real estate sector is characterized as highly interdisciplinary, different stakeholders are interested in different management aspects. Real estate management is divided into the following management concepts; Asset Management (AM), Corporate Real Estate Management (CREM), Facilities Management (FM) and Property Management (PM). The use of these concepts differs according to the building's ownership arrangements (Brown et al. 1993).

2.1.1 Asset Management

Asset Management (AM) is generally defined as: real estate management through creating a (specific) real estate portfolio by buying, selling and developing properties and supervising their cost-effectiveness (Rakli 2001). Then and Danny (1992) underlines that AM covers the entire scope of real estate business, covering facility-, maintenance- and financial management. AM is an information intensive process where BIM could be used as gathering the needed information to one source accessible for all parties involved.

2.1.2 Corporate Real Estate Management

Corporate Real Estate Management (CREM) is defined by Bon et al. (1994) as: "An organisation that occupies space is in the real estate business, as well, and needs to manage it properly. CREM covers the entire range of activities concerning building and land holdings held by an organization, starting with investment and finance, through construction and facilities planning management, to reuse and disposition of property". BIM perspectives could be brought in especially for production facilities. CREM is mainly about supporting a company's core business, and if the facilities can enhance the production or services, it should be utilized to its full potential. For example; evaluating possibilities for extensions or downsizing, logistics, automation or material flows.

2.1.3 Facility Management

Facility Management (FM) defined by Brown et al. (1993) as follows: "Facilities Management is the general function of co-coordinating the needs of people, equipment and operational activities into the physical workplace. When performed by an in-house corporate organization, it usually refers to performing those activities dealing with the acquisition and disposition, physical upkeep, record keeping and reporting tasks for corporate-owned real estate". Furthermore facilities planning (as a part of FM) is "process of developing general and precise information about real estate assets for the purpose of assisting facility decision making, developing policies and procedures for facilities operations, construction planning, cost estimating and value engineering and conducting other activities to provide efficient asset management" (Brown et al. 1993). As outlined above, in FM there are multiple issues and interfaces to consider and manage where BIM could add value and improve processes and performance of delivering FM services, thus creating value for the owner.

2.1.4 Property Management

Property Management (PM) focuses on the maintenance perspective through upholding the building at a proper condition throughout its life cycle. In other words, PM is overseeing day-to-day measures in the facilities (Brown et al. 1993). PM is maybe the most technical of all real estate management segments. A comprehensive BIM model could provide valuable information for maintenance and long-term planning of the building. Another dimension to technical management is explored by Koskelo (2005) in her dissertation where a strategic method for technical life cycle management (TLCM) is presented. Koskelo attempts to create a concept (TLCM) for managing facilities through a life cycle perspective which will enhance cost-effectiveness, quality and risk management. Technical information could be well managed through use of BIM.

2.2 Stakeholders within Real Estate Management

Various stakeholders are interested in different management aspects within REM. According to Fisher and Collins (1999), stakeholders within REM are developers, contractors, financial institutions (banks), investors and occupiers. In addition, FM/PM providers have a vital role in providing real estate services and maintenance. Driven by investor interest, real estate management focuses mainly on maintaining real estate assets with an optimal cost while maximising cash-flow for the investment. According to Eastman et al. (2011) there are substantial benefits to be gained by BIM in processes and tools, e.g. increased building performance and optimization of facility management and maintenance.

When exploring these different real estate management concepts and stakeholder interests, we recognize that there are possibilities to add value through BIM, and it may be beneficial to consider using BIM as a central data base for all kinds of information to be used in AM, CREM, FM and PM (Kiviniemi 2013).

3. Research Design and Method

This exploratory study utilises a qualitative research design in form of a case study. A case study is an in-depth analysis of a specific case (project) which is bound to specific character and time scope from where a variety of data is collected (Creswell 2013). In this study 10 in-depth interviews were executed representing three different stakeholders and various positions within the project. The interviewed stakeholders in this project were investor-developer (4), D&B contractor (2) and FM provider (4). Open-ended interview questions were prepared in accordance with the analysis concept of technological frames (see chapter 3.2) to structure and guide the interviews. The interview questions can be seen in the end of this study.

3.1 Case Study: PPP-project – Nya Karolinska Solna University Hospital

The Nya Karolinska Solna (NKS) PPP-project is a state-of-the-art university hospital currently in the construction phase in Solna (Stockholm County), Sweden. As the largest PPP-project in Scandinavia the hospital complex comprises about 320,000 m^2 and will be completed in 2017. To execute the PPP-contract a project company was established to manage design, construction, financing, FM operations and maintenance, and life cycle replacements until the year 2040. The project company has further subcontracted design and construction to a contractor entity and a comprehensive facility management scope to an FM service provider, leaving the project company with life cycle responsibility of the facilities. (Nya Karolinska Solna 2013).

BIM has been set high on the agenda by the client and within the project consortium (project company, contractor and FM provider). The client has requested that an updated BIM model/database is to be handed over to the client in 2040, which means that the BIM model produced in design is to be utilised in FM operations and kept updated. The project consortium has therefore recognized the potential with BIM adding value during the whole contractual concession/life cycle (30 years).

Combining BIM to a PPP-project to add value has been studied by Ganah & John (2013); the conclusions are that there is value to be attained by a formal information management system to support operation and maintenance in post-construction for the public sector (client). Furthermore, information management through BIM can support decision making processes within complex PPP-projects.

It is to be noted that the outcome of this particular study is case specific. However, as the focus on utilising BIM in the operations & maintenance is established, it is valuable to investigate the opportunities and challenges, as well as the added value for different stakeholders during the life cycle.

3.2 Analysis through Technological Frames

Since BIM is perceived as novel technology within REM, an analytical perspective to understand technological development, use and change in organisations (stakeholders) is offered through technological frames. Technological frames are a systematic approach developed by Orlikowski and Gash (1994) to analyse how different stakeholders understand the nature- (1), strategy- (2) and use (3) of technology (BIM) and the dependency between these three domains. The assumption is that different stakeholders have different technological frames – the target of analysis. By employing this theoretical lens we intend to identify opportunities, challenges and benefits for different stakeholders when employing BIM in REM.

4. Results

The results reveal that all three stakeholders share roughly the same understanding (nature) of the BIM technology; to structure and manage information in order to improve communication and performance. The strategy of the technology is similarly shared by all stakeholders as they all strive for performance improvement in their respective operations in terms of cost and time reduction. Whereas, when it comes to the use of technology; for the D&B contractor BIM is used as a central tool in creating the design, while for the investor-developer and FM provider, BIM is envisioned as an optional information data base for supporting operations. A general overview of the stakeholders' technological frames can be seen in Table 1.

More specifically, according to the D&B contractor one major challenge was the difference in understanding the content of the model used in D&B and facility maintenance. The content of the model (used in D&B) has to be expanded with new objects and assets which are to be managed by the FM provider. This could be managed better if the FM provider has a clear vision to order the right BIM content (parameters, classification and specification) for their operations. The D&B contractor emphasized that even though new opportunities are to be discovered with BIM in the operational phase, there still was more to learn and utilize in terms of the D&B phase.

It appeared obvious that the FM provider sought to achieve more resource and time effective performance by utilizing BIM. As objects and assets to be maintained would be traceable and easily identified in combination with having the right information (maintenance history and service manual) this would result in improved errand management. Several FM provider representatives presented a novel method were FM service operations could be turned from reactive to proactive maintenance; by gathering maintenance history data and easily combining it with a certain place and time, deeper analysis can be made to proactively maintain the facility and foresee measures to be done – creating a dynamic proactive FM service method. Combining maintenance history with a place and time would also improve managing and optimizing long-term maintenance costs, thus, lower life cycle costs can be achieved. In order to gain these benefits it would be essential that the FM provider would be involved in agreeing the scope of the created BIM dataset.

The investor-developer representatives clearly understood the effort and significance of the investment in BIM during D&B phase; thus, the initial investment should be utilized with a long-term strategy. The investor-developer revealed that the direct value would be directed to the FM provider. If utilized profitably an indirect value could be obtained to the investor-developer. The impact on sales value seemed unclear, although, with current technological development it is possible that BIM (or a similar information system) would be required, therefore a slightly higher sales price could be justified. On a long-term the investor-developer believed that by managing accurate data of the facility, technical risks and life cycle costs could be improved in cooperation with the FM provider.

One of the greatest challenges identified by all the stakeholders was the lack of overlapping interests. Especially the nature of operations between D&B contractor and FM provider are dissimilar and thus creating a gap in the development. All the stakeholders agree that there is a positive effect on life cycle management by employing BIM to REM.

Table 1: Stakeholders general overview of the technological frames

Technological Frames (Orlikowski and Gash, 1994)	*D&B Contractor*	*Investor-Developer*	*FM provider*
Nature of Technology - refers to people´s images of the technology and their understanding of its capabilities and functionality	*Structured Information management and improved communication between designers, consultants and contractor during the design and construction*	*To manage and utilize precise information of the relevant items concerning the maintenance and services of the facility*	*Structuring and managing information (assets/objects) to one common place in order to improve FM services by linking functions to a location in the facility*
Technology Strategy - refers to people´s views of why their organization acquired and implemented the technology	*To achieve higher quality, improve safety measures, decrease costs and improve timetable management during design and construction*	*Improving efficiency by cutting costs in the design and construction phase, improving operational performance (cost and time) for the FM provider and attaining lower life cycle costs*	*Improving operational service efficiency (cost and time) by having the right information at the right time Changing from reactive to proactive FM methods*
Technology in Use - refers to people´s understanding of how the technology will be used on a day-to-day basis and the likely or actual conditions and consequences associated with such use	*The BIM model was created by designers (in co-operation) and is being utilized in the construction phase to improve the overall delivery process*	*Valid information can be easily shared, analyzed, and used in reporting (asset management)*	*The BIM model is used on a daily basis for communicating, managing errands and incidents, reporting, analyzing data, performing maintenance rounds and used for maintenance planning*

5. Discussion

The results of this study uncover and identify opportunities, challenges and benefits to improve life cycle management by extending BIM to real estate management. The distinguished benefits are associated with lower life cycle costs and improved management of facilities technical risks. Critical challenges for this BIM transmission to REM is the lack of similar interests between the stakeholders resulting in different demand in formalizing the content of the BIM data to be used by multiple stakeholders (especially between D&B contractor and FM provider). Opportunities are recognized in the operational phase regarding a potential increase of the facility value (sales price) by the investor-developer, and developing a resource efficient proactive FM service method for the FM provider.

When connecting the case study to the management aspects of REM, the investor-developer stakeholder is responsible for AM and partly PM (life cycle responsibility), the FM provider undertakes FM and the remaining PM maintenance services. CREM responsibilities can be understood as transferred to the project company from the client/user in this particular case study. The results of this study uncover that there is added value to be obtained regarding REM; direct value for FM and PM, and indirect value within AM. Primarily, the added value is attained through cost and time savings in respective REM operations.

The outcome of this study is in line with Eastman et al. (2011) that significant benefits can be realized through BIM processes and tools in favour for the owner. The benefit of increased control of assets declared by Andersson and Jonsson (2013) is also seconded by this study.

In terms of validity, as a case study, this study is case specific and thus, not to be generalized outside the case study scope. Additionally, the high emphasis on BIM in this case is partly driven through contractual requirements which are not customary; therefore, it is challenging to verify if this development initiative would be commercially feasible. The validity of the empirical data can be criticized by the selection of interviewee's. In order to attain a decent understanding of BIM to utilise the technological frames framework, the interviewee's had to be somehow familiar with the BIM technology and its functionalities, consequently, the outcome of the study is reflected as more "advanced-thinking". These validity deficits can be accepted, as the purpose of the study was to identify opportunities, challenges and benefits for different stakeholders when employing BIM in REM.

5.1 Improving Life Cycle Management

Results of this study indicate that by properly employing BIM in REM, life cycle management can be enhanced through improved information management during the buildings life cycle. Lower life cycle costs and improved risk management of the facilities risks were seen as the main benefits. An analogous theory is presented by Väyrynen (2010) in an extended scope of urban (area) development, where she claims that one of the root causes for problems in the urban development process is discontinuities in transferring knowledge during the life cycle of the urban area. This view is shared by Jylhä (2013) in the real estate service context, where poor information management is seen as a barrier for creating value.

BIM has a significant role within decision-making during the buildings life cycle. For example, a recent study of an residential urban development case study reveals that by utilizing BIM in the master plan phase, more viable (economic and environmental) energy options can be identified from a life cycle context to support decision-making (Ristimäki & Tulamo 2013). Lützkendorf & Lorenz (2005) present that, the life cycle of the building should be perceived as a key performance indicator in decision-making, when valuing properties in the future.

6. Conclusions

This study has explored and identified opportunities, challenges and benefits in using BIM in REM. The identified benefits for different stakeholders are strongly associated with improving respective operations in terms of cost and time savings. Additional long-term benefits are achieved through lower life cycle costs and improved management of facilities technical risks. Recognized opportunities for the FM provider are new cost and resource effective operation methods, switching from reactive to proactive services through improved information management. The investor-developer identifies a possible sales premium in an asset where BIM is implemented to support information management. Two major challenges were identified. Firstly, there is a considerable gap in how different stakeholders (especially between D&B contractor and FM provider) understand and use BIM in their respective operations; this may lead to an impractical fragmented data set. Secondly, there is a lack of same interest between all the stakeholders which challenges the development.

Furthermore, the results revealed that life cycle management can be enhanced through improved information management during the buildings life cycle. Thus, long-term added value could be gained by different stakeholders within REM.

This research is only the beginning of employing BIM and information management from design and construction phase to operations and maintenance within the building sector. The next steps would be to investigate actual return on investment for the operational phase and thus advocate the interest of investors and other stakeholders within REM in order to create a more coherent information flow throughout the life cycle of building’s.

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Interview Questions

1. What is your ***vision*** with the integration of BIM to REM?

2. What ***opportunities*** do you envision in the future through the integrated BIM platform? (1) To whom (2) Added value for the project

3. What ***benefits*** do you perceive through the integration of BIM for ***your stakeholder group***? (1) Short-term (2) Long term

4. What ***benefits*** do you perceive through the integration of BIM for the ***Project*** (PPP-contract)? (1) Short-term (2) Long term

5. What ***challenges*** (technical, organizational, social) are there in the development and implementation of the integrated BIM platform? Do all the stakeholders in the project share the same vision of benefits in using BIM? If not, where is the greatest resistance? What do you see as the changes in the technology, process or business that is likely to make them a willing BIM user?

6. How do you see the ***functionality*** of the integrated platform on a day to day basis? How can daily/monthly/annual performance be executed in a more resource effective way?

7. By integrating BIM to REM operations; what ***affect*** will it have on ***life cycle management***?

Developing a monitor for the characterisation of supply chain collaboration and the measurement of its effectiveness in the Dutch social housing sector

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Abstract

In the Dutch building sector, and in the social housing sector in particular, supply chain collaboration between housing associations and their supply chain have been quite popular since last five years or so. Many associations and their supply chain partners have tested, and in many cases continued to apply various representations of supply chain collaboration. This has varied from newly built houses to maintenance of existing stock, and many other characteristics influencing the collaboration. In all cases the parties involved have aimed and hoped for better performance of projects as a consequence of applying supply chain collaboration. Two main issues have arisen amongst the associations and their supply chain partners: How do various representations of supply chain collaboration applied by different parties relate to each other characteristically? How does supply chain collaboration in projects of different kinds influence the performance outcomes of these projects, and thus give evidence of the appropriateness and effectiveness of supply chain collaboration. Therefore a supply chain monitor has been developed as an instrument to assess the levels of the resources and processes in projects, versus the performance outputs and outcomes of these projects. This paper presents the background, purpose, development and structure of the supply chain monitor and compares it to other models, in order to discusses the internal validity and usefulness of the monitor to characterise supply chain collaboration and measure its effectiveness in projects.

Keywords: supply chain collaboration, social housing, taxonomic characteristics, measurement, effectiveness.

1. Introduction

As in many other sectors supply chain collaboration has been shaped by the context of application. In its specific context the application of supply chain collaboration in construction has been shaped. The organisational approaches to supply chain collaboration have particularly been influenced by the one-off, temporal nature of projects; the large number of firms involved in the definition, design, manufacture and assembly of built objects involving many relatively small firms; the dispersed power and governance regimes; and the initiating role of clients. These characteristics and other specific aspects of building have influenced how firms in the building industry operate, how they manage their inter-firm relationships, and thus, how they collaborate. In order to address improvements of this situation, managerial and organisational arrangements as part of collaboration between firms need to be addressed.

A more integrated approach to supply chain collaboration has been suggested as a solution to the many problems and deficiencies existing in building, including the social housing sector. On the other hand, the restrictions on increasing the level of integration in building also need to be taken into account. The underlying principle of supply chain collaboration would be that the supply chain that is delivering a single product should not be fragmented nor consist of distributed functions. Instead, supply chain collaboration would lead to a more stable and repetitive production environment. The premise here is that the supply chain would function better when approached and reconceptualised as a single entity, an extended enterprise or a single virtual organisation. The deeper issue here is whether the industry could or should develop itself structurally towards the standards and practices of a more integrated and repetitively operating industry, and improve performance levels consequently (Vrijhoef 2011).

2. View on the Dutch social housing sector and the trend towards supply chain collaboration

Social housing in The Netherlands is the domain of housing associations. The Dutch social housing sector is larger than in most countries. Roughly one third of the total housing stock is labelled as social housing, 10% is privately rented, and 55% is privately owned property (CBS 2012). Housing associations are organizations which function as hybrid organizations between state and market: They are bound by legislation to primarily provide social housing for households with lower incomes, and households and individuals with special needs for care. On the other hand they can act as private parties being active on other (commercial) domains of the real estate market as well. This made housing associations relatively free to decide how to finance and organize their investments and activities in housing and other real estate development activities. Recent years, however, changes in European and Dutch governmental rulings have forced housing associations to diminish their commercial activities. Combined with the economic crisis, housing associations are forced to come up with different and new strategies to be able to finance and invest in the (re)development and maintenance of their current stock. One of the strategies to do so is to improve their real estate development and maintenance process.

Housings associations are typical parties on the Dutch social real estate market that perform all real estate management disciplines that regular developers would do, but in a social context including the care of neighbourhoods and its inhabitants (Figure 1). Based on this wider responsibility, they can be viewed as 'social investors', not only on the level of classical types of fund, portfolio, asset and property management of real estate development (Van der Kuij 2014). But it includes issues of social well-being and care of often socially weaker types of users. As a consequence, in contrast to many 'regular' developers on the 'normal' real estate market focussed on a limited number of activities, housing associations are used and expected by their users and governments to perform more varied activities and different types of roles typically connected to social real estate.

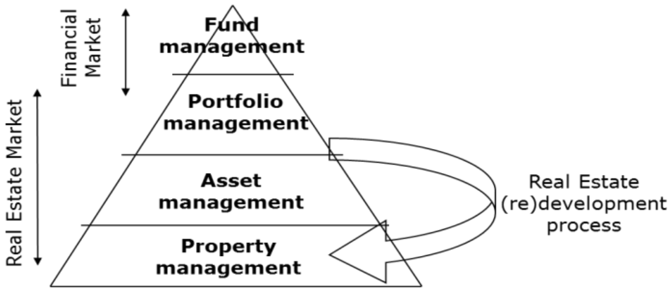

Figure 1: Real estate management disciplines

Most of the recent efforts to apply supply chain integration and strategic forms of collaboration to the Dutch building industry have taken place in new house building, notably by housing corporations in cooperation with large builders (Building Business 2010a). In addition, a few housing corporations have begun to apply supply chain integration to their renovation programmes as well (Building Business 2010b).

3. Introducing the supply chain monitoring project

3.1 Background of the supply chain monitoring project

The aims of applying novel types of supply chain arrangements have deemed to lead to increased process efficiency, increased customers satisfaction and the contribution to such goals including sustainability, liveability and energy efficiency. Explorative research in the past years, such as Koolwijk (2013), contribute to the belief the supply chain integration leads to promising results on these fields. However, from their background, as explained, housing associations are used to coordinate the activities themselves and therefore they are sceptical towards integrated models and innovation of the process on 'how they always performed'. The 'believers' in supply chain integration are convinced of the possible improvements in the process. Housing associations in general, however, still need to be convinced by actual facts and figures on what process changes really are effective.

Based on this idea, a group of leading housing associations having experimented with various, in some cases 'home grown' applications of supply chain collaboration and the main contractors involved in those collaborations have showed to be eager to know the typical differences and similarities of their respective approaches, and the effects those approaches have in projects, for instance compared to traditional projects.

3.2 Purpose of the supply chain monitoring project

Since 2008 housing corporations have shown increased interest in the principles of supply chain collaboration. Individual projects have shown variable improvements. the development and introduction of an integrated process format, the application of new collaborative tools and working methods has been a part of the supply chain integration. In terms of collaborative working methods, the integrated process formats applied have included various ways of collaborative working and supportive measures to facilitate supply chain integration on an operational level. One can distinguish a number of issues that are of importance for the successful application of supply chain integration in real estate. First of all it is key to select and involve the right supply chain partners and people. Amongst them a positive and constructive atmosphere must be created actively. Establishing trust and transparency is a major prerequisite, combined with the alignment of business objectives and commercial interests of the supply chain partners. Not only on a strategic and contract level, but also on a tactical and operational level processes, procedures and systems must be aligned. In essence it is to think and act as one firm, with everyone involved to be committed to add value to the supply chain. Besides it is important to take a multi-project approach to the business. Repetitive working must lead to strategic thinking, increased innovation and continuous improvement. This also enables to keep teams together for multiple projects, and to learn collectively as a result of continued work. The last issue is to measure the results, i.e. effectiveness of the output in terms of the levels and predictability of time, quality, costs, sustainability and health and safety, and finally the satisfaction of users and the project team (Figure 2) .

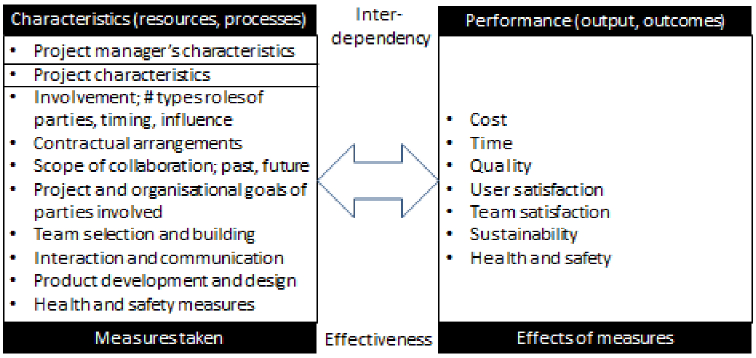

Figure 2: Purpose of the supply chain monitor

4. Literature overview of supply chain collaboration in construction and its measurement

4.1 Characterisation of supply chain collaboration and its adoption in construction

Various supply chain concepts have emerged in parallel in theory and practice, in particular in manufacturing. These concepts are highly related and show much conceptual overlap This has led to much ambiguity between the definitions of the different concepts. Generally all supply chain concepts have originated from logistics and materials management (Christopher 1992). Gradually the concepts have evolved towards broader approaches to the supply chain, including additional aspects such as marketing and supplier involvement in product development (Cooper et al. 1997). Along this development supply chain management evolved from merely focussing on inventory planning and logistics management towards more comprehensive outsourcing strategies for instance including economic issues and risk sharing with suppliers (Williamson 2008).

In addition to supply chain management, supply chain collaboration and cooperation often include the establishment of collaborative information systems, particularly in fast consumer goods and retail sectors (Soosay et al. 2008). Further to supply chain collaboration and cooperation, supply chain alliances and partnerships have fostered more equal relations between supply chain firms viewed as partners. Often such alliances and partnerships reside on a strategic or tactical level between the firms involved, for instance including integrated arrangements to finance and risk sharing, but not necessarily collaborative management of activities on an operational level (Persson & Virum 2001).

As in other sectors of industry, supply chain collaboration in the construction sector is aimed at the alignment of the supply chain from client to suppliers. In first instance supply chain integration needs to bring transparency to the building process and build trust among supply chain partners. In practice this means that all parties are involved from the very beginning to the very end of real estate projects. Moreover supply chain integration goes further. It often implies a multi-project approach, so that the group of parties and people involved are able to engage in a learning curve. Firms are then enabled to invest in innovation of products, processes and systems for a longer period of time. Therefore supply chain integration is often being supported by a long-term focus and strategic collaboration. The effects envisaged include the reduction of lead time, project risks and costs, and also the improvement of quality, satisfaction and profitability. Another opportunity for improvement is the introduction and reduction of life cycle costs while suppliers and maintenance firms are involved and play their part in the development and the design. Close and intensive collaboration, shared objectives, and the achievement of long-term success and improvement are key issues here (Vrijhoef 2011).

4.2 Measuring the effectiveness of supply chain collaboration in construction

Organizational effectiveness or performance is the ultimate dependent variable in much organization and management research (Cameron and Whetten, 1983). Discovering the independent variables that define effective and ineffective organizations is the major challenge for organizational evaluation (March and Sutton, 1997). Recent conceptualization of organizational effectiveness has been broad resulting in five major approaches: goal-attainment approach, system-resource approach, multiple/strategic-constituencies approach, competing-values approach, and the ineffectiveness approach (Glunk and Wilderom 1996, Henri 2004).

4.2.1 The purpose of measuring effectiveness of supply chain collaboration

The two main questions of this research are: (1) *How do various representations of supply chain collaboration applied by different parties relate to each other characteristically? (2) How does supply chain collaboration in projects of different kinds influence the performance of these projects, and thus give evidence of the effectiveness of supply chain collaboration?*

The purpose of this research to develop a model of organisational effectiveness that: (a) is applicable across a broad group of different types of building project organisations; (b) defines the characteristics of different organisation forms (with a focus on those characteristics that distinguish supply chain collaboration from other forms); (c) measures the output and outcomes generated by these organisations for different stakeholders.

Based on our measurements we also try to find a causal relationship between the output, outcomes and certain characteristics thus defining the determinants (or predictors) of performance. In other words, in this study the differences in the dependent measures are considered to represent performance caused by the variations in the independent measures.

4.2.2 Choosing an approach to the measurement of effectiveness

Taking the purpose and goal of this study means our model needs an integrative approach that looks at the means used for the achievement of specific goals and the degree in which the organization is able to deliver according to the expectations of different stakeholders. This integrative perspective is provided by the multiple-constituencies approach to organizational effectiveness. A model that is based on the multiple-constituencies approach broadens the scope of the goal attainment and system resource models by adding the expectations of the various interest groups that circle around the organization (Conolly et al., 1980).

The multiple-constituencies (or stakeholder) view takes explicitly into account that organizations serve multiple goals: each type of organizational constituency (such as owners, employees, customers, the community, etc.) is supposed to have different interests vis-à-vis the organization, and will therefore apply different evaluation criteria (Glunk and Wilderom, 1996). Put more simply by Carton (2004), each stakeholder will have a different perspective of what is “valuable” thus influencing their view of organizational performance.

5. Development of the supply chain monitor

5.1 Structure of the monitor

The supply chain monitor has been developed in the two year monitoring project based on interviews and monthly focus groups of the parties involved in the project including six housing corporations and seven main contractors. The elements of the monitor have been predefined based on previous research and literature introduced above, next discussed and shaped with the parties involved, and structured into sets of variables and subjects, and finally operationalised in an online questionnaire by the team of the university (Table 1). The type of scales used to measure the variables are codes as follows: continuous (con), interval (int), categorical (c), nominal (n), ordinal (o), interval (i) or ratio (r).

Table 1: Structure of the supply chain monitor

Components (dependency)	*Variables*	*Subjects, questions asked within the components (and types of scales used)*
Project (independent variables)	*Project characteristics*	*Name, type and location of project (c),Construction phase (c), Function (c), type of contract and delivery method (c), floor surface* (con), *amount of floors* (con), *technical complexity (o)*
Resources (independent)	*Project managers (client contractor)*	*Age* (con), *Education (c), Gender (c), employers' company name*
	Organisations involved	*Roles of project team (c), phase in which involved (c), names and addresses of team members.*
	People involved	*influence of each team member (o), selection criteria used to select team members(o), methods used to compose the team (c), team procedures (o), joint location for the team (c), joint history of the team (0), level of support from management (o)*

	Past and (potential) future involvement	*Extent of previous collaboration in single or multiple projects (o), intentions or agreement for future collaboration in single/multiple projects (o)*
Processes (independent)	*Transparency*	*level of accessibility of financial and additional information between client, contractor and subcontractors, and vice versa (o)*
	Systems/ Procedures	*use of joint information sharing (c), joint risk management (c), joint planning i.e. lean planning (c), joint decision making and evaluations (c), joint quality assurance (c)*
	Collaboration	*Use of team building and joint training of the project team (c), purpose of training (c)*
	Finances	*Use of financial incentives (risk/reward) (c), level of joint purchasing (c), level of project risk sharing (c)*
	Design	*Use of BIM (c), purpose of BIM (c), use of design concepts of references(c), use of prefab (or similar) solutions (c), use of maintenance history (c)*
	Logistics	*Use of integrated logistics during construction (c)*
	Health & safety measures	*Involvement of team in H&S plans during design (n), safety measures taken (c), level in which H&S plans were useable during construction (o), amount of safety visits (by authorities) (con), scores given by authorities (int), use of accident records (o)*
Output (dependent)	*Project goals*	*Areas of goals formulated (c), level of formulation of goals (o), level of goal achievement (o)*
	Finance	*Ratio between cost estimate(s), awarded bid and final costs of construction, and total investment costs (r), reasons for changes in cost (c)*
	Planning	*Ratio between estimated duration at the definition and design phases, and actual duration at the end of the project (r), reasons for changes in duration(c)*
	Quality	*Amount of defects (con), defects that postponed the final completion of project (con), working days used to solve defects (con and r, when divided by total construction time), outcome of air permeability test (o), outcome of ventilation performance test (o), outcome of thermo graphic inspection (o)*
	Sustainability	*Ratio between planned label (BREEAM, GPR or EPA energy label) at the end of definition and design vs achieved label after construction (r)*

	Health & safety	*amount of accidents leading to a non-attendance longer than 1 day (con), amount of people sent away because of violating H&S codes (con), project manager's view on H&S (o), amount of effort needed to get achieve H&S goals and attitude (o)*
Outcomes (dependent)	*User satisfaction*	*Method used to measure user satisfaction (type), Score of user satisfaction versus average of previous projects (o)*
	Project manager (client) satisfaction	*opinion about the project team (o), effort of team members (o), responsibility taken by team members (o), involvement of team members (o), performance of team (o), view on the collaboration (o), chances of repeating this way of collaboration (o)*
	Project manager (main contractor) satisfaction	*Same as above row of client's project manager*
	Team satisfaction	*Opinion about team atmosphere (o), Fun working in the team (o), Room for new ideas (o), attitude among team members (o), efficiency of the team (o), transparency amongst team members (o), involvement of team members (o), room for improvement of team functioning (o), pride in working for the team (o), self-esteem (o)*

5.2 Comparing the supply chain monitor to other models

Besides the supply chain monitor, other models have been developed in recent years aimed at the same kind of topics and the impact on performance levels. However only few models have explicitly connected the analysis of the construct of the phenomenon at hand and the effects it causes. Various aspects of those models can be compared; the topics covered, the aims, the variables used, and the types of measurement scales used. Anticipating further comparisons, in this paper we started to compare the supply chain monitor's structure to two other models (Table 2).

The comparison shows a few similarities and differences: Separate elements in the respective models' structures are comparable as such, but often formulated differently, and in some cases individual elements in the one model refer to two or more elements in another model. Two basic differences can be found in the balance between groups of dependent and independent variables within each model, and the presence of specific elements at all in the models, as shown in the table below. Different backgrounds, contexts and aims may be causes of these differences, and must be studies further.

Table 2: Structure of the supply chain monitor compared to other models

	Supply Chain Monitor	*Esmaeili et al (2013)*	*Eriksson & Westerberg (2011)*
Project	*Project characteristics*	*Contract type* *Project characteristics*	*n/a*
Resources	*Project managers*	*n/a*	*n/a*
	Organisations involved	*Timing involvement*	*number of contractors*
	People involved	*Team selection* *Team interaction*	*n/a*
Processes	*Transparency*	*n/a*	*payment based on incentives* *performance evaluation*
	Involvement	*Owner's role*	*client and contractor jointly selecting subcontractors*
	Collaboration	*n/a*	*soft parameters in bid evaluation* *use of collaborative tools*
	Design	*n/a*	*integration of design*
	Health & safety measures	*n/a*	*n/a*
	n/a	*Delivery method*	*n/a*
Output	*Finance*	*Cost performance*	*Cost*
	Planning	*Schedule performance*	*Time*
	Quality	*Quality*	*Quality*
	Sustainability	*Sustainability*	*Environmental impact*
	Health & safety	*Health & safety*	*n/a*
Outcomes	*User satisfaction*	*n/a*	*n/a*
	PM satisfaction	*Absence of conflict*	*n/a*
	Team satisfaction	*Absence of conflict*	*Work environment*
	n/a	*n/a*	*Innovation*

6. Discussion

This paper has presented the background, theoretical founding and development of the supply chain monitor for the characterisation of supply chain collaboration and the measurement of its effectiveness in the Dutch social housing sector. More specifically the paper has presented the supply chain monitor ‘from inside out’ with few comparisons with other models, and in way analysing the construct and internal validity of the monitor as it developed as such. We must be aware the monitor like comparable models have partly been developed deductively from generic theory, but partly those models have inductively been built in a particular practical context, in a segment of the construction industry of a particular country, not excluding additional contextual factors influencing the structure, aims and outcomes of such models.

Therefore the external validity of the monitor ‘from outside in’ i.e. compared to other concepts and examples of performance measurement models in theory still needs our attention and will be discussed in a following paper positioning the supply chain monitor within the field of effectiveness and performance measurement of project management and project organisation in construction theory, and wider in more generic organisational and management theory.

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A holistic method of appying Visual Management to improve planning and control on construction sites

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Abstract

This paper focuses on the development and evaluation of a Visual Management Method (known as LCM[1] in practice). The LCM method was originally developed in practice onsite in response to a practical problem, i.e. a lack of transparency in daily operations, which led to difficulties in communication, decision-making and general progress in daily work. The method also makes a theoretical contribution to areas of Visual Management and Production Planning & Control in construction. A review of the literature revealed that there is a lack of broader, holistic solutions when applying VM to construction projects. The literature also revealed that there are deficiencies in the area of planning and control of construction projects, stemming from the weak link between the functions of planning, execution and control (Koskela & Howell 2000, 2001, 2002a, 2002b). The LCM method contributes to these areas, since it is a method that applies a number of visual tools in a holistic way to construction projects to manage and link the information flow by making it transparent. By doing so, a means is provided to better link the functions of planning, execution and control. Since 2007, LCM has been applied and adapted to different types of construction scenarios from new construction projects to refurbishment and power plant construction. This paper explains the scope, main elements and characteristics of the LCM method. A summary of findings from an evaluation of the usefulness and applicability of the method to different types of construction projects is presented. Finally, a discussion on the use of visual tools to improve barriers experienced in production planning and control is also presented.

Keywords: Visual Management, Lean, Design Science.

1. Introduction

The term “Lean” or “Lean production was first used by MIT researchers in the 1990’s to describe the unique manufacturing approach of the Toyota Production System (TPS). The TPS is a sophisticated system of production consisting of different elements, all of which contribute to a whole philosophy. Visual Management is one fundamental element of the Toyota Production System (TPS). The main discussions on VM and Lean in construction are presented in the Lean Construction related papers (www.IGLC.net). Some of this literature has focused on individual tools and techniques, originally from manufacturing, and their application – sometimes in isolation – to construction (Picchi et al, 2004). The same authors further discuss that “when tools are implemented in isolation, poor implementations of lean concepts are observed’ (Picchi, et al., 2004). Therefore, while such isolated applications can provide some valuable contributions, it is argued that a more comprehensive approach is needed. This could lead to a deeper understanding of Visual Management in construction, as well as broader lean construction implementation results (Womack and Jones, 1996; Liker, 1997; Rother and Shook, 2000). Galsworth (2005) proposes a framework for applying VM in manufacturing, which recognises the importance of a visual system when implementing VM as opposed to applying isolated tools. The issue in failing to recognise the entire system when implementing solutions is that crucial interactions can be overlooked and there is little recognition that the consequences of optimising one part of an organisation or process may be damaging to the whole (Jackson, 2006). The consequence of this has been observed in the traditional approach to construction planning and control, where empirical evidence shows that the traditional functions of planning, execution and control are somewhat disconnected, which leads to activities being carried out in a way that may not have a positive impact on the construction system as a whole e.g. planning becomes a way of explaining, after the fact, what has happened, instead of appropriately focusing on defining and supporting production activities (Koskela & Howell, 2001). Furthermore, execution do not realise the plans as the uncertainty of and interdependence between the operations of the building process are not recognised, and control ends up having a negative impact on execution rather than that of correction (Laufer & Tucker 1987).

2. Visual Management and transparency

The literature suggests the lack of clear terminology and absence of an explicit definition of Visual Management (Tezel, 2011). VM has been referred to in the manufacturing context as a system for organisational improvement that aligns organisational vision, core values, goals and culture with other management systems, by means of stimuli (information), which directly address one of the five main senses: sight, hearing, feeling, smell and taste (Liff and Posey, 2004). Other authors (Ho and Cicmil, 1996) refer to VM as using visual aids to improve processes and communication and promote continuous improvement. It makes abnormalities visible so that corrective action can be taken (Imai, 1997) and it enhances communication by making information easily accessible in a production setting (Liker et al., 1995). Acknowledging its function within the TPS in construction, Koskela, 2001 refers to Visual

Management as “a sheer embodiment of management-as-organising” (Koskela 2001:5). According to Koskela (2001), the Toyota Production System is essentially based on an approach known as “management-as-organising” where it is assumed that human activity is inherently situated, i.e. a response to the situation in question. Thus, the structured nature of the environment may contribute to purposeful acting. This purposeful acting can be more controlled and planned if processes and requirements are unquestionably clear. Tezel (2011) identifies one of the functions of Visual Management as the creation of transparency. In this research, Visual Management is approached as a management strategy for organisational improvement, control and measurement which uses visual aids to externalise information and improve communication and transparency in the workplace. Formoso, et al (2002:38) defines transparency as “the ability of a production process to communicate with people” and this can be achieved by visualising the main process flows from beginning to end, through organisational and physical means, measurements and public display of information (Koskela, 2001). Visual tools and methodologies can increase transparency on a construction site, reduce information processing time and human errors, add different layers of information on workplace elements and promote self-management (Galsworth, 1997; Dos Santos et al., 1998: Formoso et al., 2002). Transparency aids communication and decision making and is necessary to support a holistic view of an organisation.

2.1 Challenges of implementing VM and planning and control

One of the challenges when implementing VM is to show how different Visual Management practices and their connections can be applied on a construction site in a holistic manner (Tezel 2011:96). Other challenges are linked to the deficiencies in traditional planning and control. Different techniques for planning and control of construction can be found in the literature (Armor, et al, 2003) such as: the critical path method (Jaafari, 1984), the line of balance method (Harris and McCaffer, 1989), simulation method (Halpin and Riggs, 1992), visualisation methods (3-4-5D) (McKinney and Fischer, 1998, Koo and Fischer, 2000, Kähkönen and Leinonen, 2001) and the Last Planner System (LPS) (Ballard, 2000). The Last Planner System appears to be the more widely used system for production and planning control in construction. A large number of papers published over 20 years describe how the system has been successfully implemented on projects in the USA, Brazil, Chile, Ecuador, England, Finland and Denmark (Viana, et al 2010). As part of this research work, a review of a number of reports on past implementations of Last Planner since the 1990’s (some 83 LPS implementations), has also revealed some barriers to implementation.

Two recurrent barriers experienced during these LPS implementation are a lack of transparency and weak communication leading to an inadequate use and flow of information needed both for daily operations and the overall interaction between the different roles involved (Alarcón et al. 2005, AlSehaimi et al 2009, Kalsaas et al, 2009, Conte, 1998). Collaboration issues were evident especially at construction worker level, which was not typically involved (Friblick et al, 2009) and the participation of sub-contractors was found to be unsatisfactory leading to misunderstandings and non-compliance (AlSehaimi et al 2009). Likewise, construction management was not always adequately involved in the planning and scheduling process. On some projects, it was found that the inadequate use of information collected in the meetings meant that it was difficult to benefit from any learning's that could be derived from that information (Alarcón et al, 2005). On other projects, information flow issues meant that there was a missing link between different phases and interfaces (production and phase schedule / financial control) making it difficult to remove constraints and create a backlog of workable tasks (Kalsaas et al, 2009, Conte, 1998).

3. Research method

Design Science is the research approach adopted in this research. Several authors (Lukka, 2003; Venable, 2006; March and Smith, 1995, Henver et al, 2004; Van Aken, 2004) describe Design Science as an approach applied to develop innovations that solve an existing problem in practice and make a contribution to knowledge. The first version of the LCM method was developed in practice by the researcher before the research work began and is the starting point for the research. A literature review and analysis of the practical and theoretical relevance of the method is an important focus of the research. An evaluation of its utility is based on four case studies which focus on a total of 9 project implementations of the method.

4. The development of the LCM method

The LCM method was initially developed and implemented in practice on a building site in Germany by the researcher in 2007. The researcher is employed by a company specialising in the management and optimisation of real estate projects, as a Project Manager in Lean. An important part of the first case study was to develop a method to improve transparency onsite, by introducing a visualised daily planning system that brought clarity, aided communication and decision-making and simplified information. It was also intended that by visualising work, progress could be measured and waste could be avoided, e.g. overproduction, waiting, transport, over processing, excess inventory, unnecessary movement, defects, unused employee creativity (Liker, 2004) and making-do (Koskela, 2004).

4.1 The LCM method

The LCM method (see figure 1) provides a framework for applying a number of visual tools in an integrated way to a construction project. It aims to manage and link the flow of information throughout the entire construction system by making it transparent. By doing so, the LCM method deviates from the traditional view of project management by providing a way to closely link the functions of planning, execution and control. The visual tools and roles involved in implementing the method give rise to additional communication cycles and ways of collaboration, which are important in making valuable tacit information explicit. LCM's focus lies in the simplification, visualisation and measurement of work from the high level processes to a daily breakdown of work, ensuring target milestones are met, quality is improved and the valuable knowledge of the construction workers is used through their active participation during implementation. The nature of problems and their effects are better recognised, leading to a more focused approach to resolving issues and a clearer understanding of the effects improvements have on the entire system. In summary, the LCM method uses visual tools as part of a holistic method to: 1) support collaboration, commitment management and constraint removal at three different levels of the construction system 2) introduce and support flow using lookahead functions at two different levels 3) shortens the cycle for resolving problems onsite and 4) provides a learning mechanism by means of visualised control. These four characteristics are detailed below.

5. Characteristics of the LCM method

1. Supporting collaboration and commitment management at 3 levels: a distinctive characteristic of the LCM method are the visual tools that it is made up of. These tools are implemented at three levels of the construction system, which link the functions of planning, execution and control. At each level, the visual tools are used to visualise and capture important information so that collaboration is improved and the relationship between parts of the process at different levels of the system becomes clearer. At the first level, all specialists in the project (owner, planners, construction management), come together to visualise the overall process and complete what is called an Overall Process Map (OPM, no.1, figure 1). At this early stage (months before construction begins), “top-down” collaboration takes place to define the optimal flow of work, the interdependencies and known constraints along with a clear plan to resolve them. This is used as a basis for the first lookahead level: the Process Planning phase (no. 2, figure 1). The team is in agreement of what the “construction system” is or should be from a “top-down” perspective and now the process of transforming this into what it will be, begins. This activity requires the collaboration of the subcontractors who provide “bottom-up” feedback to the proposed process so that further discussions are initiated. Using a visual process planning tool as a guide, the same team from the OPM stage along with subcontractors who have now joined the project, capture the relevant information that is required to prepare a feasible plan of work, for a time period of 4-6 months. The visual process planning tool is used to guide conversations regarding activities per company per area, milestones to be achieved and constraints to be removed. The third level where collaboration is required and supported through visualisation is at what is known as the detailed planning level (no. 3-12, figure 1). The focus of the detailed planning phase and the heart of the LCM method is the planning board (no. 4 & 10, figure 1). The function of the planning board is to visualise the flow of the daily work packages and to act as a pull (Kanban) system, visually controlling the amount of work entering the construction process each day. Different forms of collaboration are required (top-down, bottom-up) to complete the necessary processes at the detailed planning level. For example, subcontractors are required to prepare their daily work packages on visual cards and place them in the designated slots in preparation for the weekly detailed planning meeting. These visual tools (cards) are used to capture this information prior to the meeting so that conversations regarding its feasibility take place. Each construction card carries the “DNA” of that particular batch of work; company, task, worker capacity, material etc. At the weekly meeting, all levels of the construction system come together; planners, construction management and construction workers, contributing to the language action perspective (Kensing et al, 1991) of two-way communication (top down and bottom up) and collaboration taking place, so that any unforeseen issues can be resolved quickly. Problem cards are used to visualise issues and initiate conversations that lead to their removal.

2. Constraint removal at three levels: an important outcome of the collaboration at the three levels described above is the removal of constraints to stabilise the process. At the first level (OPA) these constraints tend to be very high-level relating to a lack of clarity in the overall process. The constraints at level 2 (PP) are usually to do with the status of milestones, i.e. approvals, material availability etc and at level 3 (DP), the constraints are mainly concerning problems occurring in the construction process. The separation of the constraints at these three levels helps to focus on critical issues at that particular level and to begin removing constraints as early as possible.

3. Lookahead at two levels of the construction system: A further characteristic of the LCM method is the use of visual tools to plan at two different levels of the construction project. The Process Planning as described above is carried out at least monthly involving all levels of the construction project and aims to prepare work in the longer term, within a 4-6 month timeframe. At this level, the overall flow of work is discussed and optimised, statuses of milestones are checked and constraints removal is tracked. The planning board represents the short-term lookahead process. A 2-4 week section of the Process Planning is broken down to a daily level of detail. The daily work packages are visualised on the planning board and the feasibility is discussed at regular meetings and informally when crews check the board through out the working day. This conforms to the idea of management-as-organising, where human activity is considered to be inherently situated (Johnston, et al 1996). During both processes, particular attention is given to the feasibility of planned work and what action can be taken to ensure this feasibility in the work environment.

4. Regular quality checks to solve problems quickly: another important characteristic of the LCM method, is that it combines different visual tools to support and control the continuous improvement of work quality onsite each day (see no.3-5 & 8-12, figure 1). The visual tools are used together to implement regular quality checks of “completed” work onsite. Colour coded cards signal the completion of work, so that the foreman knows to check it and define improvement actions if necessary. The action plan displays and tracks these identified improvement actions (see no. 9 in figure 1) and the visual Key Performance Indicators (KPI’s) visualise and monitor progress. This additional communication and collaboration loop created by the quality cycle, ensures a timely reaction to quality problems so that they are rectified while contractors are still onsite (saving time) and preventing the same problems from “spreading” to other areas.

5. Control as part of a learning process: performance of the sub contractors with regard to task completion (OTP) and quality is measured and visualised onsite during LCM implementation. The KPI’s are calculated in a very simple way by just comparing the number of completed cards to the number of planned cards per day and likewise comparing the number of quality problems per card. The visualisation of this information, combined with regular reviews onsite, promotes continuous improvement and learning, leading to clearer communication and effective problem solving.

6. Summary of findings from implementations

As part of this research work, the LCM method is evaluated based on its application and adaptation to three different types of construction scenarios: a newly built residential project (version 1), two commercial refurbishment projects (version 2) and 6 applications to power plant construction (version 3). Version 1 is the original version of the method and version 2 (presented in this paper) is how the method is typically applied in practice today. Version 3 represents how LCM is adapted to a specific type of construction such as power plant construction. The aim of the evaluation is to establish whether the method is useful and applicable and whether it contributed to improving transparency in the construction process and in particular, daily operations, during the case studies. Findings gathered from an evaluation of the implementations are summarised and discussed in the following section.

6.1 LCM version 1 – application to newly built residential building

On the first case study, observations were made by the researcher based on KPI data and informal discussions with the site manager, subcontractors and construction workers during the 8 weeks of implementation in 2007. Overall, it was found that the use of visual tools in this collective way had made the daily operations onsite more transparent. The gathering and visualising of performance data onsite, was a very new concept on this construction project which proved challenging since the site manager was not present each day to overlook the process and carry out quality checks. However, on the days where a quality check was carried out, improvements in quality of up to 50% and OTP levels of above 80% were noted, since the subcontractors were planning daily work more realistically and starting to remove constraints up to two weeks in advance. The findings from this case study also enabled the researcher to define clear guidelines on how the method should be implemented on future projects and how it could be further improved.

6.2 LCM version 2 – application to commercial refurbishments

A further evaluation of the LCM method was carried out by the researcher in 2011 and 2012 (version 2) where the realisation of some of the improvements to the process of implementation (such as the structured phases and objectives of each phase) and the adaptation and application of the method to a refurbishment project was observed. The researcher observed how the method had been further developed by third parties with the addition of the visual process planning tool which proved to be useful in stabilising the work flow, identifying constraints and controlling the available site resources such as the material lifts and containers. It was also noted at that point that the method had been now been successfully applied to approx. 25 residential and commercial projects. The nature of a refurbishment project however, made it difficult at times to identify problems in the construction process. On one project, this led to additional work that was not planned or could have been foreseen. Material availability for a key process proved to be a further challenge, which led to instability in the process towards the end that could not be resolved by the LCM method. On the other hand, a further application of the LCM method to a refurbishment project by third parties showed a reduction in the overall lead-time by two months. Improvements in transparency were also noted, as was an overall improvement in the daily planning of work onsite.

6.3 Findings: LCM version 3 – application to power plants

This evaluation focused on the application, adaptation and roll-out of the LCM method on six different power plant construction sites. The method was further developed (version 3), with the addition of some more visual tools that were needed to support the process of this type of construction. In general, the KPI data gathered on all of the power plant projects showed that a stabilisation and improvement of crane utility and OTP % of the subcontractors could be achieved. It was difficult to observe large improvements in the overall lead-time since any improvement in an individual cube (section of power plant) was often undone by delays in a following cube. On one of the power plants however, it was possible to observe an improvement in the overall lead time by a number of months. One evident problem observed on all power plant projects, was the recurrent material issues (incorrect material, missing material). A missing link in communication between engineering and construction regarding material requirements meant that the material delivered to the site was often unsuitable for assembly. The newly introduced collaboration as a result of LCM between these two areas, greatly improved this issue. In summary, findings gathered from LCM applications to different types of construction show some positive results with regard to improved lead-time, transparency and communication but also highlight some limitations of the method: a great deal of compliance is needed to ensure the method works and all problems cannot be resolved by LCM. The following section deepens the general discussion on how the LCM method improves communication and information flow in the process of planning and control in construction.

6.4 Discussion: LCM improves barriers to planning and control

The red arrows in figure 1 from 1-12, show how the flow of information through the different levels of the construction system is facilitated by the LCM method. It is argued that using visual tools in this way to manage information flow, can improve some barriers experienced during LPS implementation, namely those stemming from communication and information flow issues. With LCM, different forms of collaboration are initiated leading to an improvement in communication and a focused removal of constraints.

1. Using visual tools to "make work ready" early on: the process of "making work ready" is an important part of the LPS (Ballard, 2000). The process planning tool is one of the visual tools of the LCM method, used to control and stabilise work flow at an early stage in the process.

The use of visual tools in the process planning helps to link the phase planning with the production planning onsite, identifying key feasibility milestones months before they are due. In addition, constraints and interdependencies become clearer through the discussions initiated with the right people at the right time.

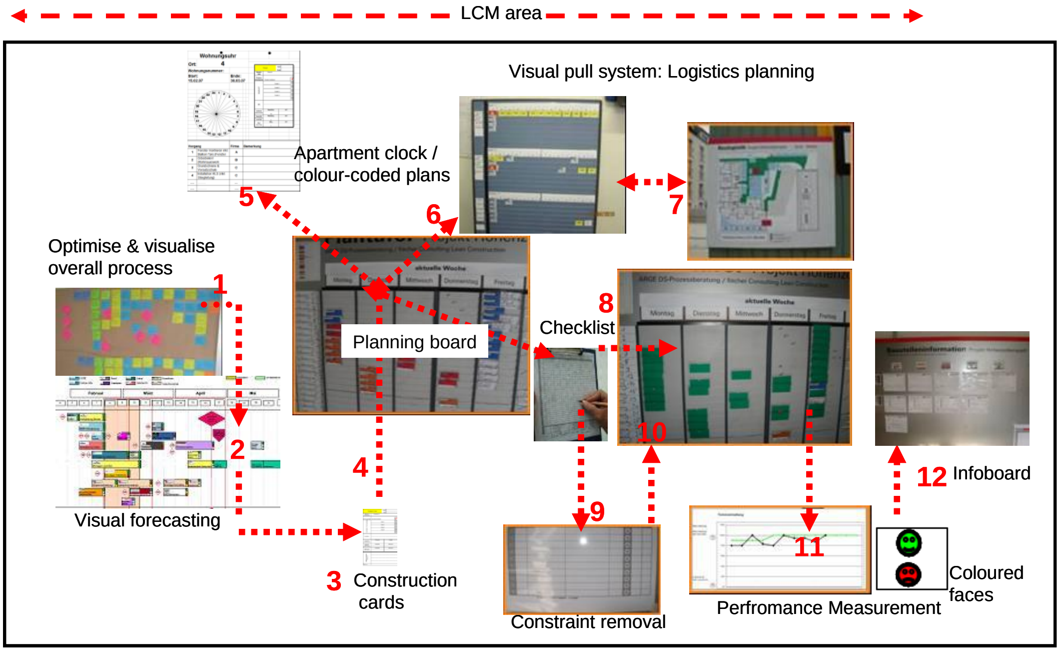

Figure 1: How the LCM method uses visual tools to manage the information flow

2. Using visual controls to support the "should-can-will" mechanism: in the LPS, the lookahead process and weekly work plans are used to control workflow by using the SHOULD-CAN-WILL mechanism, which transforms activities that SHOULD be done into commitments that actually CAN be done and WILL be done. In the LCM method, the process planning is used to visualise this process and facilitate the definition of clear commitments for realising work. It provides a common communication ground for the discussions around the preparation of work and the removal of constraints. The discussions that are encouraged through the visualisation of the individual processes, lead to a common understanding of these processes, the links between them and an earlier recognition of the problems that are in the way. The planning board is a further visual extension of this process, facilitating discussions at the construction level so that what can be done, will be done.

3. Using visual kanban for workflow onsite: the planning board onsite is a visual tool that is also used to control and visualise work flow in the short term. It is the central visual tool of the LCM method that displays, links and co-ordinates a number of other different visual tools and processes with the common goal of controlling the flow of work at production unit level. The work on the cards displayed on the board is directly linked to those activities displayed in that timeframe in the process planning tool, thus providing a further way of linking the phase and production planning. In this way, the board itself is a visual Kanban system (which is a visual signal that is used to realise pull-production in small batches, Monden, 1998), only allowing a small number (1-2) of daily packages to be placed in the slots per day for the next 3-4 weeks, thus the amount of work entering the process is controlled. If more than one card is placed in the slot, the feasibility of two companies working parallel in the same area is questioned.

4. Visualisation of work areas, work crew and work completion: the structure of the board shows all of the areas of the project and the cards that are placed on the board represent the individual companies. At a glance, one can see on the planning board what company is in what area on any particular day or week. Completed cards are placed green side up on the planning board each day, so one can also see at a glance if planned work was actually adequately completed. This visualises the WILL and DID activities described in the LPS. Finally, a certain control of the buffer areas results from this visualisation on the planning board. One can see if there are a large number of areas vacant which is important to identify further potential to improve lead time. Work is controlled visually as opposed to tracking performance alone.

5. Using visual controls to match load with capacity: the cards control work at production unit level and are a visual way of helping the sub-contractors to “match load and capacity” as is described in the LPS. Matching load with capacity is concerned with “estimating the load various chunks of work will place on production units and the capacities of production units to process those chunks of work” (Ballard, 2000:3-13). The companies use these cards as a guide to describe in detail the daily activity, how much capacity is needed and what material. In addition, problem cards are used to visualise constraints ensuring that they remain in focus until they are resolved.

7. Conclusion

This paper presented a holistic application of VM to a construction project which supports collaboration, commitment management and constraint removal at all levels. It was discussed how visual tools are used to carry out the lookahead process in the longterm and on a daily level onsite, including the integration of regular quality checks to help resolve issues as they occur. In addition, it was explained how the LCM method combines the element of control with continuous learning and improvement. The paper discussed findings with regard to the usefulness and applicability of the method, gathered from the application of LCM to 9 different construction projects in the area of residential, refurbishment and power plant construction. These findings revealed both positive effects and challenges: while there is evidence to suggest that the LCM method contributes to an improvement in transparency, company performance, quality, utility of resources and lead-time, there is also evidence to suggest that the success of implementation is very much dependent on the level of participation and management support experienced. Finally, a discussion on the use of visual tools to manage information, suggests that the LCM method can be used to help improve barriers experienced in planning and control, stemming in particular from communication and transparency issues and the weak link between the functions of planning, execution and control.

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Scenarios for Effective Climate Change Adaptation in Dutch Social Housing

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Abstract

Housing managers are constantly confronted with the changing demands that their building stock has to comply with. One of the change agents is the changing climate, caused primarily by human induced greenhouse gases. Though, even if the emissions of all these gases could now be put to a hold, the process of climate change would not completely cease. Furthermore, the impacts of climate change would most probably be felt for many more years. In urban areas, the impacts are drought, flooding caused by extreme precipitation and heat stress caused by the urban heat island effect. Besides threatening the building stock, climate change is also threatening the quality of life of people in urban environments. In the Netherlands, housing associations are responsible for managing the social housing stock and maintaining their quality of life. Research has proven they are not yet aware of the challenge that lies ahead to adapt their dwellings to a changing climate. Considering the focus on the physical adaptations of the building stock, it was chosen to discuss in this paper the effectiveness of three types of governance strategies that housing associations can directly apply in their maintenance processes. The governance strategies are hypothesised based on research results of earlier studies on the implementation of climate change adaptations in social housing. The strategies are: S1. Take up climate adaptation in the policy developments that guide the overall management of the stock; S2. Involving actors that traditionally stand aside the construction process, such as insurance companies and water boards; S3. Emphasising performance-based procurement stimulating the execution of the projects in a partnering approach.

The effectiveness of the strategies was tested by means of a SWOT analysis per strategy with practitioners. Results are five scenarios, based on the combinations of strategies that are potentially feasible for the implementation of climate change adaptation measures in the Dutch social housing stock. A crucial factor in the scenarios is collaboration, because nowadays a housing association is not (financially) capable of assuming the responsibility of climate proofing its housing stock all by itself.

Keywords: Adaptation, Climate Change, Construction Process, Policy Development, Social Housing

1. Introduction

There is clear evidence that the climate is changing globally (Füssel, 2009; Smith et al., 2009). Impacts such as the urban heat island (Salcedo Rahola, 2009) and flooding caused by intense precipitation and increased river run off are expected to become more frequent (Bessembinder, 2008) forming a threat to the living quality in cities. With more knowledge on the impacts, both behavioural and physical adaptation measures have been developed to address these impacts, resulting in respectively guidelines for citizens on how to behave during heat waves (see for example: MinHWS, 2007; Oakman et al., 2010; Department of Health, 2012) as well as design recommendations for the urban environment such as green roofs for temporary water retention (see for example: GLA, 2005).

In 2012 the Dutch Delta Programme New Urban Developments and Restructuring published a 'Measure matrix' containing 155 adaptation measures for the built environment (MWH, 2012). Important actors for the application of adaptation measures in housing are housing associations. A relatively small number of organizations (389) own and maintain approximately one third (2.4 million) of the total housing stock in the Netherlands (CFV, 2012). So, if they start adapting their dwellings a large part of the stock will be climate resilient. However, a recent study among housing associations demonstrated that they show limited awareness of applying climate change adaptation measures in their policy documents (Roders et al., 2012). Moreover, policy makers of housing associations showed in interviews that even if they were aware of adaptation measures, implementation was not likely, because of financial constraints, lack of policy, or measures were found too complex to implement (Roders et al., 2013). This implies that they are not planning alterations to their dwellings that can reduce the harmful effects of climate change. There are various reasons why they should start adapting their dwellings. First of all, housing associations can be considered 'social entrepreneurs', applying their resources and business gains to achieve the societal aims they pursue (Van Overmeeren, 2014). Moreover, housing associations have legal obligations to provide housing with future quality for their tenants according to the Social Rented Sector Management Order (MinIKR, 2005). These societal and legal conditions housing associations operate in, imply that it can be expected from the housing associations that they will commit themselves to adapt their dwellings timely to changing circumstances that can threaten the quality of life of their dwellings. Climate change is one of those threats. In addition, not taking adaptation measures may even jeopardise the future value of their dwellings, as in the Netherlands dwellings in areas with risk of flooding statistically have a lower value compared with dwellings in a non-risk area (Bosker et al., 2013).

The aim of this paper is to find strategies to implement climate change adaptations, in order to end up with a climate resilient dwelling. Therefore the study takes housing associations, being large property owners, as main actor and the underlying question is what could be an effective way to implement measures. As such, we are not focusing on governmental governance schemes that inform, stimulate or force housing associations to take action, as these schemes are still under development. In addition, the disadvantage of a government informing, stimulating or forcing action by the housing associations is that they themselves have to develop internal governance schemes to eventually start adapting dwellings. By focusing directly on this internal governance process, we expect to be more effective towards the factual implementation and it is possible to distinguish the knowledge gaps where the government should focus its national governance strategies on. To do so, we have to take a closer look at the maintenance and improvement cycle of existing dwellings to find opportunities for implementation of measures.

In the following sections we describe the methodology that was followed to carry out the research. Next we present and discuss the results, after which this paper will be finalised with concluding remarks and recommendations for further study.

2. Methodology

Potentially successful strategies were hypothesised based on and inspired by the outcomes and experiences of earlier studies (Roders et al., 2012; Roders et al., 2013), conference visits and research project meetings by the researchers[1]. The basis for the strategies was that a governance intervention on several phases in the maintenance and construction cycle of a dwelling should lead to the implementation of measures. The first strategy (S1) was hypothesised as follows: housing associations should take up climate change adaptation in their policy developments, as such they will allocate resources to the topic and they will take up adaptation in their projects. In earlier interviews (Roders et al., 2013) employees of housing associations stated that the lack of policy was one of the reasons why they did not implement measures. The second strategy (S2) was hypothesised as follows: housing associations should seek collaboration with actors that also benefit from the application of climate adaptation measures. Those actors are for example: municipalities or insurance companies. In the case of municipalities; if a housing association applies water-retention or infiltration measures, the municipality may not need to change the sewage system. The third strategy (S3) was hypothesised as follows: housing associations should aim for a partnering approach with construction companies that carry out the construction works. Partnering is promised to be a more cost-effective way of working (CII, 1991), which makes financial room for investing in adaptation measures.

The strengths, weaknesses, opportunities and threats (SWOTs) of these measures were verified in face-to-face interviews with practitioners active in each strategy field. The practitioners that were consulted to test the strategies are listed in table 1. The outcomes of the SWOT analysis were used to develop scenarios on the effective implementation of climate change adaptation measures.

[1] This study is part of a PhD project taking part in the Knowledge for Climate Program in the Netherlands (http://knowledgeforclimate. climateresearchnetherlands.nl)

Table 1: Interviewed practitioners

Practitioner function	*Stategy*	*Organisation*
Senior advisor property management	*S1. Policy development*	*Housing association (56.000 dwellings)*
Director property management	*S1. Policy development*	*Housing association (77.000 dwellings)*
Director property management	*S1. Policy development*	*Housing association (30.000 dwellings)*
Director	*S2. External actor involvement*	*Centre of expertise sewer management and urban drainage*
Strategic advisor	*S2. External actor involvement*	*Water company*
Senior advisor water systems	*S2. External actor involvement*	*Water board*
Strategic advisor long term policy	*S2. External actor involvement*	*Federation for health insurers*
Senior advisor risk management and reinsurance	*S2. External actor involvement*	*Insurance company*
Policy advisor	*S2. External actor involvement*	*Insurance company*
Employee Development and Maintenance Sewage systems	*S2. External actor involvement*	*Municipality*
Director	*S3. Partnering approach*	*Construction company (300 employees)*
Director	*S3. Partnering approach*	*Construction company (45 employees)*

3. Effectiveness on climate change adaptation

S1. Policy Development. In an earlier study by the researchers, it was concluded that awareness of the need for climate change adaptation was lacking in the policy documents of Dutch housing associations (Roders et al., 2012). As a consequence, there is no policy that guides implementation of adaptations. Following the definition of policymaking used by several scholars (see Dankert, 2011), stating that in a policy strategy goals are established and the respective resources to reach those goals are allocated, this inversely means that a lack of policy strategy implies that there are no financial resources available for adaptation. However, even if housing associations were aware of the need for climate change adaptations and developing policy strategies for their implementation, the current situation is that there is little money available (Nieboer and Gruis, 2013). So if the government would have drawn up governance arrangements in the regulation and information field targeting action by housing associations, leaving them no other choice than implementing measures, the housing associations will start allocating resources from other policy fields to the adaptation policy. This could result in quality decrease on the other policy fields which is not desirable either. Moreover, financial stimulation by the government is not possible because of a lack of resources. Nevertheless, the power of policy development to allocate resources to the adaptation policy field and its decision framework for action makes this strategy worthwhile to investigate.

S2. Involvement of External Actors in the construction process. A second arrangement is an innovation of the plan development process to generate financial resources for adaptation. This arrangement focuses on actors that could benefit financially from adapted dwellings. Considering that for example a water resilient dwelling has less chance to get damaged because of flooding, insurance companies have a lower risk of claims. They save money that can be invested in adaptation measures. The money can be paid directly to the owner of the dwelling or the insurance premium can be lowered so that the house owner can use that money for adaptations. (McEvoy, 2010; CEA, 2007). Other beneficiaries of adaptation measures in the flooding field can be municipalities, as they do not need to change their sewage systems and water boards, as they do not need to change their drainage systems, water cleaning plants and pumping stations. The water volume that they deal with now will remain the same; the increase caused by climate change should be annihilated by adaptation measures in the urban environment.

S3. Carrying out projects in a Partnering Approach. In the third type of arrangements, focus lies on removing the barrier of finance that is impeding the implementation of measures. The solutions can be found in increasing the effectiveness of current 'traditional' construction processes. Increasing effectiveness implies less costs for the same product, so there will be financial room for investments in adaptation measures. In this paper we use the definition of partnering developed by of the Construction Industry Institute (1991): "A long-term commitment by two or more organizations for the purpose of achieving specific business objectives by maximizing the effectiveness of each participant's resources. This requires changing traditional relationships to a shared culture without regard to organization boundaries. The relationship is based upon trust, dedication to common goals, and an understanding of each other's individual expectations and values. Expected benefits include improved efficiency and cost-effectiveness, increased opportunity for innovation, and the continuous improvement of quality products and services.'' (CII, 1991.) Following this definition, partnering is can be considered a solution to obtain among others a more efficient construction process.

4. SWOT Analysis

In the following section the results of the SWOT analysis with the practitioners will be presented, categorised according to the three strategies Policy Development, involvement of External Actors and carrying out the projects by using a Partnering Approach.

S1. Policy Development. The strategy was tested by the following question: What are the Strengths, Weaknesses, Opportunities and Threats of taking up adaptation as a specific topic in (any kind of) policy documents? The respective arguments given by the respondents are listed below:

Strengths: Adaptation has to be a topic in the policy strategy to take it up in plan developments. A policy plan legitimises investments and sets project boundaries, indicating what should be done. A policy plan puts a marker on the horizon and describes the way to get to this marker, guiding decision making on product and process level.

Weaknesses: A policy strategy can be perceived as a restraining, top down management instrument. Climate change adaptation has low priority and a poor marketing among the housing association's employees and renters. At the moment insufficient resources are available to develop a stand-alone strategy for the implementation of adaptation measures, they have to be combined with other projects.

Opportunities: Policy strategies of the housing association can be matched with the policy strategy of the municipality, therewith creating a base for collaboration. Regarding heat, guidelines for a higher comfort level of the dwellings could be defined as a policy topic. Policy on topics such as adaptation, mitigation, sustainability gives insight in the possibilities to combine measures to reach synergies.

Threats: Even if the housing association has adaptation in its policy strategy, support of the tenants is necessary to implement the measures. Taking up measures in policy documents does not necessarily mean immediate implementation as risk management and ad hoc measures to solve unexpected urgent issues can have higher priorities. The dwelling or plot level may not be the right level of taking measures, as it can be more efficient and effective to provide one large scale measure in the public space.

S2. External Actors. The strategy was tested by the following question: What are the Strengths, Weaknesses, Opportunities and Threats of involving External Actors in the plan developments? The respective arguments as stated by the interviewees are listed below:

Strengths: Collaboration with external actors such as municipalities and water boards can lead to more efficiency in the development process, because these actors can notify the housing association in an early stage if a project does not fulfil the legal requirements. Housing associations and municipalities both benefit from a healthy living environment resulting from adaptation measures. Housing associations and insurance companies both profit from the prevention of damage by implementing adaptation measures.

Weaknesses: If a housing association collaborates with a water board, the housing association becomes partially responsible for water-related issues that are unknown to it. There is no market for a rain insurance for housing associations, as they do not feel the need to cover the risk of damage to the structure of the dwelling (they do have their properties insured against fire and storm). There is no urgent need for health insurers to engage in the implementation of climate change adaptations as their main focus lies on delivering good care once a person gets ill, not on the prevention of getting ill. Moreover, the direct relationship between people not getting ill and applying measures to dwellings is difficult to prove, whereas other measures such as assuring that elderly people drink enough could be much more effective.

Opportunities: Implementing adaptation measures that lower the impact on the sewage system can result in a lower sewage tax. Adaptation measures can be mainstreamed at a neighbourhood level with initiatives such as a circular economy and the implementation of mitigation measures, therewith engaging more stakeholders in the project who can generate support among the inhabitants of a neighbourhood. The different actors have to collaborate to divide tasks and responsibilities because the measures at the building and neighbourhood level need to be matched.

Threats: Many measures do cost extra money whereas the revenues are uncertain in many cases. Water boards and municipalities only have public money which they cannot easily spend on private properties of housing associations. Municipalities cannot fully apply their knowledge in projects of housing associations as they feel they are perceived more as controlling authorities than as partners. Insurance contracts with housing associations are relatively short (1-3 years), causing the risk for an insurance company to not profit from its contribution to adaptation measures, because the housing association switches from insurance company.

S3. Partnering Approach. The strategy was tested by the following question: What are the Strengths, Weaknesses, Opportunities and Threats of working in a partnering approach? The following arguments were given by the interviewees:

Strengths: Practical knowledge about technology can be applied early in the plan developments. The housing association allocates construction risks during the execution of the works to its partners in the supply chain. Repeating processes with the same partners can reduce costs and can improve quality.

Weaknesses: The 'ultimate' market test by selecting from competitive alternatives with respect to price and/or quality is not possible. It is uncertain if the best solution offered by the partnering consortium is the best solution in general. The current partnering models focus on relationships between housing associations and construction companies whereas most innovation potential lies with manufacturers. Strategies and processes of housing associations are a blind spot for construction companies, as they are used to work in a solution-driven environment.

Opportunities: Sub-optimal solutions are prevented by synchronization of the goals of the partners and parties from outside the partnership. Within the supply chain knowledge is freely available for all parties. Partnering can prevent spilling of societal money, as partners have a more long-term view, whereas in money-driven environments many times the short-term solution prevails.

Threats: In a partnering setting the spread of risks is lower because much of the work is done by one (or few) consortia. The dependence on the partnering consortium can be too big and the control of the housing association can decrease. Once they have been awarded a long term contract, the partners in the consortium can become less motivated to continuously improve their service.

5. Discussion: Evaluation of scenarios based on SWOTs

The next step in this study was to develop scenarios that appeared to be feasible for the implementation of climate change adaptation measures to dwellings. The researchers have evaluated the feasibility by questioning if the scenario was likely to lead to the implementation of measures. The likelihood was based on the outcomes of the SWOTs.

One scenario was based on the strategy of policy development (S1):

The housing association takes up the implementation of adaptation measures in its policy, allocates resources for adaptation and prescribes exactly what has to be done by the construction company.

The positive argument in this scenario is the fact that policy development takes place, therewith profiting from the strengths and opportunities of policy making as listed above. However, the weaknesses and threats are not avoided. Especially the financing of measures is a weakness that should be avoided to implement the measures. This could be done for example by teaming up with external actors who financially contribute to measures because they profit from the measures as well. The barrier of finance could also be removed by working in a partnering approach challenging the supply chain to deliver adaptation measures for a lower price, taking into consideration the benefits of a more efficient planning process. However, as this scenario only deals with policy making and neither the external actors nor partners are involved, the weaknesses are too strong to consider the scenario feasible. Likewise, the scenarios solely based on involving new actors (S2) and on a partnering approach (S3) are not feasible, because the weaknesses are not or not sufficiently avoided.

Potentially more feasible are the scenarios that are based on combining two strategies:

Scenario A (S1+S2): *The housing association takes up the implementation of adaptation measures in its policy, allocates money for carrying out the measures and looks for collaboration with an external actor (e.g. municipality / water board / insurance company) to develop and realize the project together with this actor based on unifying their goals.*

Scenario B (S1+S3): *The housing association takes up the implementation of adaptation measures in its policy, allocates money for carrying out the measures and starts a partnership with one or more construction supply chains for all renovation works on its building stock. The delivery of climate resilient dwellings is set as performance indicator. The supply chains have to develop knowledge on adaptation measures and apply this knowledge in the design of the project.*

Scenario C (S2+S3): *A construction company collaborates with an external actor (e.g. municipality / water board / insurance company) and proactively takes up adaptation measures in a project of a housing association, without the housing association having requested adaptation measures. The construction company looks together with supply chain partners and external actors for solutions that fit in the project boundaries that are set up by the housing association.*

The combination of two strategies makes the scenarios more feasible. For example, in scenario A, the financing weakness of policy making by the housing association is still there, but in the scenario the strengths regarding collaboration with municipalities and insurance companies; and the opportunity of saving money on sewage tax can be utilized, resulting in more investment capacity. In addition, the weakness of policy being perceived as restraining and top down will be less important, as there is the pressure from the external actors to work on adaptation. In other words, the weakness is not decisive any more. The same type of benefits can be distinguished for scenarios B and C.

Even more feasible is the combination of all three strategies:

Scenario D (S1+S2+S3): *The housing association takes up the implementation of adaptation measures in its policy, allocates money for carrying out the measures and looks for collaboration with an external actor (e.g. municipality / water board / insurance company) to develop and realize the project together with this actor based on unifying their goals. The project is handed over to a consortium with which the housing association has a partnering agreement. The delivery of a climate resilient dwelling is set as a performance indicator.*

In this scenario the challenge of implementing climate change adaptations is taken up from three sides, and there is much flexibility to work around the weaknesses and threats. However, as both the second and third strategy imply the involvement of extra parties the risk of developing a project with both external actors and a partnering consortium can cause again ineffectiveness (Provan and Kenis, 2007) because of too much communication, too much goals to be aligned etc.

In the SWOT-interviews with the practitioners from the housing associations, an argument was raised that did not really belong to one of the strategies stated in the beginning of this study. The interviewees stated that tenants are the most important stakeholders a housing association works for, and it is the societal task of the housing association to fulfill their needs in the best possible way. Accordingly, housing associations are sensible for tenant requests. Moreover, if tenants are really in need of a measure, it is likely that they are accepting a slight increase in rent that covers the costs for the investment of the adaptation measure. Therefore, a fifth scenario was developed, putting the occupants of the dwelling in a central position.

Scenario E: *The housing association and/or an external actor (e.g. municipality / water board / insurance company) inform tenants and make them aware of the benefits (more comfort, less risk of nuisance) of an adapted dwelling. The tenant requests the housing association to take action, resulting in the housing association making policy on the implementation of climate change adaptation measures on request.*

6. Conclusion

In this paper we have elaborated three strategies to enhance the implementation of climate change adaptation measures in social housing. The three strategies regard policy development, collaboration with external actors and using a partnering approach in the construction process. The feasibility of the strategies was verified with practitioners by means of a SWOT analysis. The outcomes of the SWOTs made clear that the single strategies are not likely to be successful because their weaknesses or threats cannot be avoided by using another strategy. This means that housing associations are at the moment not in the position to adapt their building stock all by themselves. It has become clear that a combination of strategies has much more potential to be feasible. A closer look on the feasible scenarios shows that collaboration plays an important role, as every scenario has a collaboration component included. Scenario A, C and D deal with collaboration with the external actors, and Scenario B and D deal with enhancing collaboration among the partners that are responsible for the execution of the works. When further developing the scenarios the literature on network governance will be a valuable source of reference.

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Construction Process Categorisation towards Developing an E-Business Maturity Model

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Abstract

The rapid pace of change in technology coupled with global economic and environmental changes has had considerable impact on all business sectors. Consequently, organisations are forced to drive towards efficiency savings, productivity improvements and increased collaboration to cope with current demands. This has resulted in execution of electronic ways of conducting business activities increasingly becoming a key strategic approach for many organizations. Electronic business (e-business) processes have taken businesses to new dimensions and organisations are moving away from traditional processes to modern ways of working through the use of electronic media. These new approaches create new pathways to gain competitive advantage and they guarantee valuable rewards for organizations. Even though the possibilities afforded are evident, compared to other industries the level of e-business implementation within the construction industry is not widespread and robust as anticipated. This indicates that there is a need for advancement of construction e-business practices. Hence, for construction organisations currently using e-business tools and for those who have yet to utilize and seek to adopt e-business tools, there is a need to undertake an analysis of their business processes and working methods to ensure a productive and beneficial implementation of these tools. This necessitates undertaking an analysis of current construction e-business processes to ensure productive implementation in order to develop their e-business capabilities and levels of maturity. This paper acknowledges the niche for research into e-business capability and maturity of e-business processes and presents a protocol for categorizing the construction processes for the development of a construction e-business capability maturity model. Process classification methodology comprised of two stages; initially an archival analysis to identify and categorise construction processes followed by expert interviews to review and refine the categorisation. Results of this classification aided in developing a construction e-business capability maturity model which can use to identify the status of their current e-business process implementation.

Keywords: Construction Processes, Process Classification, e-Business, Maturity Models, Construction Industry

1. Background

1.1 E-Business in Construction

Construction industry plays a significant role in the economy of any country and the UK is no exception. It accounts for 8% of the Gross Domestic Product (GDP) of the nation (National Statistics, 2010). There are number of industry reports published, within which the sector has been identified as incompetent in addressing problems, innovate and improve performance (Latham, 1994; Egan, 1998; 2002). In his report "Accelerating Change", Sir John Egan (2002) highlighted the need of process thinking in construction. Construction process generally deals with unique outputs, a specific building within a specific context of conditions and requirements. There are number of parties and project teams involved whereas the process and information flow is highly complex. This requires a detailed appraisal and consideration of business activities; where ICT applications can be of great assistance (Sun & Howard, 2004).

Current literature reveals a wide range of definitions for e-business. Chaffey, 2009 states e-business initiated by adopting the internet to commercial activities and subsequently extended towards many areas and business processes with the development of new technologies (). Li (2007) defines e-business as "developing new ways of working by innovatively exploiting the new capabilities of ICTs in general and the Internet and related technologies in particular". This broader view of e-business further supported by many other auth 2002; Aranda-Mena & Stewart, 2005 ; Anumba & Ruikar, 2008; Goncalv Quaddus, 2010), while describing e-comme ; co e fo sactions conduct s wh s all ncluding such co

The ma approac ate organisational activities across industry boundaries to achieve economic advanta is similar in the construction sector and e-procure lding, e-tendering, e-collaboration nagement, BIM (E delling), cloud computing, Inte ntified as some o s tre indu common constru entif ar (2

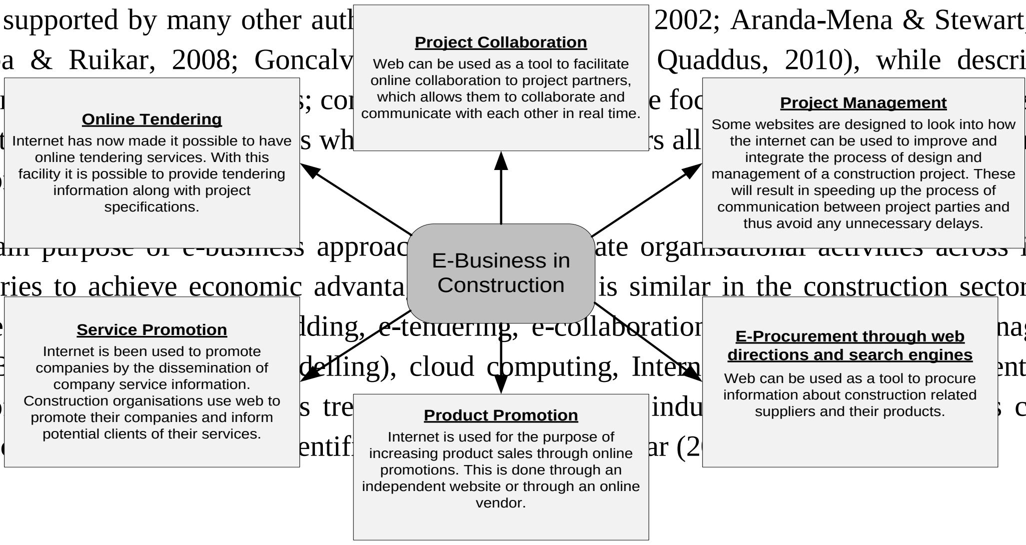

Figure 1.1: Common construction e-business trends (adopted Anumba and Ruikar, 2008)

ICT applications can play important roles in each of the various stages of a construction project and therefore it is vital for organisations to consider how e-business can be utilised and develop strategies to adopt these further enhancing business processes. Stewart et al. (2002) present a strategic ICT implementation framework for construction by considering SWOT (Strengths, Weaknesses, Opportunities and Threats) factors. Alshawi (2007) also identifies ICT infrastructure, process focus, supply chain focus and internet focus as the patterns of ICT focus in construction. In addition he suggests that ICT strategy of an organisation should be carefully balanced between the technology push and business pull within the industry. Moreover, many authors (Macomber, 2003; Craig & Sommerville, 2006; Henderson & Ruikar, 2010) have emphasised the importance of following a strategic plan for successful technology implementation and have proposed approaches for organisations.

1.2 E-business evaluation approaches

1.2.1. E-Business and IS/IT Evaluation Approaches in Organisations

Literature reveals a wide range of e-business evaluation approaches where organisations used to measure their ICT success across different disciplines. Table 1.1 presents a categorisation of Information Services/Information Technology (IS/IT) evaluation approaches in organisations (Saleh and Alshawi, 2007; Alshawi, 2007).

Table 1.1: Categorisation of current IS evaluation approaches

<table>
<tr><th>Approach</th><th>Type</th><th colspan="2">Explanation</th></tr>
<tr><td rowspan="3">Product-based</td><td>System quality</td><td colspan="2">Focuses on performance characteristics such as resource utilisation and efficiency, reliability and response time</td></tr>
<tr><td>System use</td><td colspan="2">Reflects the frequency of IS usage by users</td></tr>
<tr><td>User satisfaction</td><td colspan="2">Widely approach which is based on the level of user satisfaction</td></tr>
<tr><td rowspan="5">Process -based</td><td>Goal centred</td><td colspan="2">Measures the degree of attainment in relation to specified targets</td></tr>
<tr><td>Comparative</td><td colspan="2">Benchmarking approach</td></tr>
<tr><td>Improvement</td><td colspan="2">Assesses the degree of adaption of a process to the related changes in requirements and work environment</td></tr>
<tr><td rowspan="2">Normative</td><td>Maturity based</td><td>Measures performance</td></tr>
<tr><td>Non maturity based</td><td>Compared to external standards</td></tr>
<tr><td>Organisational maturity</td><td>General models</td><td colspan="2">Examples of such models are those by Nolen; Earl; Bhabuta; and Gallier and Sutherland</td></tr>
</table>

1.2.2. Performance Analysis Approaches

Performance analysis approaches can be identified as one of the most commonly used techniques for business improvements. Levenburg & Magal (2005) identified gap analysis and importance performance maps as the two main streams in performances analysis. Gap analysis is based on current and target performance levels. Current performance level address the present status of organisation in terms of pre-identified evaluation criteria and target level identifies the expected status based on same criteria (Alshawi, 2007). The difference between the two levels is known as the opportunity gap and it can direct organisations to focus on how best to progress from the current to target performance. Gap analysis has identified as an appropriate approach to evaluate IS and ICT systems but the accuracy of this practice is highly dependent on how the business functions are measured and what criteria is used (Levenburg & Magal, 2005; Alshawi, 2007). Benchmarking, balance score card and SWOT analysis can be identified some of the commonly available techniques that organisations can utilize to identify the opportunity gap.

1.2.3. E-Readiness Models

E-readiness can be defined as “the ability of an organisation to successfully adopt, use and benefit from ICT” (Ruikar *et al.*, 2006). In other terms it is how able an organisation is to adapt electronic processes within their day to day business processes. Evaluating and measuring organisational e-readiness is important to companies to ensure a productive and beneficial implementation of e-business tools within their businesses. An increasing number of readiness assessment tools have been developed over last few years (Mosiac Group, 1998; APEC, 2000; Khalfan, 2001; Kirkman *et al*., 2002; Risk, 2004; K3 Technology Group, 2006; Al-Osaimi *et al*., 2006; Ruikar, 2006).

1.2.4. Maturity Models

Maturity is defined as the degree to which organisational processes and activities are executed following principles of good practice (Alshawi, 2007). Maturity concept encourages repeatable and predictable outcomes within a process or practice. Eadie (2009) and Eadie *et al.* (2012) has comprehensively investigated and categorised maturity models in their papers. Furthermore, many models have been developed to assess the e-business activities uptake such as E-Commerce Maturity Model, Commitment-Implementation Matrix Model, E-Commerce Levels Model, E-Business Lifecycle Model and Growth for e-business (SOG-e) model (Prananto *et al.*, 2001; Prananto *et al.*, 2003).

This research is based on a detailed systematic analysis of e-business implementations in construction organisations and the construction processes with a view on their systematic progression in capability and maturity. Aforementioned models do not offer a stepwise systematic approach to assess level of e-readiness of an organisation together with strategies to mature in e-business applications. Therefore Capability Maturity Model (CMM) can suggest as satisfying the requirement of a step-by-step methodological mechanism to assess e-business capability and maturity within organisations. This paper presents the construction process classification which forms a fundamental component of the construction e-business capability maturity model.

2. Methodology

The process classification methodology comprised of two stages; initially an archival analysis to identify and categorise construction processes followed by expert interviews to review and refine the categorisation. RIBA (Royal Institute of British Architects) Plan of Work and OGC (Office of Government Commerce) Gateway Reviews were identified as main standard process protocols established for construction projects. Those archives were analysed to identify construction project related processes in order to develop the conceptual process categorisation. Then a series of expert interviews were conducted to refine and validate the conceptual process categorisation.

2.1 Archival Analysis

2.1.1. RIBA (Royal Institute of British Architects) Plan of Work

The RIBA plan of work is considered as one of the most reliable and complete model in the UK for delivering the design and construction process of a building project. It has been widely used in building projects as a process map and a management tool, providing important work stage reference points for contractual, appointment documents and best practice guidance (RIBA, 2013). The latest edition; RIBA (2013) plan of work brings together the briefing, designing, constructing, maintaining and operating in a continuous cycle into a number of key stages . This version improves on the previous versions by incorporating issues addressing; all sizes and types of projects, all forms of procurement, usage by the whole project team and the flexibility of using planning procedures. It is made up of eight work stages viz. strategic definition, preparation and brief, concept design, developed design, technical design, construction, handover and close out and in use. These eight work stages were thoroughly analysed to identify the construction project processes for the classification.

2.1.2. OGC (Office of Government Commerce) Gateway Reviews

OGC Gateway Review Process is a framework that increases the likelihood of early identification of threats to the successful delivery of major projects. The OGC Gateway Process examines a programme or project at critical stages in its lifecycle to provide assurance that it can progress successfully to the next stage. It is designed to be applied to delivery programmes and procurement projects, including those that procure services, property/construction, IT-enabled business change and procurement using framework contracts (OGC, 2007). OGC Gateway Review for building projects consist of gateway reviews and decision points. These were also analysed to identify possible processes that relate to construction projects.

2.2 Expert Interviews

A series of expert interviews were conducted to verify and refine the process categorisation obtained from the archival analysis. In total 12 expert interviews were conducted. Experts were selected based on satisfying a set of selection criteria. 3 academic experts and 9 industry experts were selected based on their expertise areas and experience. The industry experts represented 6 large scale and 3 medium scale organisations. In addition they consisted of client, contractor and consultant practices and experienced with both civil and building projects. The main focus of these interviews were to get their views and feedback on the conceptual construction process classification developed through archival analysis. Nvivo 10 software was used for the analysis of the interviews and for the further development of the process classification.

3. Findings

Identification of construction project processes was carried out using Nvivo data analysis software which provided a systematic way of storing, analysing and presenting data. All the identified construction processes from RIBA and OGC were then assigned to five process categories according to construction project life cycle phases. The following Figure 3.1 presents the process classification attained from the archival analysis.

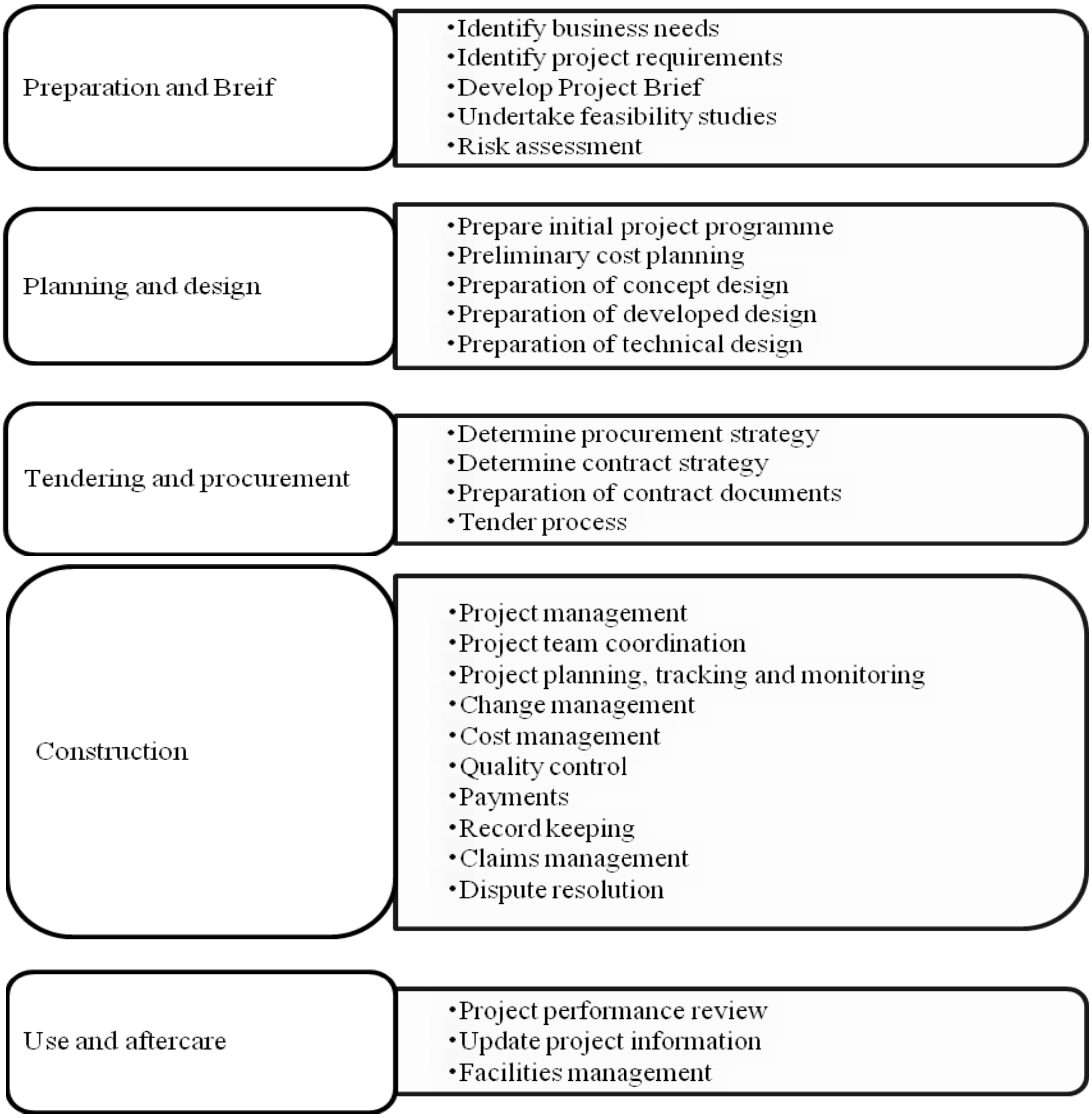

Figure 3.1: Construction process classification

This process classification was further refined through the series of expert interviews to aid the development of the construction e-business maturity model.

According to the archival analysis five processes were categorised under the preparation and brief category as illustrated in Figure 3.1. Positive responses were received from the experts for the process categorisation and constituent processes. Majority of the experts agreed to consider the processes as proposed but there were some instances where experts disagreed or carried neutral views. One expert disagreed, identifying the need to consider identification of business needs and feasibility studies in the preparation and brief stage. The reason behind this agreement was that he proposed to have an additional process category before preparation and brief. He further argued that there should be a category for the processes involving the business decision to proceed with the project. However other experts agreed to consider those in the proposed category. Some experts suggested merging this category with planning and designing processes because planning and designing processes can also be considered as preparation and they found it difficult to separate the processes of those two categories. Some experts had neutral views on some processes and their confidence levels also neutral and uncertain on them. Although there were some suggestions and diverse views, majority of the experts agreed with high confidence levels to the proposed processes under the Preparation and Brief process category.

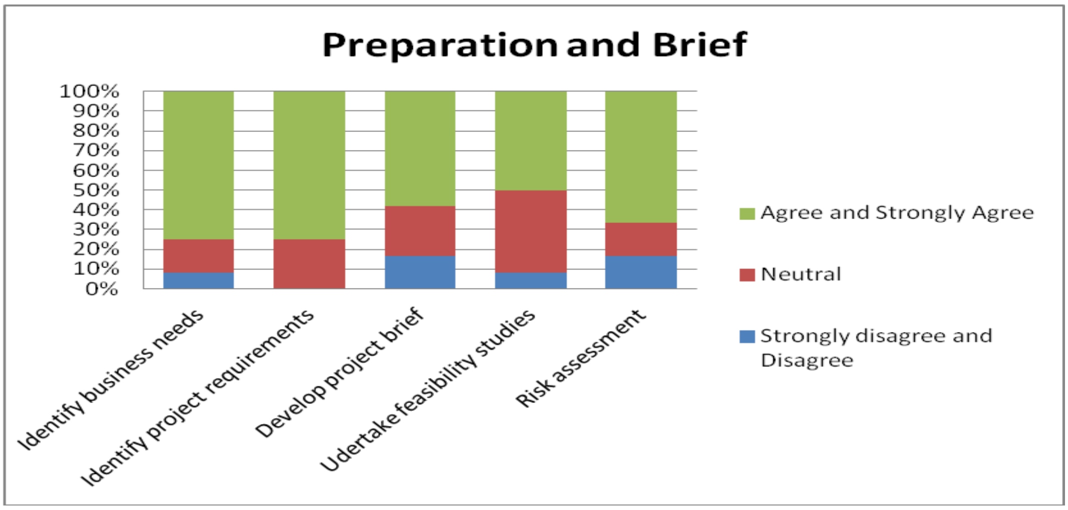

Figure 3.2: Expert opinions on Preparation and Brief process category

Planning and Design category consisted of five processes. Experts agreed to consider those processes in the category. There were some suggestions to merge this process category with the Preparation and Brief category and some views arguing that detailed designs might be categorised in later categories. But overall opinion of the experts was positive towards the processes identified for the category.

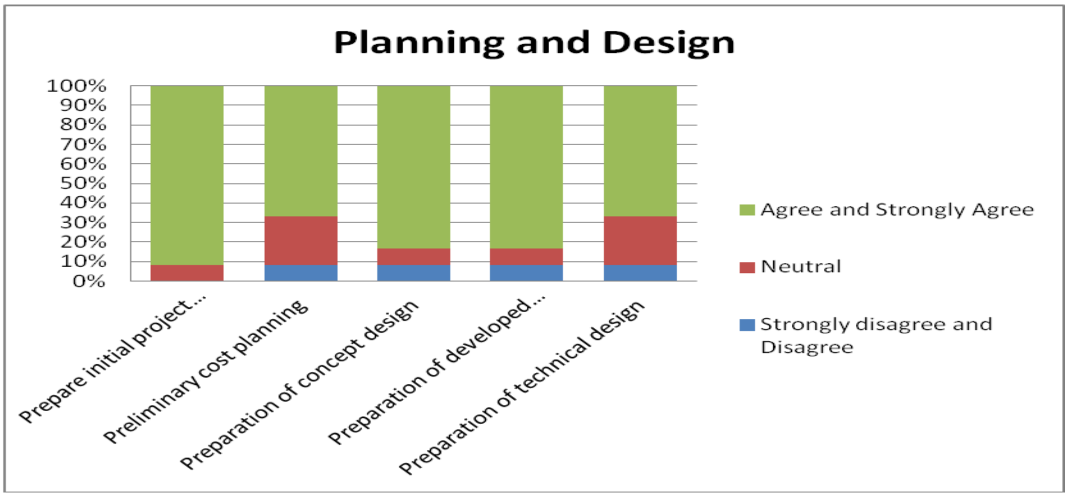

Figure 3.3: Expert opinions on Planning and Design process category

Expert views on Tendering and Procurement category were mixed with both positive and negative opinions towards the proposed processes. Most of the experts thought that determination of procurement strategy and contract strategy are processes which should be classified under planning and design category. The reason behind this was that the determination of both the procurement strategy and contract strategy has an impact upon every other process in the first two categories. Therefore experts proposed to move those processes to the earlier categories.

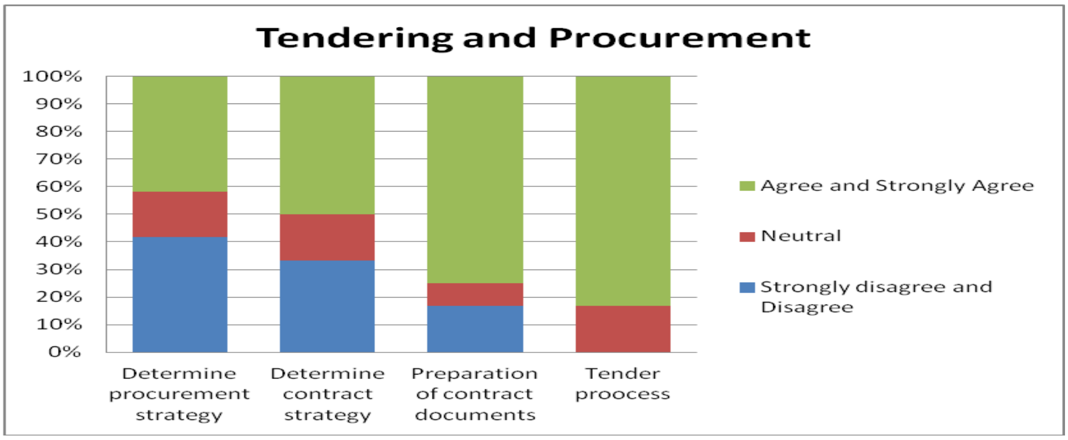

Figure 3.4: Expert opinions on Tendering and Procurement process category

There were ten processes considered under the construction process category. The main scrutiny on this category was the conflict between project management process and other processes. Because in general terms project management would cover most of the other processes in the category as well as some processes like prepare initial project programme and preliminary cost planning from other categories. Therefore if this proposed classification to be used; experts proposed to rename it as post contract project management and to be very specific about the definition of each process. Some experts explained that claims management and dispute resolution processes might be dragged further beyond this category in practise. Overall agreement on the processes was positive with high levels of confidence towards the construction process category and proposed processes.

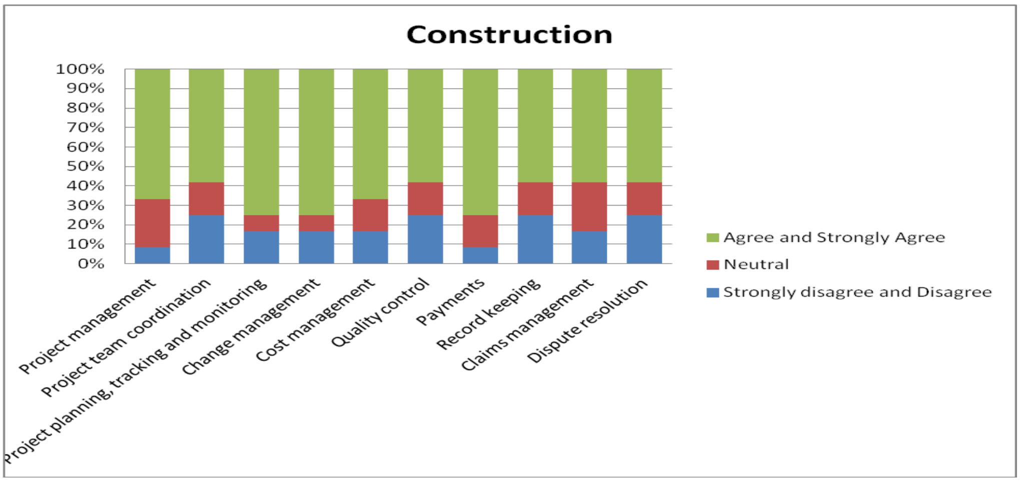

Figure 3.5: Expert opinions on Construction process category

The Use and aftercare category consisted of three processes such as project performance review, update project information and facilities management. One of the experts requested to consider the project performance review within the construction category. However other experts agreed for the proposed classification.

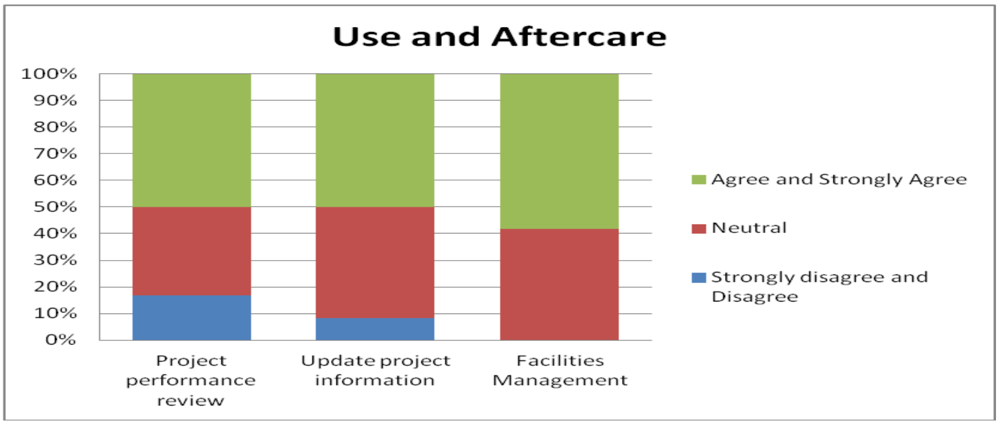

Figure 3.6: Expert opinions on Use and Aftercare process category

4. Conclusions

Current economic conditions and rapid development of technologies are driving organizations towards greater competition and innovation. Organizations are forced to towards efficiency savings, productivity improvements, greener technologies and increased collaboration using new innovative approaches. This has resulted in implementation of e-business processes as a key strategic approach to create new pathways to gain competitive advantage and economic reward. It requires construction organizations to follow the same and develop e-business approaches innovating and integrating ICT in to traditional construction processes. This paper presented a key construction process classification as a part of development of an e-business capability maturity model for construction organizations. It presented an analysis of current construction e-business processes to ensure its mapping to e-business capabilities and their levels of maturity. It discussed the process of developing a protocol for categorising the construction processes for the development of a construction e-business capability maturity model. The process classification was initially built up through an analysis of RIBA and OGC archives as a conceptual categorisation and subsequently reviewed and refined through a series of expert interviews. The processes classification consists of 27 processes which are categorised into five process categories as preparation and brief, planning and design, tendering and procurement, construction and use and aftercare. This categorisation forms the basis of developing the key process areas of the construction e-business capability maturity model to be developed. It will facilitate identification and mapping of the status of e-business process implementations of construction organizations.

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SCM and Extended Integration at The Lower Tiers Of The Construction Supply Chain: An Explorative Study In The Dutch Construction Industry

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Abstract

Several studies have underlined the potential of Supply Chain Management (SCM) in meeting the formidable challenges associated with fragmentation, adversarial relationships and insufficient customer focus in the delivery of construction projects (e.g. Dainty *et al.*, 2001; Cox and Ireland, 2002; Gadde and Dubois, 2010). However, there remains a paucity of properly documented examples of successfully implemented SCM initiatives, particularly at the lower tiers of the supply chain. This study sets out to explore the enablers and barriers to the implementation of SCM at the lower tiers of the supply chain, particularly the problematic collaboration between main contractors and subcontractors. A SCM Maturity Model is developed based on Holti *et al.*'s (2000) seven principles of SCM organisation. An explorative study is conducted based on interviews from eight large main contractor and subcontractor organisations in the Dutch construction industry. Discouragingly, across the organisations, more barriers than enablers to supply chain management are identified. Organisations are found to be particularly struggling to compete through superior value, manage costs collaboratively, and develop continuous improvement within their supply chains. The findings also underline the low SCM maturity of main contractors and their inability to play the essential role of supply chain managers. Indeed the principles of integrating project activities and mobilising and developing people are found to be better exercised by subcontractors. The study may highlight the need for a greater degree of contractor leadership and improved internal organisation of both types of firms in order to achieve greater collaboration at the lower tiers of the construction supply chain.

Keywords: SCM, Construction supply chain, Contractor-subcontractor relationships, extended integration

1. Introduction

The construction industry is widely criticised for adopting highly adversarial and fragmented approaches to relationships, where design is separated from production and a lack of suppliers' involvement exists at the early stages of projects (Egan, 1998; Chan *et al*., 2003; Bresnen and Marshall, 2000). Although fragmentation originally developed as a flexible way of dealing with highly variable workloads, it has resulted in complex contractual relationships and discontinuity of teams (Egan, 1998). Several studies have underlined the need for radically different approaches to supply chain relationships that achieve 'customer delight' and minimize turbulence in stakeholders' relationship (Latham, 1994; Cox and Ireland, 2002; Pryke, 2009).

In response to UK government reports such as Latham (1994) and Egan (1998), criticising the industry, there has been a move towards better supply chain integration and the formation of strategic partnerships and collaborative agreements between supply chain actors (Akintoye *et al*., 2000; Rimmer, 2009; Holti *et al*., 2000; Briscoe and Dainty, 2005). These approaches have been extensively adopted by parts of the industry as possible instruments for improving performance and inter-organisational relationships (Briscoe *et al*., 2004; Wood and Ellis, 2005; Akintoye and Main, 2007; Bygballe *et al.,* 2010). Arguably, these improvements are achieved through the adoption of a holistic approach by focussing on the network of relationships between supply chain actors involved in construction projects (Pryke, 2009).

However, there remains a paucity of properly documented examples of successfully implemented SCM initiatives, particularly at the lower tiers of the construction supply chain (Cox and Ireland, 2002; Gadde and Dubois, 2010). Construction projects are characterised by a high subcontractor/supplier involvement and rely heavily on subcontracting (Mbachu, 2008). Subcontracting has been adopted as the dominant procurement strategy as a consequence of the uncertainty faced by main contractors in obtaining continuous work and the need to accommodate the different, increasingly specialised and complex, requirements of each project (Morledge and Smith, 2013). However, while several studies underlined the importance of main contractor-subcontractor collaboration (Kale and Arditi, 2001; Wood and Ellis, 2005; Eom *et al,* 2008; Hartmann and Caerteling, 2010) opportunistic, arms-length and adversarial relationships are still prevalent among main contractor and subcontractor organisations (Greenwood, 2001). There appears to be a belief that existing SCM initiatives are adopted by contractors in order to increase their profitability at the expense of other members of the supply chain (Dainty *et al*, 2001). Where challenges arise, subcontractors and suppliers are often the most affected (Morledge and Smith, 2013).

This study sets out to explore the enablers and barriers to the implementation of SCM at the lower tiers of the construction supply chain, particularly the problematic collaboration between main contractors and subcontractors. Several studies have emphasised the need for collaborative relationships between main contractor-subcontractor organisations (Zou and Lim, 2006; Hartmann and Caerteling, 2010). The aim of this research study is to extend the existing debates on the issue by adopting an alternative approach focusing specifically on the internal SCM organisation of both main contractor and subcontractor organisations, and their direct inter-relationships. A SCM Maturity Model is developed according to relevant SCM concepts and based on Holti *et al*.'s (2000) seven principles of SCM organisation. The model is applied within the context of the Dutch construction industry and used to examine the SCM maturity of eight large main contractor and subcontractor organisations.

2. Conceptual development

2.1 SCM concepts

Supply Chain Management (SCM) first appeared as a term in the early 1980s with its core concepts primarily originating from the Japanese automotive sector (Womack *et al*., 2007; Peck, 2006). It is a new way of thinking about management and processes, in order to coordinate supply chains more efficiently, by managing the associated relationships to delivery customer value, through innovation and continuous improvement (Akintoye and Main, 2007; Pryke, 2009; Christopher, 2011; Meng, 2012). Harland (1996) categorises SCM into four different levels:

1. The management of an internal supply chain integrating the activities of a firm;
2. The management of a dyadic relationship between two immediately connected suppliers;
3. The management of a chain of businesses with which a firm has no contractual relationship; and
4. The management of a network of interconnected businesses involved in the ultimate provision of a product to customers.

The interest in adopting SCM techniques has been growing in the construction industry since the 1980s (Segerstedt, 2010). The management of the different levels proposed by Harland (1996) is necessary as they form an integral part within a greater context: the supply network (Harland, 1996). Dainty *et al*. (2001) and Pryke (2009) describe SCM in construction as the management of the network of relationships within which firms are embedded. A holistic view is required for each of these levels to ultimately contribute to performance improvement and customer delight within the industry (Pryke, 2009). This contribution is fundamental in the creation of competitive advantage, which reflects the influence of efficient and constructive network relationships on a firm's short-term financial position and long-term competitive power (King and Pitt, 2009; Van Weele, 2010).

Porter (1985) developed the concept of the 'Value Chain' which reflects the importance of a focus on value and relates to all activities, both inside and outside the firm that contribute to its delivery (Van Weele, 2010). Management objectives have therefore moved away from the attention focussed on the finite domain of a single organisation to deliver competitive advantage. Attention is now focussed on ensuring competitive advantage for the integrated supply chain (Green *et al.,* 2005). Lambert and Cooper (2000) affirm this paradigm shift, stating that businesses no longer compete as a sole business entity, but rather in a 'supply chain versus supply chain' manner. Pryke (2009) states that the main objective of SCM is to enhance mutual competitive advantage and that this can be achieved through improved relationships, integrated processes and increased customer focus.

In essence, SCM is based on integrating supply chain actors to enable the sharing of knowledge and information (Holti *et al*., 2000; Martinsuo and Ahola, 2010; Christopher, 2011). Under traditional procurement, firms have the tendency to withhold vital information, such as those relating to risk (Gann, 2000). Edkins (2009) points out that such practice can hinder collaboration and prevent the establishment of trust and long-term relationships. SCM is based on a 'holistic' management approach by bridging the gap between actors, thus, providing the supply chain with the flexibility in adapting to changing client's needs, as uncertainties are reduced through the sharing of knowledge and information (Cox *et a*l., 2006; Pryke, 2009).

2.2 Towards SCM maturity in construction

Holti *et al*. (2000) offered an approach to managing a supply chain that provides support to supply chain actors and encourages collaboration. One of the main concepts is that all supply chain partners make contributions as team members, with no single discipline claiming a privileged view as to the nature of value (Holti *et al*, 2000). There is a tendency towards informality, a move away from contract management towards relationship management, and with it a demand for methods of effectively managing these new types of linkages between project actors (Pryke, 2009).

Holti *et al*. (2000) recommend a single point responsibility to effectively integrate supply chains. This is deemed to be necessary as construction supply chains are fragmented, complex, highly uncertain and with many stakeholders, requiring a leading actor to coordinate the process and relationships. It is believed that contractors have more influence on the organisation of the project and on the performance and quality of the work of its subcontractors/suppliers (Latham, 1994). Despite the fact that they have such an important role in channelling client demand through their own supply chains, contractors are overlooked when it comes to research and useful advice (Pryke, 2009). Holti *et al*. (2000) acknowledge a potential leading role for the contractor.

Figure 1: The seven underlying principles (Holti et al., 2000)

Their approach is based on the following seven principles, described as essential ingredients for a construction company to function in a SCM-driven environment:

1) **‘Compete through superior underlying value’**
The first principle centres on enhancing the value of what is actually delivered by the supply chain by improving quality and reducing underlying costs. All members of the construction supply chain therefore, use their capabilities to take the ‘right’ costs out. This main principle embraces all the other six (see Fig. 1).

2) **‘Define client values’**
Holti *et al*. (2000) define client value as a built-up of the functional requirements, the design character and the target through-life cost profile for the desired building. The latter is a more in-depth approach to value, which requires knowledge of both capital and operational costs.

3) **‘Establish supplier relationships’**
The procurement and delivery method influence the performance of the entire supply chain and the outcome of the project. This principle encompasses commitment to forming long-term relationships with a small number of suppliers in each key supply category around major and core-business.

4) **‘Integrate project activities’**
Whereas the preceding principle focuses on the decision on strategic long-term partners, this principle describes a mechanism for effective management of the partners that collaborate on a project. The goal is to resolve all the design-related issues at key interfaces at an early stage by creating clusters and simultaneous engineering, with specialist suppliers involved early in the process to create commitment to subsequent phases.

5) **‘Manage costs collaboratively’**
This principle necessitates the involvement of all members of the supply chain with the knowledge and skills needed for a particular decision. It employs a unique approach to dealing with and managing costs, referred to as 'target costing'. The approach involves suppliers working backwards from the client’s functional requirements and the maximum market price of the item and is supported by two mutually reinforcing techniques: Value and Risk Management.

6) **‘Develop continuous improvement’**
The central role of continuous improvement is to achieve decreasing prices and/or improving functionality and value for future projects. It is a vehicle for achieving long-term performance improvement, with the help of techniques such as lean principles and kaizen events, and to make these a regular, reliable and long-lasting occurrence by taking control of the supply chain (Blanchard, 2010).

7) **‘Mobilise and develop people’**
Adopting all these principles imposes substantial cultural changes on the construction industry which must be accompanied by great commitment in order to drive progress and achieve the

strived benefits. Part of SCM therefore, includes the mobilisation and development of employees so that the human workforce excels through the benefits of the SCM approach.

The seven principles outlined above demonstrate that implementing SCM encompasses the recognition of essential SCM elements internally, within an organisation. The aim of this research study is to underline the challenges on the path towards becoming a well-functioning or 'mature' SCM organisation within an interdependent supply chain in main contractor and subcontractor organisations. For this reason Holti *et al*.'s (2000) principles are used as a framework and transformed into a usable maturity model, as will be explained in the next section.

3. Research method

Given the exploratory nature of the study, a qualitative approach was considered the best-suited for this research (Blumberg *et al*, 2011). Data collection was largely based on primary data, which, building on Yin (2003), was gathered from semi-structured interviews with representatives from main contractor and subcontractor organisations. Four large main contractors and four larger subcontractors, operating in the Dutch construction industry, were included in the research. The participating companies, like most other European firms, were confronted with a difficult economic climate, during the period of this research, characterised by increasing competitive pressures and profit demands. The research was limited to the managerial level of the companies and involved respondents with the responsibility of implementing SCM. Table 1 provides an overview of the participating companies and representatives.

Table 1: Overview of companies involved

MAIN CONTRACTORS			
Name	***Position***	***Company***	***Company Profile***
Interviewee 01	*(Ex-)Director Purchasing*	*Ballast Nedam (BN)*	*Building and development, infrastructure, services and specialist activities.*
Interviewee 02	*Director Purchasing*	*Royal BAM (BM)*	*Construction, mechanical/electrical services, civil engineering, property and PPP.*
Interviewee 03	*Director*	*Dura Vermeer (DV)*	*Construction, real estate and infrastructure.*
Interviewee 04	*Director*	*Waal (WB)*	*Housing, social/commercial properties, and renovation.*

SUBCONTRACTORS			
Name	***Position***	***Company***	***Company Profile***
Interviewee 05	*General Director*	*De Groot and Visser (GV)*	*Supplier/manufacturer of aluminium windows, facades, doors and blinds.*
Interviewee 06	*Business Leader*	*Geelen Beton (GB)*	*Precast concrete floor systems and other concrete construction elements.*
Interviewee 07	*Director*	*Trijselaar Vermeer (TV)*	*Plumbing and sanitary installation company.*
Interviewee 08	*General Director*	*Berkvens (BV)*	*Manufacturer of the interior door/frame package.*

A general group session was organised to introduce the process of primary research. This session clarified the exact research topic, refined the research aims and values, and shaped the following methodology together with the interested companies. It was decided to adopt a two-stage approach. First, a series of eight individual open discussions was held to explore the perspectives of the companies involved with regards to their role and their partners' role within the SCM relationships and the existing barriers inhibiting integration and collaboration.

It was surfaced that the companies involved have several uncertainties regarding their own and their partner's position and role in an effective SCM collaboration. It seemed that most barriers in the relationship flow from these uncertainties and that chain integration cannot be established when the parties involved are not SCM-organised themselves. The second stage of the research thus focused on the analysis of the current SCM status of all individual companies involved. The themes and accompanying questions for this analysis were derived from the seven principles that Holti *et al*. (2000) describe in their 'Handbook for SCM' as essential ingredients for an SCM organisation. Appendix 1 outlines the developed SCM Maturity Model. The SCM maturity levels in the model were developed after the interviews were held, and thus the range of answers given by the participants influenced the five different levels established per theme. The model thus provides a relative comparison of SCM maturity among participating companies rather than an absolute measure.

4. Research findings

This section presents the research findings. It should be noted that the research findings have limitations presented by the chosen research methodology. The findings concern only eight main contractor and subcontractor organisations. Therefore, as Yin (2003) argues, the findings stemming from this type of methodology are merely hypotheses that need to be confirmed or rejected. In order to be representative of the industry, the research findings need to be tested using quantitative research.

4.1 The SCM Maturity Model

The analysis of the research findings is based on the developed SCM Maturity Model which attempts to measure the SCM maturity level of the companies involved in the research. Emphasis is placed on the current characteristics of the organisation and its level in implementing SCM. The scores achieved in relation to the seven themes are summarised in Table 2 below.

Table 2: Overview of the themes

	BN	*BM*	*DV*	*WB*	*GV*	*GB*	*TV*	*BV*
General								
Insight into the construction supply chain	*0*	*2*	*2*	*2*	*0 / 1*	*1 / 2*	*3 / 4*	*3 / 4*
Principle 1: Compete through superior value								
Insight into profit/turnover level	*0*	*1*	*2*	*0*	*0 / 1*	*0 / 1*	*2*	*2 / 3*
Value adding activities and wastage	*-*	*0*	*2*	*2*	*1*	*1*	*2*	*2 / 3*
Principle 2: Define client values								
Client's wishes and specifications	*0 / 1*	*2 / 3*	*3*	*1 / 2*	*1 / 2*	*1*	*3 / 4*	*1*

Customer delight	*1*	*2*	*3*	*3*	*1*	*3 / 4*	*3*	*3*
Principle 3: Establish supplier relationships								
Black box of subcontracting	*0*	*1*	*1*	*3*	*1 / 2*	*1 / 2*	*2*	*2 / 3*
Strategic partners	*0*	*3*	*1*	*2*	*1*	*2*	*3*	*3*
Principle 4: Integrate project activities								
Partner involvement	*1*	*1*	*1 / 2*	*2*	*1 / 2*	*2 / 3*	*2 / 3*	*2*
Integration of processes	*0*	*0*	*2 / 3*	*2 / 3*	*1 / 2*	*2*	*2*	*2*
Principle 5: Manage costs collaboratively								
Initial price	*2*	*1 / 2*	*2*	*2*	*1*	*1 / 2*	*1 / 2*	*1 / 2*
Risk management	*1*	*1*	*3*	*1 / 2*	*0 / 1*	*2*	*2*	*2 / 3*
Principle 6: Develop continuous improvement								
Continuous improvement	*0*	*1*	*3*	*1*	*0 / 1*	*1*	*1 / 2*	*3*
Principle 7: Mobilise and develop people								
Development of people	*0*	*2*	*2 / 3*	*1 / 2*	*1 / 2*	*3*	*3*	*3*

The individual ratings as shown in this table mirror the status of each participating organisation against Holti *et al*.'s (2000) ideal SCM organisation. The table shows scores that range between 0 and 3 and just occasionally reach higher than 3, for both contractors and subcontractors. As set out in Section 2, the construction industry is known to be a challenging industry for SCM implementation (Gadde and Dubois, 2010). The ratings achieved for Principle 1, 5 and 6 are the lowest across the seven principles.

Principle 1 ‘Compete through superior value’ requires insight into the built-up of costs and clarity about ‘right’ and ‘false’ costs, however, this clarity seems to be missing. As interviewee 02, BM commented: “*The construction world is familiar with the concept of failure costs, but nobody knows how much these costs really are or even what the real definition is*” *(interviewee 02, BM).* Findings in relation to Principle 5 ‘Manage costs collaboratively’ reflect practices that favour short-term financial gains in the difficult economic climate currently facing the firms, such as non-legitimate risk transfer, contradicting SCM. Principle 6 ‘Develop continuous improvement’ was found to be a well-understood principle, however doubts exist on how to correctly implement it in an industry characterised by one-off projects. Some of the issues raised by interviewees were the difficulty of applying project-specific knowledge to other types of project (interviewee 01, BN) and the fact that knowledge, particularly tacit knowledge, often resides with people (interviewee 07, TV).

4.2 A relative comparison of main contractors and subcontractors

In comparison between the two types of companies, it is easily noticed that Principle 4 and 7 are better exercised by subcontractors. Principle 4 ‘Integrate project activities’ encompasses the involvement of partners and the integration of processes and activities, which due to subcontractor’s greater specialisation is found to be more straightforward to manage. For example, one subcontractor company depends on long-terms strategic partners for 70% of their contracts (interviewee 07, TV), another works with the same supplier of sand, grind and cement (interviewee 06, GB) or many partnerships involve commodities (interviewee 05, GV). Principle 7 ‘mobilise and develop people’ could be explained with similar reasoning as individuals are of greater importance in the delivery of actual value in relation to their particular speciality. In addition, although the variation in scores is not high, it should be noted that main contractors, largely considered by Holti *et al*, (2000) as the leaders of SCM implementation, do not score particularly high in order to take up that role.

4.3 Effect on contractor-subcontractor relationship

Although the focus of the SCM maturity model lies essentially on the internal organisation of the companies, the data collected shows that a company's processes and activities are interrelated with the processes and activities of its surrounding companies. This shows the impact of partners, or even the entire supply chain, on the individual implementation of effective and efficient SCM. In other words, the way in which an individual company implements SCM might influence the implementation of SCM in the relationship, chain and network. This refers to the first two related SCM uses as described by Harland (1996).

The findings indicate that principle 3 'Establish supplier relationships' influences the basis for partnerships and the degree of trust, certainty and respect. Interviewee 02, BM, for example, spoke about the importance of reciprocity for a valuable partnership and interviewee 04, WB, about the necessary equal perceptions on collaboration. In order for Principle 1 'Compete through superior value' and 5 'Manage costs collaboratively' to work, insight in relation to value, costs, risk and profit is needed which demands an increase in transparency and openness. This necessary increase is confirmed through examples such as improved discussions that take place when using self-developed sheets or checklists (interviewee 07, TV), initiatives that develop during in-depth discussions of material use and processes (interviewee 06, GB) and joint risk calculations (interviewee 08, BV). Principle 2 and 4 relate to communication, demonstrated for example by how interviewee 03, DV, values both client and partner sessions. Principle 6 and 7 relate to communication, commitment and a change of thinking. As interviewee 01, BN commented: *"There is no truth in the construction industry. All projects are unique and therefore, an exception and each project comprises a new belief system and set of rules. This inhibits the recognition people are able to find in solutions that are offered to the industry" (interviewee 01, BN).*

5. Conclusion

SCM can support the move away from traditional adversarial relationships prevalent in construction supply chains and provides an opportunity for the delivery of more value to clients. This value is derived through collaborative working, easier knowledge transfer and the creation of long-term effective working relationships. This research focuses on collaboration at the lower tiers of the construction supply chain, particularly the problematic collaboration between main contractors and subcontractors. All participating companies were found to be aiming at a similar outcome: performance improvement in order to create competitive advantage in the difficult economic climate they were facing. Despite their familiarity with SCM, and their enthusiasm and willingness to create the best environment in order to implement SCM appropriately, the construction industry was described as challenging with characteristics that obstruct successful implementation of SCM. The

SCM maturity model proved to be valuable in reflecting the environment in which the participating companies attempted to deal with SCM, and to discover the particular elements that either enabled or inhibited SCM implementation. The seven principles by Holti *et al*. (2002) remained central throughout the entire research.

Discouragingly, across the organisations, more barriers than enablers to supply chain management were identified. Organisations were found to be particularly struggling to compete through superior value, manage costs collaboratively, and develop continuous improvement within their supply chains. The findings also underline the low SCM maturity of main contractors and their inability to play the essential role of supply chain managers.

In terms of managerial implications, the study may highlight the need for a greater degree of contractor leadership and improved internal organisation of both types of firms in order to achieve greater collaboration at the lower tiers of the construction supply chain. In addition, the SCM maturity model developed may work as an improvement framework that could be applied to main contractors' and subcontractors' SCM activities towards extended integration and through this, a more collaborative relationship.

Research is currently undertaken in order to quantify the different levels of SCM maturity, including useful and known 'best-SCM-practices' to allow an absolute SCM comparison and to guide construction companies better in their growth towards SCM maturity. Moreover, the model will be adapted to focus analysis on subcontractor maturity more towards the relationship with its contractor rather than with its own subcontractors/suppliers.

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Appendix 1: SCM Maturity Model

PRINCIPLE 1: 'COMPETE THROUGH SUPERIOR VALUE'

Insight into profit/turnover level	
0	No insight
1	Information related available
2	Engagement in discussions
3	Involvement and contribution to this level
4	Reciprocal contribution to this level

PRINCIPLE 2: 'DEFINE CLIENT VALUES'

Client's wishes and specifications	
0	Client's wishes and specifications received
1	Direct contact and discussion with direct client
2	Direct contact and discussion with final client
3	Wishes and specifications openly communicated through to partners
4	Wishes and specifications openly discussed with client and partners
Customer delight	
0	Customer delight is not considered
1	More is done to discover the real wish of the client
2	Value is reviewed
3	Customer delight is considered
4	Investment in customer delight without direct benefit

PRINCIPLE 3: 'ESTABLISH SUPPLIER RELATIONSHIPS'

Black box of subcontracting	
0	Criteria for subcontracting do not really exist and are not shared
1	Criteria for subcontracting are established
2	Criteria for subcontracting are project exceeding and based on best project outcome
3	Criteria are shared with all partners
4	Criteria are sustainably applied and in line with commonly identified goal of supply chain
Strategic partners	
0	No distinction is made between strategic/key and normal partners
1	Awareness of distinction exists
2	Long-term partnerships are established
3	Strategic long-term partnerships exist
4	More than one strategic long-term partnerships exist within each key supply category
Power leverage	
	Power and responsibilities shift all the time

PRINCIPLE 4: 'INTEGRATE PROJECT ACTIVITIES'

Partner involvement	
0	Partners are not involved in the process
1	Partners are involved in the process
2	Partners are involved as soon as own involvement starts
3	Partners are involved before own involvement starts
4	Partners get involved as cooperating construction supply chain
Integration of processes	
0	Processes are not integrated and many problems occur at interfaces
1	Internal processes are aligned with company's strategy/goals
2	Internal processes are integrated; problems related to external non-integration
3	External process are integrated; simultaneous/concurrent engineering
4	All processes are aligned with strategy/goals of construction supply chain

PRINCIPLE 5: 'MANAGE COSTS COLLABORATIVELY'

Initial price	
0	No commitment to initial price; initial price unrealistic
1	Initial price realistic, based on information received; occasional claiming
2	Competent people and/or partners are involved in improved price calculation
3	Construction supply chain tries to stick to initial price; transparent price calculation
4	Target-costing approach in construction supply chain
Risk management	
0	No awareness of risks; risks are transferred as much as possible
1	Awareness of risks; risks are transferred as much as possible
2	Awareness of risks; (some) risks are absorbed
3	Risks are discussed with partners; (some) risks are absorbed
4	Risks are actively managed and avoided

PRINCIPLE 6: 'DEVELOP CONTINUOUS IMPROVEMENT'

Continuous improvement	
0	No continuous improvement
1	Activities on continuous improvement exist within company
2	Awareness of activities of partners on continuous improvement
3	Involvement in partner's activities on continuous improvement
4	A jointly appraisal scheme of targets related to continuous improvement exists
Standardisation/Specialisation	
	Standardisation in certain formulated product niches

PRINCIPLE 7: 'MOBILISE AND DEVELOP PEOPLE'

Development of people	
0	No commitment
1	Awareness of people's experiences and commitment within company
2	People are informed and involved in the company's development
3	People are actively developed
4	Construction supply chain is used in the development of people

Risk Management with Real Options in Public Private Partnerships

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Abstract

Public Private Partnerships (PPP) have secured a position as an alternative to direct investment in construction projects in the municipal sector. The construction costs of PPP projects are often justified by stating that the quality of construction is better and the overall lifecycle costs are optimized according to the client's needs. Recently a need for flexibility in PPP contracts has emerged. In some cases the client demand for services may vary during the concession period. This generates a need to make flexible contracts between client and provider.

Providers in PPP projects have an increasing need to identify and manage uncertainty and risks related to contract flexibility. In order to do this effectively, the economic feasibility of risk management actions must be evaluated. In this paper real options analysis (ROA) is used to evaluate risk management actions related to PPP projects with long life cycle. A large Finnish healthcare facility PPP project is used as a case in the study. The key performance metrics used in the study is to secure high building occupancy and rental yield.

Three main sources of uncertainty were identified related to the flexible contract and long contract period. Accordingly, the risk management actions for coping with the uncertainties were proposed and examined with the developed ROA procedure. The provider stated to have received several benefits from the ROA analysis such as decision-making information directly applicable to investment decision and guidelines for developing briefing and design management documents; thus, potentially improving project profitability in later life-cycle stages.

The actual monetary values provided by ROA assessment were, for example, 680 000 € for flexibility designed in parking structure compared to the original design. The proposed physical flexibility for coping with the uncertainty in final space demand was found to have a value of 460 000 €. The building integrated on-site energy source production for addressing the uncertainty in raising energy costs was found to have an option value of 440 000 €.

The theoretical implication of the paper is that real options analysis can reveal opportunities and risks inside a PPP project that might remain unnoticed with the traditional investment analysis methods. The identification of separate investments as options can be used for managing risk and value inside a PPP project.

Keywords: Risk management, real options, PPP, life cycle, valuation

1. Introduction

1.1 Background

Public Private Partnerships (PPP) is seen as a mechanism for producing more efficiently real estate services to public organisations. Often PPP projects are so large that the public organisation (client) does not have the necessary resources for implementing the project. This is also tied to financing of the project; the client may not have the necessary initial financing to implement a project of such a large scale. The client may find it more attractive to allocate the costs over the lifecycle of the investment. This mind-set of monthly compensation is also argued to reduce the risk and increase the quality of the investment because the real estate service provider has to optimize the lifecycle costs of the investment. When the provider knows in the design and construction phase that it will stay as an operator in the project, it will have motivation to optimize the maintenance and renovation costs by better design solutions. These arguments are well founded and are used for promoting PPP projects (e.g. Shen et al., 2006; Cumming, 2007).

Recently there has emerged a need for flexibility in PPP contracts. In some cases the client demand for services may vary during the concession period. This generates a need to make flexible contracts between client and provider. For example, the contract may have a claim, which enables the client to increase or decrease the amount of services that it compensates for the provider.

Providers in PPP projects have an emerging need to identify and manage uncertainty related to contract flexibility that can have a great impact in project profits. In order to do this effectively, the economic feasibility of risk management actions must be evaluated. In this paper real options analysis (ROA) is used to evaluate risk management actions in a large Finnish healthcare facility PPP project.

The PPP project has been planned and implemented with a model that aims to maximize the value and flexibility to the client (municipality of Järvenpää). The key target of the provider in the investment project is to secure high building occupancy and rental yield. The concession period is 40 years. The target of the PPP contract is design, construction, operating and financing the healthcare facilities. The contract is highly flexible, as the amount of needed space is not fixed. In contrast, the client will compensate only the costs of the spaces that it currently needs.

The purpose of this paper is to demonstrate how ROA can enhance risk management of a PPP project. ROA is used for identifying and valuating uncertainties from the provider's perspective.

1.2 Real options analysis

Real options analysis is an approach that is often considered to complement the popular traditional discounted cash flow (DCF) analysis when evaluating real capital investments.

Trigeorgis and Mason (1987) argued that the DCF cannot properly capture the asymmetric value of managerial flexibility (i.e. *"future managerial decisions can improve upside potential while at the same time limiting downside losses"*) and proposed an options based framework for valuing managerial flexibility. Later Trigeorgis (1988) categorized two option types that can capture managerial flexibility: *"operating flexibility, i.e. collection of options enabling management to make or revise decisions at some future time"* and *"strategic value, i.e. interdependencies with future, follow-up investments and competitive interaction"*. Furthermore, Dixit and Pindyck (1995) stated that the DCF assumes investments are either reversible or now or never decisions, where the decisions regarding future cash flows have to be made at the initial stages of an investment. This was found problematic when future uncertainty may affect the expected cash flows with a much larger impact than in a change in discount rates. Thus, the options approach emphasizes uncertainty rather than adjusting financial variables such as the discount rate that often result in myopic decisions. This was further discussed that by emphasizing the role of risk can encourage to invest in strategic investments that create important opportunities in the future.

To conclude the DCF analysis assesses uncertainty and risk mainly with the discount rate that can be problematic when investment decisions have asymmetric value and when the uncertainty (regarding the value) is not resolved continuously at a constant rate (Trigeorgis, 1988). Additionally uncertainty and risk can be examined with sensitivity analysis that is used for projecting the range of expected cash flows. The sensitivity analysis is an effective tool for demonstrating the range of different values an investment can have. Nevertheless, neither of the uncertainty assessment methods can on their own value embedded options (i.e. possible lines of action during the life cycle of an investment) that are created in investments through initial investments and decision-making. ROA was proposed as a method to address these issues (e.g. Trigeorgis, 1988; Dixit and Pindyck, 1995).

ROA is an application of option pricing theory into real assets, where embedded options in a real capital investment is valued using an option pricing techniques which have been originally used in the financial world. The most widely known techniques are the Black-Scholes equation, binomial option pricing model and the Monte Carlo method (Amram and Kulatilaka, 1999). In all of the methods, the option value is calculated by determining the range the values of the underlying asset. The main component in determining the range is finding out the volatility of the asset that. This has been easy in the original applications of finance where detailed historical data has been available. However, with real assets this is problematic and ROA has received criticism (e.g. Lander and Pinches, 1998; Oppenheimer, 2002) for this exact reason, even though the usability of the approach has been well acknowledged.

Earlier literature on real options in the context of PPP is limited and focused on large infrastructure projects. For example, Alonso-Conde et al. (2007) develop a real options framework for analysing a large toll road project, the Melbourne CityLink Project, as a case study. The authors argue that the project's imposed conditions can be treated as real options. Furthermore, the options affect the incentive to invest and how the public sector may be transferring considerable value to the private sector through government guarantees.

1.3 Research methodology

The research strategy of the study can be described as an embedded single-case study design (Yin, 2002), where the units of analysis are the identified sources of uncertainty. In the case study, ROA is applied to a case study according to real options process developed by Greden et al. (2005). In the process, sources of uncertainty are identified and then the current design is benchmarked against these sources. Then, additional investments which helps coping with the uncertainty are determined and costs are calculated. After that the benefits of these extra investments are quantified with real options valuation. Finally, results are analysed and best lines of actions are suggested.

In this study the selected technique for real options valuation is the fuzzy pay-off method (FPOM) (Collan et al., 2009). FPOM was originally developed on the basis of the Datar-Mathews method (2004), which calculates the real options value from the pay-off distribution of net present values generated by Monte-Carlo simulations. Collan et al., (2009) realized that the probabilistic theory used in the Datar-Mathews method (and in other mainstream ROA methods) to treat for uncertainty can be replaced with fuzzy set theory (Zadeh, 1965). In the fuzzy set theory, different propositions have a degree of membership in a set, i.e. membership is 0 (complete non-membership), 1 (complete membership) or a value between 0 and 1 (an intermediate degree of membership).

This realization allowed a simplification of the projection of uncertainty into three scenarios: minimum, best guess (i.e. the most likely scenario, which is normally drawn up in investment analysis) and maximum. These three scenarios are treated as triangular fuzzy numbers that form a triangular pay-off distribution where the best guess scenario has complete membership, the minimum and maximum scenarios have complete non-membership, and other scenarios between have intermediate degrees of membership. This asymmetrical information is used as the basis to form a triangular pay-off distribution that is *"a graphical presentation of the range of possible future pay-offs the investment can take"* (Collan et al., 2009). For a more detailed description of the method and mathematical formulas, please see Collan et al. (2009) and Collan (2012).

2. Case study

2.1 Sources of uncertainty

Finnish municipality of Järvenpää (client) with a population of nearly 40 000 inhabitants recognized the need for a new healthcare facilities in 2008. The need was imminent due to three major reasons. First, the demand for healthcare services is increasing due to the rapidly ageing population. For example, the number of people over 75 years of age is expected to triple by 2030. Second, the existing healthcare facilities were in relatively poor condition. Third, a new agile, low cost and high impact process for delivering healthcare and social services was urgently needed as local healthcare costs and budget deficit were projected to rise substantially by 2020.

In this situation, the city decided that new facilities should be procured with a PPP model. The concession and contract period was selected to be 40 years and the scope of the contract was set flexible as the amount of space the client uses, and thus the compensation for provider, should change according the client needs. In essence, the target of the PPP contract was design, construction, operating and financing the healthcare facilities. The provider was selected in 2010 and the aim is to complete the building in autumn 2016.

The key target of the provider in the investment project is to secure high building occupancy and rental yield. The provider had to start the design of the new building under high uncertainty. Three main sources of uncertainty to the building investment were identified:

1. The need of parking space was strongly linked with the development of the surrounding urban area of the building and there were no decisions of the schedule of development actions.

2. The client space need correlates strongly with the future population growth, which was not unambiguous because there were different forecasts for the growth, and the healthcare processes were under development.

3. The raising volatile energy costs for heating was identified as a major risk that could radically decrease the profit of the provider during the contract period.

Three extra investments were identified for coping with these uncertainties: a phased parking garage solution, physical flexibility and on-site energy source. Two of the first investments are related to the population growth and the latter investment is related to the raising costs of energy prices.

The role of population growth is very important when planning new long-term public investments. Often there are different projections for population growths that can complicate the decision-making for the stakeholders in an investment project. In this case there are three main projections for the population of Järvenpää in 2030. The municipality itself estimated it as 54 514 persons (Järvenpää, 2011). The Statistics Finland's (Statistics Finland, 2013) official estimation is 43 928. A healthcare consultant nominated for the project estimated it as 50 000 that was regarded as the most likely scenario. Since the other two estimates are also well founded, they should be taken into consideration as well because we want to assess the uncertainty regarding the space and parking demand which are closely tied to the population growth in the area. Therefore, these three estimates are set as the maximum, minimum and best guess estimates for FPOM, respectively.

2.2 Parking garage

The first step of the investment analysis for the parking garage was to model the local demand of parking lots in three population scenarios. Following that, four potential parking investment alternatives were analysed and valuated.

The new healthcare facilities were estimated to require 182 parking spaces. A dedicated lot next to the facilities allows for building 185 spaces in one level. However, the lot has also been dedicated as a parking space for other new developments in the area. These are two apartment buildings with a need of 30 and 48 parking spaces as well as other planned healthcare related buildings with a requirement for 250 parking spaces. Thus, when the area is fully developed the total demand is 510 parking spaces. This demand can be supplied by constructing a four-story parking garage. However, there is uncertainty how the demand is actually realized in time. In Figure 1 is presented the demand for parking spaces in the three different population growth scenarios

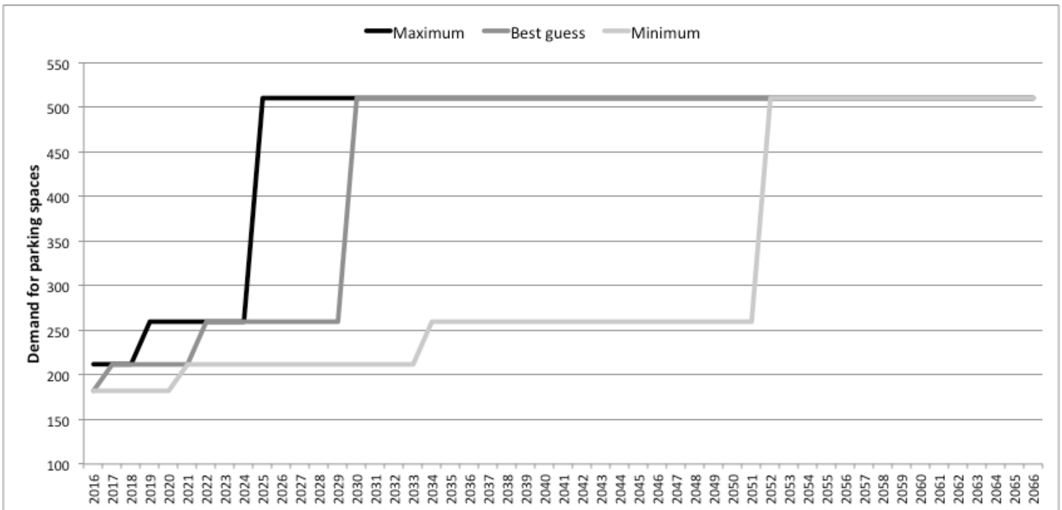

Figure 1: Demand of parking spaces in different scenarios

The smaller jumps in the demand in the figure are due to construction of the two apartment buildings. It was estimated, based in Järvenpää statistics that 3.5% of the annual population growth is focused in the district where the lot is. From this could be derived the demand for new housing in the district and eventually determining the approximations when the new apartment buildings are constructed in the different population growth scenarios. The larger jump of 250 spaces is due to the extension of the healthcare campus. The extension will be developed when the population of the area reaches a level that cannot be handled only with the new healthcare facilities.

Originally the provider was given three alternatives for developing the lot. All of them included the eventual construction of a four-story parking garage with 460 spaces (115 per story) and a ground level parking of 50 spaces. However, a fourth alternative of staged construction was presented to provider as a new alternative. The idea of this alternative was based on de Neufville's (2006) real options paper where the flexibility (i.e. the upfront costs of the footings and columns) allowing the garage to be built in stages (i.e. additional levels could be built on top of the initial structure at a later date) rather than all at once reduces the risk and increases the expected value of the investment. Table 1 presents the alternatives for developing the lot.

Table 1: Alternatives for developing the parking lot

Alternative	*Investment costs per parking space (€)*	*Maintenance costs (€/space/a)*	*Rental income (€/space/a)**
1) Temporary gravel field with a life cycle of 2 years	*500*	*180*	*602*
2) Temporary plated field with a life cycle of 10 years	*2 000*	*180*	*1 203*
3) Parking garage with a life cycle of 50 years	*15 000*	*300*	*2 407*
4) Parking garage constructed in stages with a life cycle of 50 years	*17 130 (1st floor),* *14 870 (2nd to 4th floors)*	*300*	*2 407*

** Assuming parking garage is open 12 hours a day, 70 % occupancy rate during the weekdays, 20 % during the weekend, and a parking fee of 0.25 €/h, 0.5 €/h and 1.0 €/h for the alternatives 1, 2 and 3/4, respectively.*

In the 1st and 2nd alternatives it is assumed that the temporary fields are continuously constructed until the demand requires construction of the parking garage. In the 3rd alternative, the parking garage is constructed immediately. In the 4th alternative, the construction starts with the first and second floors (the first floor is more expensive due to the staged construction process), then when the demand is high enough, first the 50 ground level spaces (5 000 € per space for a lifecycle of 50 years) are constructed and after that the 3rd and 4th floors of the parking garage are constructed.

Since we know the timing of construction (demand), construction costs and net rental income, we can use FPOM for calculating the option values for the different alternatives. In the calculations have been assumed that discount rate is 3.0 % (lending rate for the provider), annual rise of construction costs is 2.5 %, annual inflation (rental appreciation) is 2.0 %, and annual rise of maintenance costs is 3.5 %. The calculated real option values for different alternatives are 1) 21 430 000 €, 2) 21 400 000 €, 3) 21 800 000€ and 4) 22 480 000 €. From the values we can see that the staged construction has the best net present value for the project. The value difference is mainly due to the potential gain in the minimum demand scenario where downside losses are limited but upside gain is not. This observation is in line with the one found in de Neufville's (2006) paper: flexibility of the staged construction limits downside losses while retaining the advantage of upside potential.

2.3 Physical flexibility

The investment costs for the healthcare building is estimated as 38 500 000 € including everything, i.e. construction costs, furnishings and project reservations. The building size is approximately 13 500 gross sqm with an operative area of 8 000 sqm. Nearly all social and healthcare operations of Järvenpää will move in to occupy this area. This operative area is designed in accordance with the best guess scenario of 50 000 persons in the year 2030. Since the hospital building is constructed according to the population of the year 2030, the building will not have a 100 % utilization rate in the beginning. Figure 2 presents empty consulting rooms in different growth scenarios.

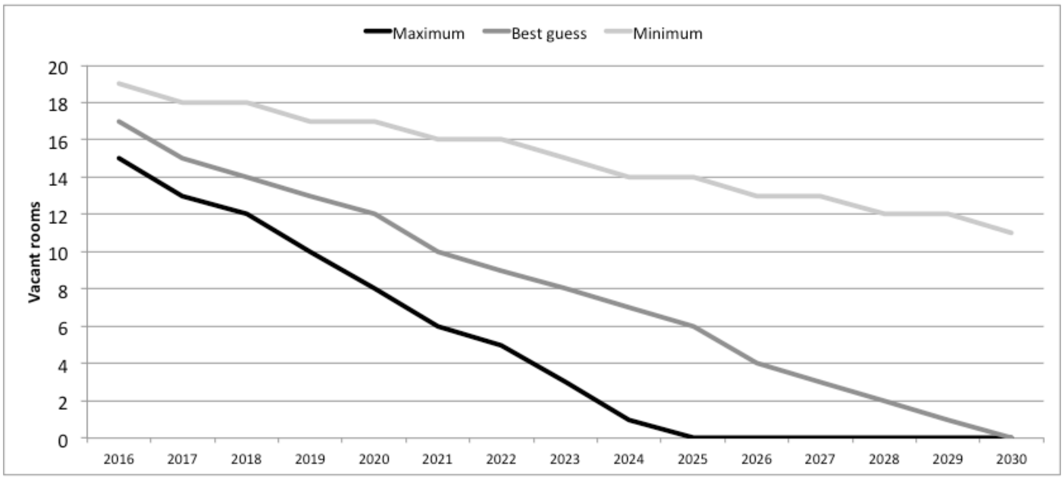

Figure 2: Vacant rooms in different population growth scenarios

These vacant rooms can be regarded as unnecessary space costs to the provider if the contract only requires the client to pay for the rooms it needs (or they would be unnecessary space costs to the client if the client would have to pay for them). However, these unnecessary space costs could be transformed into rental income, if they could be rented to an outside operator (e.g. a private practitioner) for the years they are not needed by the client. This real option is acquired by investing into physical flexibility. The extra investments is only 50 000 € because the investment is executed at a very early-stage of design process so that it involves just incremental improvements into locking, passage functionality, etc.

The real option value is tied to the potential rental income generated from the rooms. The average room size (including hallways) is 22 sqm, annual net rent is 240 €/sqm, discount rate is 3 % and occupancy rate is 85 %. This information can transform the empty rooms into net present values of rental income. These cumulative net present values (for years 2016-2030) are 304 000 €, 482 000 € and 845 000 € the minimum, best guess and maximum scenarios. Applying these numbers into FPOM calculates the real option value of 510 000 €, which is 460 000 € more than the extra investment.

2.4 On-site energy source

The provider has a possibility to invest in a ground heat system that removes a large portion of energy price risk. Additionally, on-site energy source enables provider to gain a LEED Gold certificate, which may have a positive impact for the property value, occupancy and rental yield (Wiley et al, 2010). The proposed ground heat system is calculated to remove 80 % of the need for district heating. This saving is attained with an electricity usage equivalent to 26 % of the district heating energy. The investment costs for the system is 750 000 € with a lifecycle of 20 years.

Three scenarios were formed for the real option valuation. In the best guess scenario, the electricity and district heating prices were expected to have an annual increase of 4.0 % and 5.0 %, respectively (expert estimation). The following numbers for the maximum and minimum scenarios were 6.0 % and 8.0 % (Statistics Finland, 2013), and 2.5 % and 3.0 % (expert estimation), respectively. The starting amount of energy needed for heating the building was calculated (using the most widely used construction cost software in Finland i.e., Haahtela) as 1 031 404 kWh with a cost of 0.083 €/kWh. The same numbers for electricity were 777 104 kWh with a cost of 0.101 €/kWh. Figure 3 presents the cumulative savings from the ground heating system in three scenarios.

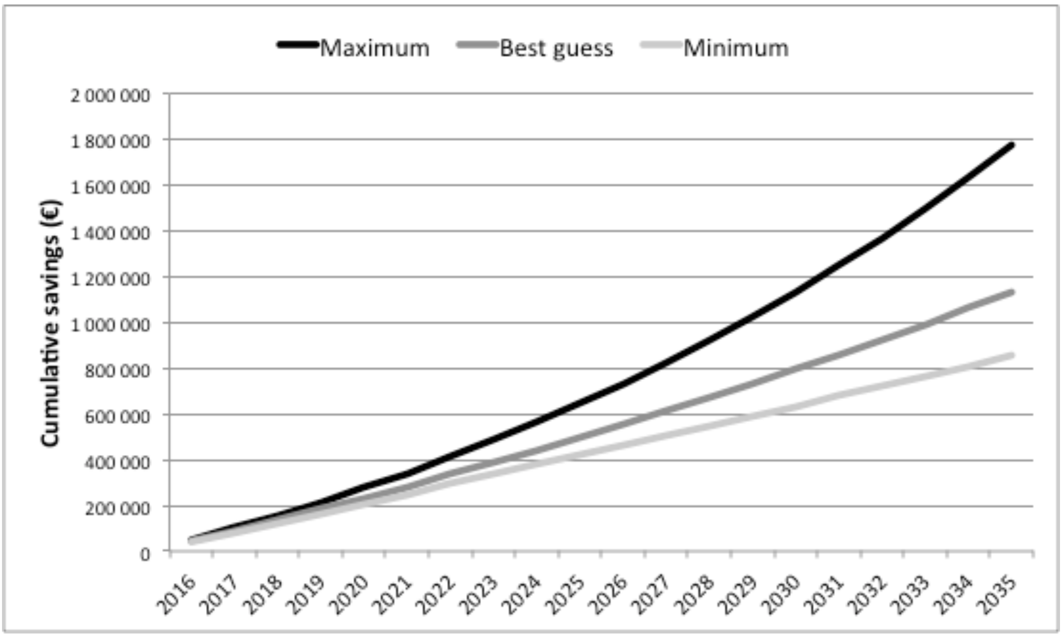

Figure 3: Cumulative savings from ground heating in different energy scenarios

When FPOM is applied to the cumulative savings, the real option value of 1 190 000 € is calculated. This is 440 000 € more than the investment cost. From the figure can be seen that even the minimum scenario the investment is profitable. Additionally it is easier to plan maintenance costs when a large portion of them is fixed to the on-site energy source.

3. Conclusion

Providers in PPP projects have an emerging need to identify and manage uncertainty related to contract flexibility that can have a great impact in project profits. In order to do this effectively, the economical feasibility of risk management actions must be evaluated. In this paper real options analysis (ROA) was used for evaluating risk management actions in a Finnish healthcare project.

Three main sources of uncertainty were identified and risk management actions for coping with the uncertainties were proposed and examined with ROA. As a result, the provider may radically improve the profitability of the project. The staged construction alternative for addressing the uncertainty in parking space demand was found to have a value premium of 680 000 € compared to the second best alternative. The physical flexibility for coping with the client's uncertain space need was found to have a value of 460 000 €. The on-site energy source for addressing the uncertainty in raising energy costs was found to have a value of 440 000 €.

This paper illustrates that real options have practical applications in managing risks in PPP projects. In fact, the provider of the project has already received benefits from the analysis. For example, the output of the analysis presented in this study was used as an investment analysis document in the actual investment decision-making process by the provider's board of directors. Later on the building briefing process and design team selection were partly based on the results from the analysis.

The findings of the research are in line with real options literature suggesting that embedded options inside projects can help managing the downside risk without abandoning the upside potential. The application presented in this paper manages risk by projecting uncertainty according to the best available information using a novel real options valuation method which can be easily constructed to supplement the dominant DCF method. The values calculated using the method are transparent and are easily connectable to the uncertainty sources used for the calculus.

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Determinants of Organizational Commitment: A Case From Turkish Construction Industry

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Abstract

This research focuses on job satisfaction, organizational justice, and organizational commitment among professionals in the construction industry. Although there is a substantial amount of research demonstrating the importance of organizational justice and job satisfaction and their influence on organisational commitment, construction management literature lacks the empirical implications of the relationship between these organizational factors, which determine the success of an organization in a competitive environment such as construction. The present study aims to fill that research gap. In order to assess organizational justice, job satisfaction and organizational commitment of individuals in the context of construction industry, a questionnaire survey was utilized based on three well-known and widely accepted instruments. Research findings will be one of the initial studies that clarify the interrelations between organizational justice, job satisfaction and organizational commitment from the perspective of construction industry professionals.

Keywords: Organizational justice, organizational commitment, job satisfaction, construction industry, INDCOL.

1. Introduction

Employees are one of the most important factors that determine the success of an organization in a competitive environment. This is the case for all organizations, but particularly so in construction, which is distinctly different from other industries. The potential positive relationship between organizational commitment and organizational effectiveness caused many research studies to investigate the predictors of organizational commitment (see among others, Bakhsi et.al.2009; Mathieu and Zajak, 1990; Wasti and Can, 2008). Although identifying predictors of organizational commitment has been an important area of investigation, few studies have examined the motivators of organizational commitment within the context of construction industry (Chiu and Ng, 2013; Lingard and Francis, 2004; Loosemore et al. 2003; Malone and Issa, 2013). This study aims to fill this gap in organizational behaviour literature within the specific context of construction.

While an extensive amount of research has been conducted on organizational commitment, the question of whether employees' cultural values influence commitment formation is still largely unanswered. Even in a single collectivist culture, a certain number of people will display the traits of individualism. Consequently, individuals within these countries may have different organizational behaviour. The main purpose of the present study was to examine the effects of cultural values on organizational commitment. While examining the role of cultural values, the mediating roles of job satisfaction and organizational justice were taken into account in order to better understand how cultural values affect the organizational commitment. This research examined self-reported of the relationship between organizational justice perceptions, job satisfaction and determined their effects on an employee's organizational commitment, within the construction industry.

2. Background

2.1. Organizational Commitment

Organizational commitment has become an important topic for organizational research because of its positive contribution to job satisfaction, reduced absenteeism (e.g. Gellatly, 1995) and reduced staff turnover (e.g. Somers, 1993; Walker, 2011). Organizational commitment can be described as an employee's involvement with and motivation for a particular employer. Meyer et.al. (1993) identified a three-dimension model of organizational commitment: (1) *Affective commitment*, which is represented by the respect which employees hold for their organization. One of the most common reason for this commitment within the construction industry is that there exit well establish and reputable firms. (2) *Continuance commitment*, which is based on the costs that employees associate with leaving the organization. This is evidence in the construction industry due to the fluctuating workloads, and in times of high unemployment as a result of economic conditions. Therefore, better alternative employment opportunities will be limited. (3) *Normative commitment*, which refers to employees' feelings of obligation to remain with an organization for ethical or moral reasons. Walker (2011) argues that this commitment can be seen for people who have significant roles in projects being executed and who have responsibility of not leaving at a critical time.

2.2. Job Satisfaction

For the last few decades, job satisfaction has been one of the most popular interests' among scientists, researchers and practitioners (Blood et al, 2002; Klassen & Chiu, 2010b; Malik et al., 2010; Platsidou & Agaliotis, 2008; Perrachione et al., 2008). Job satisfaction or Employee Satisfaction (also referred to as morale) is one of the most used variables in organizational behaviour. It is the way of expressing an employee attitude-response to his or her organization.

Scientists have recognized that job satisfaction is strongly influenced by situational factors, which are internally or externally generated. Internal factors (i.e budgets, physical work facilities and uncertainty) are within the control of the organization, whereas external factors (i.e. economic conditions, legal requirement and external political forces) are generated by the external environment of the organization (Walker, 2011). Along with these factors, job satisfaction is dependent upon personality and job characteristics.

2.3. Organizational Justice

A review of organizational justice literature shows that organizational justice is a significant predictor of work attitudes and behaviours (Cohen-Charash and Spector, 2001; Colquitt et al., 2001). Research findings indicate that perception of organizational justice is correlated with several organizational factors, such as job satisfaction (Dowden and Tellier, 2004), and organizational commitment (Kwong and Leung, 2002). It is popularly accepted that organizational justice consists of three constructs: (Masterson et al., 2000; Cohen-Charash and Spector, 2001; Cropanzano et al., 2001). (1) *Distributive justice*, which refers to the perceived fairness of the allocation of resources by the organization (Alexander and Ruderman, 1987; Folger and Konovsky, 1989). (2) *Procedural justice*, which refers to the perceived fairness of the process used to make allocation decisions (Korsgaard et al., 1995; Alexander and Ruderman, 1987). (3) *Interactional justice*, which refers to the fairness and quality of interpersonal treatment individuals are given during the implementation of procedures.

Findings in literature show that organizational justice have been linked to important organizational variables (Folger & Konovsky, 1989; Dailey & Kirk, 1992; McFarlin & Sweeney, 1992; Martin & Bennett, 1996). Perceptions of procedural justice are significantly correlated with organizational commitment whereas distributive justice perceptions tend to be a strong predictor of job satisfaction (Martin & Bennett, 1996; McFarlin & Sweeney, 1992).

2.4. The Relationship between organizational justice, job satisfaction and organizational commitment

Since the 1970s, scholars have studied the correlation between organizational justice, job satisfaction (Masterson et al., 2000; Cohen-Charash and Spector, 2001; Colquitt et al., 2001), and organizational commitment (Allen and Meyer, 1996; Masterson et al., 2000; Colquitt et al., 2001). Some scholars have admitted that organizational commitment may be an independent variable with job satisfaction (Bateman and Strasser, 1984; Vandenberg and Lance, 1992) while others claim just the opposite. Most of the research has treated job satisfaction as an independent and organizational commitment as a dependent variable (Mowday et al., 1982; Gaertner, 1999; Lok and Crawford, 2001; Jernigan et al., 2002).

In a review of organizational commitment, Allen and Meyer (1996) assessed the relation between organizational commitment and organizational justice and found strong relationships among the three dimensions of organizational justice and affective commitment. Loi et al. (2009), for example, investigated the influence of organizational justice (e.g. distributive, procedural, and interpersonal) on job satisfaction. The result revealed that, along with distributive and procedural justice, interpersonal justice was positively related to employees' job satisfaction. Most of the researchers have claimed that organizational commitment and job satisfaction are interrelated (Mowday et al., 1982). Many researchers have discussed job satisfaction as an antecedent of organizational commitment (Bartol, 1979; Mowday et al., 1982; Gaertner, 1999; Hrebiniak and Alutto, 1972; Yousef, 1998; Gaertner, 1999). However, a few studies have examined the relationship between organizational justice and job attitudes (i.e. job satisfaction and organizational commitment) in a non-Western culture (e.g. Pillai et al., 1999; Yusef, 2002; Suliman, 2007; Bakhshi et al., 2009; Xinyan, 2010). Also, studies based on a Western theoretical framework have tended to generalize their findings across cultures. Lam et al. (2002, p. 2) argued that: "studies of the effects of distributive and procedural justice do not provide consistent and mutually supportive conclusions as to generalizability across cultures". Some researchers have attributed satisfaction and commitment to cultural values (i.e. Dorfman & Howell, 1988; Randall, 1993). Therefore, it is worth examining the justice-job attitudes relationship in the non-Western context such as Turkey.

Although many studies examined the relationship between organizational commitment and job attitudes, only few studies have examined the subject within the context of construction industry. (Du et al., 2007; Yi, et al., 2009; Chiu, and Ng, 2013). Based on the literature reviewed, the following hypotheses were investigated within the context of the Turkish construction industry:

H1: Job satisfaction relates significantly and positively to organizational commitment.

H2: Organizational justice has significant impact on organizational commitment.

3. Research Methodology

The survey consisted of four major sections. The first section includes questions about demographic information of the respondents. The second section includes the items for measuring three dimensions of organizational justice. The third section consists of the items to measure job satisfaction. The forth section contained the questions about how much respondents agreed or disagreed with statements concerning their feelings toward their employer.

Data were collected through a questionnaire survey administrated to professionals associated with the construction industry. There are 68 returned questionnaires from a total of 250 contacted survey sample; giving a response rate of 23.6%. All returned questionnaires are acceptable for analysis as the number of missing data is small and affect a few questionnaires only.

Organizational justice was evaluated using the scale developed by Niehoff and Moorman (1993). The scale intended to determine distributive, procedural, and interactional justice. Distributive justice construct was measured by five-items assessing the fairness of different work outcomes including work schedule, pay level, workload, rewards, and job responsibilities (i.e. “I think that my level of pay is fair”). Procedural justice construct was measured by six-items assessing the degree to which job decisions included mechanisms that insured the gathering of unbiased, accurate, and complete employee voice, as well as an appeals process (i.e. “all job decisions are applied consistently across all affected employees”). Interactional justice construct was measured by nine-items assessing the degree to which the employees felt they were considered and respected by the managers, and adequate and clear explanations concerning job decisions.

Organizational commitment was measured by using both the emic and the Meyer et al. (1993) organizational commitment items, as described in more detail below. Affective commitment construct was measured by eight-items to assess the affective recognition and participation of people originating from work experience (“I would be very happy to spend the rest of my career with this organization”). Continuance commitment construct was measured by seven-items to assess the requirement and tendency to stay with an organization when employees realize the cost of resignation. (“I feel that I have too few options to consider leaving this organization”). Normative commitment construct was measured by ten-items to assess obligation or repayment to a specific organization based on loyalty and gratitude (“I was taught to believe in the value of remaining loyal to one organization”).

Job satisfaction was measured with Job Description Index (JDI) (Smith et al, 1969) as revised by Roznowski (1989). The measurement equivalence of this scale in Turkish was established by Wasti et al., (2000). This scale is designed to measure employees' satisfaction with their jobs. The JDI is a “facet” measure of job satisfaction, meaning that participants are asked to think about specific facets of their job and rate their satisfaction with those specific facets. The JDI is comprised of five facets, including satisfaction with: coworkers (e.g., ‘‘boring”), the work itself (i.e. “challenging”), pay (i.e “underpaid”), opportunities for promotion (i.e. good opportunities for promotion”), and supervision (i.e ‘‘praises good work”). Each scale includes a checklist of adjectives or adjective phrases, and respondents are asked to fill the blank beside each item as follows: “Y” (agreement), “N” (disagreement), and “?” (can not decide). We scored all scale items (after reverse coding where necessary) with 0 for each “no” response, 1 for each “?”, and 3 for each “yes.”

The major shortcoming of the scales and constructs used to in this study has been its relevance mostly to the North American context. Based on Wasti’s argument that researchers have typically employed a ‘pseudoetic’ approach, where instruments composed of items reflecting Western conditions are translated and used in other cultures with little regard to the reliability or validity of the instrument in the new culture. For this reason, in her study, emic (culture-specific) items were generated through in-depth interviews with Turkish employees, and the commitment scales by Meyer et al. (1993) were revised for use in Turkish samples.

In order to control, at least to some extent, their effects, the study included a number of demographic characteristics. The demographic variables are gender, age, occupation, and tenure in the organization. The survey also included the INDCOL scale (Singelis et al., 1995), which is composed of four 8-item subscales, namely *horizontal individualism, vertical individualism, horizontal collectivism, and vertical collectivism*. In this study, we only considered vertical collectivism because vertical collectivism in essence is about prioritizing in-group preference. It measures the extent to which an individual is concerned with maintaining the social harmony of the in-group and willing to subordinate personal interests to the wishes of in-group authorities (e.g., ‘‘I usually sacrifice my self-interest for the benefit of my group”). All responses were on a 5-point scale ranging from 1 (strongly disagree) to 5 (strongly agree).

The original English instruments used in this study were finalized using translation and back-translation by Wasti et.al. (2000). The items that had discrepancies were rewritten to be clearer and back translated once again.

4. Analysis of Results

Descriptive and inferential statistics were used to analyze the data. Descriptive findings include the following: (1) respondents ranged in age from 23 to 68 years old, with 31% of the respondents being between 46 and 55 years old, 24% between 36 and 45 years old, 24% between 26 and 35 years old, and 15% between 56 and 65 years old, In terms of the age composition of the sample 30.6 percent represented those below 30 years, 59.6 percent were in the 31-45 age bracket, and 9.7 percent were above the 46 years age bracket. (2) Bachelor and master degrees were the highest educational degree received for approximately 38.5 and 31.4 % of respondents respectively. The mean age was 31 years.

In terms of occupation, 55.9% of the respondents are architects, 35.3% them are civil engineers and 8.8% them have other educational background. The modal tenure was between 1 and 5 years (51%), 6-10 years (%34), 11-15 years (%6) and over 15 years (%9). With regard to the size of the respondents‘ organizations, 32.4 percent belonged to organizations with 100 staff or below, 28.2 percent were in the 101-500 organizational size bracket, 14.5 percent were in the 501-2,000 size bracket, and 24.8 percent were in the over 2,001 size bracket.

In terms of the JSI, it can be noted that employees at the construction sector are most satisfied with the promotion (m = 1,7892; SD =, 95783), followed by the nature of work (m=1,1772; SD=,85176), and the pay (m=1,0605; SD=,79597). They are however, less satisfied with the supervision they receive (m=,8473; SD=,77694) and least satisfied with their co-workers (m=,6422; SD=,68388). Walker (2011) states that if the professionals involved in the construction industry would be likely to achieve a great job satisfaction if they see a project through to completion. However, this may not be the case for those who work intermittently on a number of projects, or are involved in projects including large tracts of relatively monotonous work.

The mean scores of the Organizational Commitment scales ranged from 2,7196 to 3,1275. The sample of participants obtained the highest mean score on the affective commitment (m =3,1275; SD = ,46822) sub-scale and the lowest score on the normative commitment sub-scale (m = 2,7196; SD = ,73485). This finding means that employees with a high degree of affective commitment stay in their organization because employees with a collectivistic orientation appreciate being part of a group and have a stronger striving for belonging to a social entity (Felfe et.al. 2008).

Descriptive statistics were used to examine respondents’ views on organizational justice, job satisfaction and organizational commitment. To analyze the relationship between organizational justice job satisfaction and organizational commitment, hierarchical multiple regression analysis was used. Multiple regression analyses are generally used to predict a dependent variable (in this case, organizational commitment) on the basis of two or more independent variables (predictor variables, in this case organizational justice and job satisfaction).

In hierarchical regression analysis, on the contrary, variables are entered into the model in stages: first, a group of independent variables are evaluated in terms of how much information they provide about the independent variable, and then, another group of variables are entered into the model, and a statistical test of whether we gain any more information about the dependent variable with their inclusion is conducted. Because it fits the purposes of the present study better, a hierarchical multiple regression analysis was used in the study.

The hierarchical ordering of the independent variables is as follows: the first set includes the control variables (i.e. age, gender, occupation); the second set includes the facets organizational justice and job satisfaction; the third set includes cultural values. These sets are entered into the analysis through three steps. Hierarchical multiple regression analysis was conducted for each of the facets of organizational commitment as dependent variables. These statistical analyses are termed Models A, B and C. Tables 1,2 and 3 show the percent of variability in the dependent variables that can be accounted for by all the predictors (independent variables) together (that's the interpretation of R-square). The change in R^2 is a way to evaluate how much predictive power was added to the models by the addition of another variables in step 2 and 3.

The findings of Model A (Table 1) point out a significant negative relation (-.452) between job satisfaction and in particular satisfaction with type of work done (set 2 factor) and affective commitment to the organization. This implies that high scores on satisfaction with type of work are associated with low scores on affective commitment. As a result, the type of work has an

Table 1. Regression analysis results for 'affective commitment'.

Independent Variables	*Standardized Beta Coefficients*	*t-value*	*Significance level (2-taied)*	*Collinearity Statistics*	
				Tolerance	*Variance Inflation factor*
Constant		*2,471*	*,017*		
Age	*-,074*	*-,566*	*,574*	*,446*	*2,241*
Gender	*,189*	*1,630*	*,109*	*,574*	*1,742*
Occupation	*-,090*	*-,773*	*,443*	*,570*	*2,275*
Org.Tenure	*,159*	*1,205*	*,234*	*,440*	*1,754*
DistribJustice	*,041*	*1,205*	*,740*	*,510*	*1,960*
ProceJustice	*,139*	*,872*	*,387*	*,303*	*3,303*
InterJustice	*,298*	*1,883*	*,065*	*0.308*	*3,251*
Work	*-,452*	*-3,534*	*,001*	*0.471*	*2,123*
Coworkers	*,064*	*,562*	*,577*	*0.589*	*1,697*
Supervisor	*-,205*	*-1,598*	*,116*	*0.467*	*2.141*
Pay	*,203*	*1,824*	*,074*	*0.621*	*1,611*
Promotion	*,002*	*,017*	*,987*	*0.358*	*2,795*
Collectivist	*,079*	*,814*	*,419*	*0.825*	*1,213*

Table 2. Regression analysis results for 'continuance commitment'.

Independent Variables	*Standardized Beta Coefficients*	*t-value*	*Significance level (2-tailed)*	*Collinearity Statistics*	
				Tolerance	*Variance Inflation factor*
Constant		*2,471*	*,002*		
Age	*-,552*	*-,566*	*,001*	*,446*	*2,241*
Gender	*,037*	*1,630*	*,794*	*,574*	*1,742*
Occupation	*-,225*	*-,773*	*,119*	*,570*	*2,275*
Org.Tenure	*,556*	*1,205*	*,001*	*,440*	*1,754*
DistribJustice	*,138*	*1,205*	*,363*	*,510*	*1,960*
ProceJustice	*-,062*	*,872*	*,751*	*,303*	*3,303*

InterJustice	*,000*	*1,883*	*,997*	*0.308*	*3,251*
Work	*-,113*	*-3,534*	*,474*	*0.471*	*2,123*
Coworkers	*-,144*	*,562*	*,306*	*0.589*	*1,697*
Supervisor	*,168*	*-1,598*	*,291*	*0.467*	*2.141*
Pay	*-,248*	*1,824*	*,074*	*0.621*	*1,611*
Promotion	*-,190*	*,017*	*,293*	*0.358*	*2,795*
Collectivist	*-,021*	*,814*	*,860*	*0.825*	*1,213*

effect above and beyond the effects of control variables and organizational justice. Model B uses continuance commitment as the dependent variable (Table 2) .The first set of predictors (i.e.age and organizational tenure) explain significantly in the variance in continuance commitment, but the second and third sets account for an insignificant amount of chance in the variance. It means that job satisfaction and cultural values do not have an effect above and beyond the effects of control variables such as organizational tenure and age. As a result, increasing age(-.552) might lead to lower levels of continuance commitment within the context of construction industry.

Continuance commitment (CC) is said to be expected to be weak (Dunham et.al., 1994). As individuals gain experience alternate employment opportunities may increase and this decreases the magnitude of one important cost of leaving, that of having no job (Cohen, 1993). Additionally, the exploratory power of the model is provided by the control variable "organizational tenure (.556)". This finding provides confirming evidence, which Cohen (1993) argues " CC-tenure relations can develop only after the employee has spent some years in the organization and, hence, develops investments, evaluates them, and decides, based on the exchange relation, whether or not to commit himself or herself to the organization". In Model C (Table 3), the type of work (set 2 variable) and cultural values (set 3 variable) explain most of the variance in normative commitment. This means that high scores on the work itself and collectivism (allocentrism)"are associated with low scores on normative commitment. Yet, this evidence of the present study is in contrast with the view that highly allocentric values tend to be more normative (Hofstede, 2001).

Table 3. Regression analysis results for 'normative commitment'.

Independent Variables	*Standardized Beta Coefficients*	*t-value*	*Significance level (2-taied)*	*Collinearity Statistics*	
				Tolerance	*Variance Inflation factor*
Constant		*0.249*	*0.804*		
Age	*-0.289*	*-0.251*	*0.029*	*0.446*	*2,241*
Gender	*-0.010*	*-0.093*	*0.927*	*0.574*	*1,742*
Occupation	*0.192*	*1.482*	*0.144*	*0.440*	*2,275*
Org.Tenure	*0.063*	*0.553*	*0.583*	*0.570*	*1,754*
DistribJustice	*-0.003*	*-0.022*	*0.983*	*0.510*	*1,960*
ProceJustice	*0.157*	*1.010*	*0.317*	*0.303*	*3,303*

InterJustice	*0.183*	*1.183*	*0.242*	*0.308*	*3,251*
Work	*-0.341*	*-2.730*	*0.009*	*0.471*	*2,123*
Coworkers	*-0.187*	*-1.670*	*0.101*	*0.589*	*1,697*
Supervisor	*0.099*	*0.789*	*0.434*	*0.467*	*2.141*
Pay	*-0.041*	*-0.381*	*0.705*	*0.621*	*1,611*
Promotion	*-0.159*	*-1.107*	*0.273*	*0.358*	*2,795*
Collectivism	*-0.332*	*3.511*	*0.001*	*0.825*	*1,213*

Table 4 presents model summaries based on hierarchical multiple regression analysis. The exploratory power of Models A, B and C is in the range of 11.5% to 51.0%. Such a range of exploratory power may be mainly due to the sample size and complexity of the problem. The exploratory power of Models A and C are partly consistent with the majority of studies on organizational commitment.

Table 4: Model Summaries Based on Hierarchical Multiple Regression Analysis

Dependent Variable	*R*	*R^2*	*Adjusted R^2*	*Change Statistics*		
				R2 Change	*F Change*	*Sig. F Change*
Model A: Affective Commitment						
Step1 – (1st Set)	*.212*	*.045*	*-.001*	*.045*	*.974*	*.441*
Step 2 (1st and 2st Sets)	*.765*	*.585*	*.500*	*.540*	*8,769*	*.000*
Step 3 (1st, 2st and 3rd Sets)	*.768*	*.595*	*.497*	*.005*	*.676*	*.415*
Model B: Continuance Commitment						
Step1 – (1st Set)	*.308*	*0.95*	*.051*	*.095*	*2,165*	*.101*
Step 2 (1st and 2st Sets)	*.512*	*.263*	*.112*	*.168*	*1,535*	*.167*
Step 3 (1st, 2st and 3rd Sets)	*.528*	*.278*	*.115*	*.016*	*1,170*	*.284*
Model C: Normative Commitment						
Step1 – (1st Set)	*.243*	*.059*	*.013*	*.059*	*1,293*	*.285*
Step 2 (1st and 2st Sets)	*.719*	*.517*	*.419*	*.458*	*6,404*	*.000*
Step 3 (1st, 2st and 3rd Sets)	*.775*	*.600*	*.510*	*.083*	*11,030*	*.002*

5. Conclusion

The current study seeks to contribute to the literature by exploring the relationship between organizational commitment and job attitudes in a non-Western context such as Turkey. In addition, this study attempts to expand the literature by clarifying the role of cultural values for the relationship between these two organizational factors among the construction professionals in Turkey. Quantitative research approach and survey data collection method were adopted in this study to achieve the stated objectives.

Since this study was conducted on a relatively small sampling (n=68), the results cannot be applied to other contexts and regions. Another limitation of this study is its focus on allocentrism/ idiocentrism (individualism- collectivism at the individual) without considering other cultural values. Further research is needed to determine the generalizability of our results.

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Supporting Sustainable Transportation by Urban Structure Development – The Role Of Air Travel

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Abstract

Vast amount of studies have demonstrated that denser urban structures lead to smaller GHG-emissions from transportation. As a consequence increasing the urban density has become one of the key means to mitigate the emissions from urban areas. However, many of these studies have been limited to private driving or the local ground transportation. Yet flying is becoming increasingly frequent and air travel habits also heavily depend on socio-economic as well as spatial issues. In addition many of the previous studies have not taken into account the potential methodological problem of self-selection, which may cause statistical bias to the results. For example, the lifestyles, family structures and values may well be stronger determinants for residential location and transportation choices than the qualities of the urban form. In this study we illustrate the effect of one aspect of self-selection, the family structure, and the importance of including air travel in the GHG-emission assessments. Our results show that the urban form affects more strongly the single- and couple-households than larger families. Families are more car-dependent and their car-ownership remains strong even in the densest urban forms. We also found a clear trade-off relationship between motorization and air travel. This evens out, though does not reverse, the differences in the GHG-emissions of transportation between motorized and non-motorized households. The study uses data from the Finnish Transportation Agency's passenger traffic survey 2010-2011, which includes detailed information on one-day travel for over 12 000 people and over 35 000 trips. The scope of the study is the Helsinki Metropolitan Region (HMR). Methodologically we utilize a traveller based assessment, i.e. all trips of the HMR residents are included whether they take place inside or outside the metropolitan region. The main policy implication of our study is that urban densification has only limited possibilities to reduce the GHG-emissions and these limitations should be better understood. Furthermore in the transportation sector the technological development is much more rapid than the structural changes in the built environment, which should be taken in consideration when assessing the GHG mitigation potentials.

Keywords: sustainable transportation, urban structure, air travel, greenhouse gas emissions, self-selection

1. Introduction

The greenhouse gas emissions of transportation make up about a quarter of all GHG-emissions in EU. Furthermore the GHG-emissions of transportation are still growing. According to the European Commission's report (*Hill et al. 2012*) the GHG-emissions from transportation have increased by 36 % between 1990 and 2007, while the emissions from other sectors have decreased by 15 %. In the report it is shown that in a business as usual -scenario, the GHG-emissions of transportation will be 74 % higher in 2050 than they were in 1990. Thus the transportation sector alone jeopardizes EU's target to cut the GHG-emissions to 80 % below 1990 levels by 2050, unless action is taken. Air travel is expected to be one of the fastest growing modes of transportation.

Vast amount of studies have demonstrated that denser urban structures lead to smaller GHG-emissions from transportation (e.g. *Newman & Kenworthy 1989 and 1999, Mindali et al. 2003, Norman et. al 2006, see also review by Badoe & Miller 2000*). However, many of these studies are limited to private driving or the local ground transportation. Yet flying is becoming increasingly frequent and can form an important substitute or complement to other modes of transportation with significant environmental impacts as shown e.g. by Ornetzeder et al. (2008). In addition, the potential methodological problem of self-selection, which may cause statistical bias to the results, is seldom given much consideration in the studies analysing transportation patterns related to the surrounding urban structure (*Ewing & Cervero 2010*). For example, the lifestyles, family structures and environmental attitudes may well be stronger determinants for residential location and transportation choices than the qualities of the urban form.

To take a step towards filling this gap, this study will analyse the connections between the urban form, household size and travel behaviour in Finland from the perspective of sustainability. The study has two aims: (1) to find out how the urban form affects the GHG-emissions of transportation of different types of households, i.e. is the connection between urban form and GHG-emissions stronger in single/couple-households than in families and (2) to find out what is the role of air travel, i.e. do similar relationships between the urban form and air travel exist as in private driving, or does air travel form a significant substitute for driving.

The study uses the data from the Finnish Transportation Agency's passenger traffic survey 2010-2011, which covers the whole Finland. Methodologically the study utilizes a traveller based assessment to capture the GHG impacts of transportation. We also take into account that the GHG-emissions from private driving vary significantly in relation to the speed and driving distance, i.e. street- or highway driving, and those from air travel in relation to the flying distance. The study depicts how the lifestyle and family structure -based need for transportation play an important role when the households choose their residential location and the modes to travel. The family sizes and the degree of motorization increase significantly towards the less dense areas. Air travel habits are more strongly connected to the household income than the urban form, but there is a clear trade-off relationship between motorization and air travel.

2. Research design

2.1 Methodology

In the study we have a traveller based accounting perspective, i.e. we count the emissions of the residents of a given area based on the trip generation and all trips are included whether they take place inside or outside the boundaries of the area of residence. This differs from the production based methodology, which is used to count the emissions generated inside a given geographically restricted area regardless of who is causing the emissions – a resident of the area or an outsider.

The strength of the traveller based methodology is that it gives insights to the differences in the lifestyles and travel behaviour of different groups, for example people living in different urban forms. It also makes it simple to include air travel in the calculations. In production based methodology air travel is usually left out, because it would increase excessively and rather unfairly the GHG-emissions of cities that have an airport. Similarly, the traveller based assessment includes driving related to free-time residences or on vacation abroad, which in geographically restricted assessments are allocated to the area where driving takes place. In addition traveller based methodology can be used to capture the trade-off-relationships between different modes of transportation or, more generally, the rebound effects of consumption (*Wiedenhofer et al. 2013, Heinonen et al. 2013c*).

In the study, as in traveller based methodology in general, the business trips are left out because they should be allocated to the corporations rather than the individuals. Commutes on the other hand are included because one can affect the distance and mode of transportation by one's own choices.

In the assessment of the GHG-emissions of private driving, busses and air travel we utilize a simple screening assessment of the direct tailpipe emissions based on travel distance. For rail traffic we use GHG-coefficients [CO_2-ekv g/km/person] based on the energy consumption per km and travel distance. However, there is significant variation in the GHG-emissions even within modes of transportation. Since the private driving and air travel make up the majority of the GHG-emissions of transportation, we make an effort to increase the accuracy of the calculation of these transportation modes. The GHG-emissions of air travel vary significantly depending on the travel distance because during a flight the highest amount of emissions is released during the rising which means that short flights cause disproportionately more emissions per km than longer flights (*Chapman 2007*). Thus we employ gradually changing GHG-coefficients for air travel depending on the travel distance. As for private driving, the GHG-emissions depend on whether the driving takes place on a highway or in a population centre. We create a model to take this into account. All the GHG-coefficients used in the study are based in the LIPASTO study of the Technical Research Centre of Finland VTT (*2012*, see the Research process -section).

In the analysis we separate five different levels of urban density. There are various possible indicators for the density and urban form. In this study we use an areal efficiency ratio e_a developed in Finnish Environment Institute (FEI). It is a similar measure to commonly used floor area ratio, but takes into account a larger area than just the building site. It is calculated as

e_a = floor space / area

FEI has dived Finland in 250 m * 250 m squares and the value of the e_a-ratio of each square is the average of the nine neighbouring squares. Thus the e_a-ratio describes the average density of a wider area.

The scope of the study is the Helsinki Metropolitan Region (HMR), which stands for the Helsinki-Espoo-Vantaa metropolitan area and 15 smaller municipalities around it. The population of HMR is about 1,4 million and density ranges from 2830 inhabitants/km^2 in Helsinki to 90 inhabitants/km^2 in the commuter belt, i.e. the 15 smaller municipalities. Espoo and Vantaa together fall in between these with 840 inhabitants/km^2.

2.2 Research material

The primary data source utilized in the study is the most recent National Travel Survey (2010-2011) by the Finnish Transport Agency. The survey provides an overall picture of Finnish passenger mobility and is conducted regularly every six years. It includes detailed information on one-day travel for over 12 000 people and over 35 000 trips, including over 2 500 people and over 10 000 trips in HMR. The information includes the modes of transportation, travel distance, destination etc. and also background information about the respondents such as possession of motor vehicles, age of the respondent, household size and housing type. While the survey covers just one day per respondent, the whole survey covers every day of the year. In addition the respondents were asked to report their over 100 km trips in past four weeks before the test day to get a more complete picture of long distance travel. We used the data of long distance trips to calculate the GHG-emissions of air travel.

2.3 Research process

We started by calculating the GHG-emissions for each trip by multiplying the travel distance by GHG-coefficient. For private driving we developed a model to define the GHG-coefficient. The model was based on the GHG-coefficients provided in the LIPASTO study, where street driving (coefficient 214 CO_2-ekv g/km) is defined as typical street driving in Finland, i.e. the average speed is 30 km/h and there are 1-3 stops per km. In highway driving (coefficient 141 CO_2-ekv g/km) the average speed is 95 km/h. In the study average driving (coefficient 167 CO_2-ekv g/km) means a combination of highway and street driving so that the proportion of street driving is 35 %, which is derived from measured data in Finland. We created a model that takes the urban form of the starting and end point of the trip and also the timing, i.e. rush hours, into account. According to this information the trips got a GHG-coefficient 141, 154, 191 or 214 CO_2-ekv g/km. The trips with missing information got a GHG-coefficient of average driving, 167 CO_2-ekv g/km. For public transit and air travel we used directly the GHG-coefficients provided by the LIPASTO study of the Technical Research Centre of Finland VTT (*2012*) and represented in Table 1 below.

Table 1: The GHG-coefficients for public transit and air travel (VTT 2012)

Public transit		*Air travel*	
Mode	*CO2-ekv g/km per person*	*Flight distance*	*CO2-ekv g/km per person*
Train	*22*	*<463 km*	*260*
Bus, long-distance	*43*	*463-1000 km*	*178*
Bus, local	*36*	*1000-3000 km*	*149*
Subway	*11*	*>3000 km*	*114*
Tram	*54*		

In the second phase we summed the GHG-emissions of each respondent in the test day and kept separated the emissions of public transit, air travel and private driving. After this we were able to calculate the mean GHG-emissions per capita for different groups. We used the analytic weights provided in the data to correct the demographic biases in the sample.

As noted before we used an areal efficiency ratio e_a to describe the urban form. However in our data even the most dense area is only $e_a > 0,32$ which compared to Finland average is very dense, but in the metropolitan area there are a lot denser areas as well. Thus we employed also one accessibility zone to describe the densest areas of the city, the pedestrian zone. The pedestrian zone is the inner zone of the city, where the accessibility to the commercial centre and public transit is at the best level. According to our data about the same amount of people live in the pedestrian zone as in the sparse area (see Table 2), so these two groups represent the extreme ends of the urban form. Our data supports the general observation that the household size decreases towards the denser urban structure, as shown in Table 2.

Table 2: The sample sizes and average household size (persons) in different urban structures

Urban structure	*Areal efficiency e_a*	*Sample size*			*Proportion (weighted)*	*Average household size*
		Sin./cou.	*Families*	*Total*		
Sparse	*< 0,02*	*57*	*94*	*151*	*6,3 %*	*3,6*
Loose Low-rise	*0,02 - 0,08*	*150*	*211*	*361*	*14,2 %*	*3,2*
Low-rise	*0,08 - 0,16*	*260*	*333*	*593*	*23,2 %*	*3,1*
High-rise	*0,16 - 0,32*	*396*	*294*	*690*	*26,8 %*	*2,5*
Dense High-rise	*> 0,32*	*403*	*181*	*584*	*24,2 %*	*2,1*
Pedestrian Zone		*98*	*25*	*123*	*5,3 %*	*1,9*

Our data also shows that there is a significant difference in the level of motorization between small households and families as represented in Table 3. About 80 % of the residents with a family have a car in their household even in the densest areas of the metropolitan region whereas in singles/couples subgroup the proportion of residents living in a motorized household is only 44 % in the densest area.

Table 3: The proportion of residents living in a motorized household

	e_a	Singles/Couples	Families
Sparse	*< 0,02*	*96 %*	*100 %*
Loose Low-rise	*0,02 - 0,08*	*91 %*	*100 %*
Low-rise	*0,08 - 0,16*	*79 %*	*97 %*
High-rise	*0,16 - 0,32*	*66 %*	*89 %*
Dense High-rise	*> 0,32*	*51 %*	*77 %*
Pedestrian Zone		*44 %*	*80 %*

Another important aim of this study was to find out whether there is a trade-off relationship between private driving and air travel. To study this we divided our data in household income classes represented in Table 4. We analysed the differences between motorized and non-motorized households in these income classes. To avoid the bias caused by household size, i.e. the split in motorized families and non-motorized singles, we looked separately the single-/couple-households and families. We used higher income classes for families than singles/couples subgroup to make the sample sizes about the same and the results more meaningful. Respondents with missing information in household income were left out. Also the non-motorized families in the two highest income classes were left out from the results, because of the small sample sizes.

Table 4: Sample size in different household income classes

	Household income (€/year)	*Non-mot.*	*Motorized*	*Total*
Singles/couples	*<30 000*	*229*	*160*	*389*
	30-60 000	*139*	*377*	*516*
	60-90 000	*35*	*247*	*282*
	>90 000	*18*	*147*	*165*
Families	*<60 000*	*38*	*258*	*296*
	60-90 000	*20*	*310*	*330*
	90-120 000	*(5)*	*230*	*235*
	>120 000	*(1)*	*110*	*111*

3. Results

The main findings of the study are that (1) the urban form affects more strongly the GHG-emissions of private driving in single-/couple-households than families and (2) there is a clear trade-off relationship between air travel and private driving which evens out the differences in the GHG-emissions of transportation in different urban forms. Figure 1 depicts the first main finding and also shows how the air travel breaks the pattern of decreasing GHG-emissions towards denser urban structures. Figure 2 depicts the trade-off relationship between motorization and air travel.

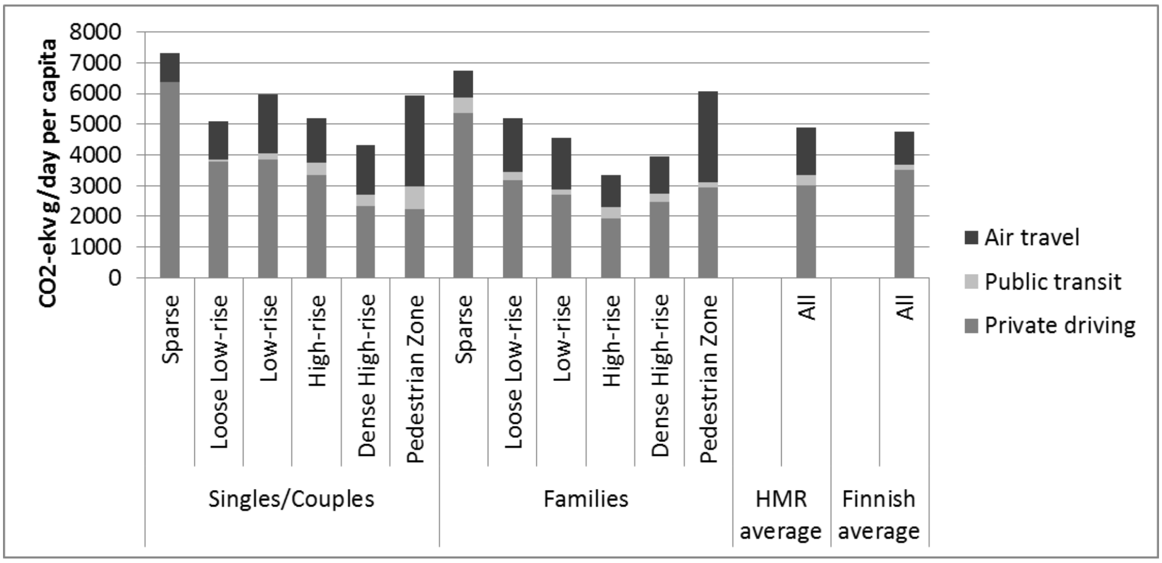

Figure 1: The GHG-emissions of transportation per capita in different urban forms in singles/couples and families subgroups in HMR

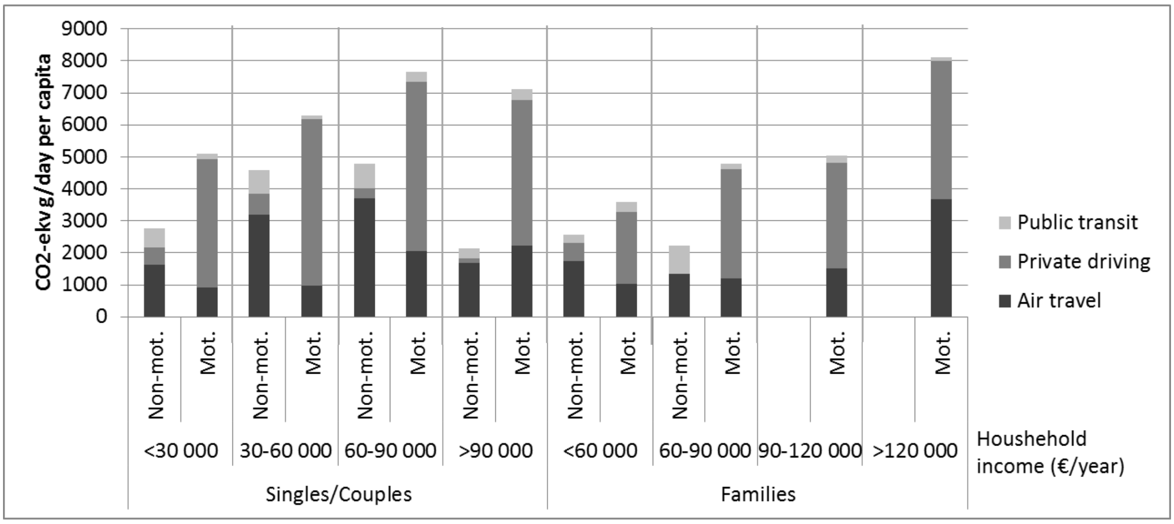

Figure 2: The GHG-emissions of transportation per capita in motorized and non-motorized households in different income classes in HMR

In Figure 1 it is noticeable that the GHG-emissions of private driving are clearly higher in the sparse areas than any other urban structure in both subgroups. The differences between the other urban forms are smaller. In the single-/couple-households the emissions of private driving clearly decrease towards denser areas and the difference between the highest and lowest emissions (not including the sparse area) is about 1600 CO_2-ekv g/day per capita (diff. -43 %). In the families subgroup the GHG-emissions of private driving first decrease towards the denser areas but then start rising again in the densest urban structures. The difference between the highest emissions in the loose low-rise area and lowest emissions in the high-rise area is about 1200 CO_2-ekv g/day per capita (diff. -39 %). It seems however that the difference is due to some other cause than the urban form since the emissions increase again in the very densest areas.

In Figure 1 it is also striking that the GHG-emissions of air travel roughly double in the pedestrian zone compared to the other urban forms. The GHG-emissions of flying are smallest in the sparse-areas. There does not seem to be clear differences in other areas or between singles/couples and families. However compared to Finnish average the residents of the HMR fly significantly more and this clearly compensates the differences in the GHG-emissions of private driving in the HMR and the rest of Finland. Thus the average GHG-emissions of transportation per capita are about the same but the profile is different. The main airport of Finland is located in Vantaa in HMR.

Figure 2 shows the GHG-emissions of transportation in motorized and non-motorized households in different household income classes. It comes up clearly that air travel is a substitute commodity for private driving in the low- and middle-income classes especially in the singles/couples subgroup. In the highest income class air travel complements private driving. Furthermore, in the families subgroup there are virtually no non-motorized households in the highest income classes. Notwithstanding, the members of the motorized households obviously drive more, and the GHG-emissions of private driving in the motorized groups exceed the GHG-emissions of flying in the non-motorized groups in all the income classes.

Public transit is also shown in the Figures. It seems to be a substitute for private driving, but interestingly has different patterns in single-/couple-households and families. The emissions from public transit increase along with density in the singles/couples subgroup, but are the highest in the most sparsely populated areas in the families subgroup.

4. Discussion

4.1 Interpretation of results

This study was set to analyse the connections between the urban form, household size and travel behaviour in Finland from the perspective of sustainability. The study tackles two issues which have previously given less attention in the research: the role of air travel in the travel patterns of different types of households, and the methodological self-selection bias in comparing the travel-related emissions of households living in different types of areas. It is of high importance to improve understanding of these issues, since increasing the urban density has become one of the key means to mitigate the emissions from urban areas.

In this study we analysed one aspect of self-selection: family structures. Families are more car-dependent than singles and couples and this may be one reason why they prefer looser urban form as their residential location. Our results show that families do not give up their cars as easily as single-/couple-households in the dense urban form (see Table 3). The issue of GHG-emissions, however, is somewhat more complicated. The GHG-emissions of private driving are clearly highest in the sparse urban form. In the other urban forms there is variation in the emissions within families subgroup but not a clear decreasing pattern towards the denser areas. It seems that the household income may affect the travel behaviour and car-ownership of families as in the HMR the highest household income levels are found in the low-rise area and the pedestrian zone, which both have a relatively high level of motorization and high GHG-emissions of private driving compared to the density areas between them.

In the singles/couples subgroup the GHG-emissions of private driving increase strongly towards the sparse urban forms and are also generally greater than in the families subgroup, except for the densest urban forms. This is due to the economies-of-scale-effect: people with family have more often more than one or two persons on a car trip than singles and couples and thus the emissions are divided among more travellers. On the other hand in the densest urban forms the car-ownership of families is much higher than that of singles and couples and thus the emissions of private driving are greater in the families subgroup.

Our results also show that the GHG-emissions of air travel should not be neglected when assessing the GHG-emissions of transportation. They form a substantial part of the total emissions and may change the outcomes of the calculations and interpretation of the results significantly. In our study the air travel seems to be connected to the proximity of the airport since the residents of the HMR, where the main airport lies, fly about 50 % more than Finns on average. The air travel also seems to be connected to the household income level. Within the HMR, no systematic relationship between the urban form and flying patterns was found. However, the highest emissions from flying seem to be caused by the residents of the pedestrian zone, whereas the residents of the sparsest areas cause the lowest emissions.

We also found a clear trade-off relationship between motorization and air travel in the low- and middle-income classes, which is consistent with previous studies showing how in the lower income classes the income is a constraint on the consumption and consumers have to make choices between consumption categories (*Heinonen et al. 2013c*, *Ornetzeder et al. 2008*). In consequence lifestyle choices, such as giving up a car, lead to monetary savings and increased consumption in some other category – affecting air travel potentially very strongly since it provides a substitute good for especially holiday traveling. Although Ornetzeder et al. (2008) concluded that in their case-study in Vienna there was no indication that the money saved from not owning a car is systematically diverted to air travel, in our study, which was specifically set to study this phenomenon, it is clearly evident.

In the highest income class the difference in air travel between motorized and non-motorized subgroups disappears. This is probably because of the phenomenon that in the most affluent households the main constraint of consumption is not money but time (*Heinonen et al. 2013b and 2013c*). In the singles/couples subgroup the average emissions of air travel are also smaller in the highest than in the second highest income class. Our data shows that business flights pile up in the highest income class, so perhaps people who fly a lot in their daily job, do not wish to fly so much in their leisure time. Business flights are not included in Figures 1 and 2.

4.2 Uncertainties

The uncertainties of the study can be divided in two categories: data related uncertainties and methodological uncertainties. The data from National Travel Survey is based on interviews and travel diaries and thus the travel distances are respondents own estimates. There is some missing information especially in the income classes, since about 20 % of respondents have not provided any information of their income level. However, the large sample size and use of analytic weights reduce these uncertainties. Another shortcoming is that the data contains no information about the cars' models or average GHG-emissions and thus we had to assume that everybody has an average car. In reality it is likely that in the HMR the fleet is in general newer and perhaps more energy efficient than in the rest of Finland. Brownstone & Golob (2009) found in their case study of California that urban density had a direct effect on the vehicle type choice and thus the fleet fuel economy.

The GHG-emissions coefficients also involve uncertainties. The coefficients for public transit are only rough estimates, but their effect on the overall results is rather small. In air travel the GHG-emissions vary depending on the plane type and the total impact on radiative forcing depends on the flying altitude. In addition the effect of vapour trails is uncertain (*VTT 2012*). However our accounting method more likely underestimates than overestimates the GHG-emissions of flying, since the coefficients provided by VTT only include the direct emissions.

The model that we created for defining the coefficients for private driving is at its early state. Due to the restrictions of our data, we only know the urban form of the start- and endpoint of the trip, but not the journey in between. However, our model seems to work as expected: it increases the GHG-emissions of the residents living in the densest urban areas and decreases the emissions of the residents in sparser areas. Nonetheless the change is only approximately 1-2 % whereas the standard errors in our study are an order of magnitude greater.

In the future it would be important to take a LCA-perspective to the accounting. As shown e.g. by Chester and Hovarth (*2009*) and Chester et al. (*2013*) the infrastructure and vehicle and energy production significantly increase the GHG-emissions of each transportation mode. In their generalized example of US, Chester and Hovarth resulted additional 63 % GHG-emissions for onroad, 155% for rail and 31 % for air systems compared to only the vehicle tailpipe emissions. Moreover the contribution of infrastructure increases further if the time-corrected life cycle emissions are considered (*Kendall & Price 2012*). Time-correction tackles the dilemma that the GHG-emissions occurring at the beginning of a product life cycle have a greater global warming impact, than those occurring in the future.

5. Conclusions

Increasing the urban density has become one of the main measures to mitigate the GHG-emissions from urban areas. Our results show, however, that the effect of urban structure is not straightforward. Air travel breaks the pattern of decreasing emissions towards denser structures and acts as a substitute commodity for private driving in the low- and middle-income classes. Furthermore Heinonen et al. (2013c) and Ornetzeder et al. (2008) have shown that the money saved from not owning a car also increases consumption in other consumption categories.

Also the self-selection bias causes the reduction of emissions towards denser urban forms appear stronger than it truly is. It has been noted that for example lifestyles, family structures, environmental attitudes and values affect the choice of residential location (e.g. *Schmidt-Thomé et. al 2013*, *Ewing & Cervero 2010*). Our results show that the urban density has a much clearer decreasing effect on the GHG-emissions from private driving of single- and couple-households than families with children in HMR.

It has also been noted that the behavioural change in transportation habits, especially the reduction of car use, is difficult to achieve and that the political interventions are often ineffective (*Graham-Rowe et al. 2011, Steg & Gifford 2005*). Thus it might be more efficient to direct the mitigation measures to the technological development, which is much more rapid than the structural changes in the built environment. In Finland the average CO_2-emissions of newly registered cars have decreased from around 165 g/km to about 130 g/km in past five years, 2008-2013. Mostly the reduction is due to the EU-legislation. It should also be taken notice that when the GHG-emissions of private driving decrease the weight of air travel increases further.

In the future the assessments should be developed further to include the lifecycle emissions including the infrastructure, vehicle manufacture etc. Furthermore the attributional assessment of GHG-emissions is insufficient because of the rapid changes in the transportation field.

Bastani et al. (2012) showed in their recent study that the uncertainty of future transportation needs and technologies affect significantly the expected value of the fleet fuel consumption and GHG-emissions. A consequential approach would thus be more informative considering policy implications. It would also be important to study other urban areas than HMR, since the characters of a specific city have their own effect to the results. E.g. Li et al. (2010) showed in their study of Chinese megacities that car ownership has different drivers in different cities.

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Greenhouse gas effects of rural-urban migration of households: case of apartment dwellers

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Abstract

Urbanization is on a continuous rise in nations both developing and developed. Often the direction is from less urbanized areas to cities and metropolitan areas, as the ever rising housing prices and rents in these most urbanized areas indicate. However, besides being just a transition from one place to another moving usually leads to behavioral changes as the surrounding infrastructure and the consumption and leisure possibilities it offers can be even essentially different. In addition, the rapid urbanization requires continuous development of the receiving urban areas, especially in the form of new construction.

Even if different kinds of footprint calculations are becoming more and more mainstream, the economy-wide greenhouse gas effects of a household moving from place A to place B are largely unknown. The purpose of the paper is to shed a light on the greenhouse gas impact of household moving from a less dense area to denser urbanization. We also analyze the difference of living in a newer and older urban apartment building and investigate what, if any, behavioral changes in i.e. personal travelling behavior are involved.

We employ statistical census data of Statistics Finland to estimate the average emissions of a dweller living in a dense metropolitan area and compare those to estimated average emissions caused by dweller living in a non-urban area. In addition, two groups of urban households are compared: those living in new building stock built in the 2000s and those living in the suburbs built in the 1960s and 1970s. The greenhouse gas emissions are assessed with consumption-based environmentally-extended input-output (EE I-O) model and further elucidated with regression analyses. Urban areas where at least 90 % of the population lives in urban settlements and non-urban areas, namely less densely populated semi-urban and rural municipalities, are utilized as case areas.

Our results facilitate the understanding of urban lifestyles and in particular lifestyle changes related to moving from non-urban to urban area or from an older building to a new one. We find out that the effect on the total greenhouse gas emissions of an economy depend on the affluence of the moving households and also the age of the building seem to have a certain role. We believe that our approach offers an important insight to the search for sustainable lifestyles.

Also housing policies could benefit if also the climate change related externalities would be kept in mind.

Keywords: urbanization, life cycle assessment (LCA), greenhouse gas, household, consumption/behavior’

1. Introduction

1.1 Cities and climate change

It is evident that the climate is changing across our planet, largely as a result of human activities, and for example the atmospheric concentration of carbon dioxide has increased by 40% since pre-industrial times (IPCC, 2013). There is a scientifically unanimous consensus on the existence of climate change and the human role in it (Cook et al., 2013).

Cities and climate change remain a hotly debated topic (e.g. Brown et al., 2009; Hoornweeg et al., 2011). On one hand there is a consensus that sprawling and non-dense urban development tend to grow emissions from driving and home heating (e.g. VandeWeghe & Kennedy, 2007; Glaeser & Kahn, 2010; Ewing & Cervero, 2010). On the other hand, there is evidence on the possibility that consumption-intensive lifestyles of affluent urban dwellers also play a role and can undermine some of the density's benefits especially when the indirect or embedded emissions are taken into account (Druckman & Jackson, 2009; Sovacool & Brown, 2010; Heinonen et al. 2013, Minx et al. 2013). This is in line with the more general notions of the unsustainable lifestyles of those living in the developed countries (e.g. Jackson, 2005; 2009).

These above mentioned discussions stem at least partly from the confrontation between production and consumption based perspective on emissions. The production based view is based on territorial emissions whereas consumption-based analyses take a global stance and emissions are allocated to the emission driver not to the source (see e.g. Wiedmann, 2009 Baynes and Wiedmann, 2012). For example Marin et al. (2012, 72) highlight the potential positive effects of policies emphasizing consumer's broad responsibility for consumption's spillover effects also outside their home countries. In this paper the consumption-based perspective is adopted and all private consumption GHG-consequences are taken into account. To be precise, we calculate consumption based carbon footprints i.e. life-cycle greenhouse gas emissions, that can take place either home or abroad, but which are ultimately caused by the final demand of products and services.

1.2 Research setting: the GHG-impact of moving from A to B

More and more people are moving to urban areas. UN predicts that the share of urban population will be 85.5 % in Finland by 2025 (UN, 2014). The popularity of cities and urban areas is based on accumulation benefits, which make the concentrations of the population and economic activity profitable, and density makes the trade of goods and services easy (The World Bank, 2009). Even though more dense urban settlements have claimed to be more GHG efficient, the change in the consumption patterns and the potentially increasing wealth level (see e.g. Broersma & Oosterhaven, 2009) of the urbanizing residents, together with the required heavy construction activity, makes it very uncertain how this migration affects the caused GHGs in overall. Derived from this current situation, the purpose of the paper is to analyze the greenhouse gas impact of household moving from a less dense area to denser urbanization.

In the literature there are not many assessments of the economy-wide GHG-effect of household from moving A to B. However, for example Glaeser and Kahn (2010) and Zheng et al. (2011) have estimated the emissions of a standardized household living in new building stock, and used it to estimate new household's impact on emissions. When comparing the household living in houses built years 1980–2000 to households living in older houses, Glaser and Khan found that those living in newer houses consume more fuel, which is likely due to the fact that new houses are typically located further away from the city center. However, at the same time, the new houses were more energy efficient and therefore energy consumption's carbon dioxide emissions tended to be smaller (Glaeser & Kahn, 2010).

What we add to the previous discussions is the perspective of how the emissions from consumption in its broad sense, beyond those from driving and housing energy, change along with non-urban-urban migration. The results may help to design location-specific mitigation policies that could impact or encourage behavioural change to more sustainable lifestyles by taking into account the GHG impacts of the potentially occurring changes in the lifestyles of the residents associated with urbanization.

2. Research design

2.1 Household budget survey and other data

In this paper we utilize Finnish Household consumption survey from year 2006. This one period cross-section of data consists of 4,007 households. In this data, expenditures are either based on a two-week diary or an interview about the purchases made on the preceding 12 months. The data is very comprehensive and it covers detailed consumption expenditure data, classified according to the international COICOP (Classification of Individual Consumption by Purpose) system, and a wide array of background and income variables for each household (OSF, 2013). The household consumption survey is a sample survey using a single-stage stratified cluster sampling design and it contains probability weight coefficients that we use in all the analyses.

We also utilize Statistics Finland's statistics on the finance of housing corporations that measure the cost of housing in housing corporations, and analyse composition of these costs. This is because the majority of apartment dwellers pay their utilities (including heating energy as well as maintenance fees) as part of the rent or housing management fees (e.g., Kyrö et al., 2011). Housing corporation statistics show what residents are paying for with their housing management fees and also differentiate based on the year of construction of the building (OSF 2014a). By utilizing living space information reported by each household and the average expenditure per square meter per month information from these statistics, we estimated additional heating, electricity, and maintenance expenditures for each household.

2.2 Case areas and households

As urban case areas we use urban municipalities in Finland. According to a definition of Statistics Finland in these areas at least 90% of the population lives in urban settlements, or the population of the largest urban settlement is at least 15,000 (OSF, 2014b). We compare these municipalities to the rest of Finland, namely to less densely populated semi-urban and rural municipalities, which we call non-urban municipalities. Even though these less dense municipalities cover 84 % of the land surface the majority of population lives in the denser urban municipalities. In 2013 69 % of the population (or 3.7 million people) lived in urban municipalities. The average population density per square kilometer is 11-times higher in the urban than in non-urban municipalities on average.

The internal migration flows in Finland have been towards urban areas since the 1960s and 1970s and the trend has continued throughout the whole 21st century. In 2012 there were approximately 276,000 moves within the country. Around half of these relocations (142,695 moves) were internal moves within urban municipalities. In addition, there were 57,790 moves to urban municipalities from either semi-urban or rural municipalities, making the total amount of moves to urban municipalities to 200,485. The amount of moves from urban to non-urban municipalities was 52,132 (OSF, 2014c.) It is worth a note that the statistical unit here is the amount of moves, not migrants.

We restrict the households analyzed to those households living in the apartment houses. This allows us to standardize the sample and make comparisons more reliable. The households who live in the apartment houses are likely to have at to some extent similar preferences and possibilities with each other's whether living in an urban or non-urban area. For example, in recent years it has become more common that young families decide to live in an urban apartment house that indicates that has become at least partly a life-style choice. Residential choice can be considered as a signal (e.g. Lester & Piore, 2004).

Further, we differentiate between urban households according to the age of a building where households lives. New building stock is defined as buildings that are constructed in the 2000s and the comparison group is households living in apartment buildings constructed in the 1960s and 1970s. The age of the buildings in the comparison group was chosen as the rapid depopulation of the Finnish countryside started in those years and a large amount of urban suburbs with concrete apartment buildings were constructed then. These suburbs can be located on shorter or longer distance from the urban centers but are nowadays often characterized with problems such as aging and energy-inefficient building stock, diminishing supply of services within the walking-distance, and social and economic segregation. Finally, after all the adjustments the total sample size is 894 households.

2.3 Environmentally extended input-output analysis

Environmentally extended input-output life-cycle (EE I-O) analyses measure the direct and indirect environmental impacts of the functional unit under consideration, i.e., the impacts from cradle to grave (e.g., Ferrão & Nhambiu, 2009; Crawford, 2011). Life-cycle analysis can be also done with process-based life-cycle analysis which is based on physical inputs or hybrid-analysis which combines the two methods (see e.g. Suh et al., 2004).

The EE I-O assessment is based on the input-output tables for national economies. The technique was developed by Wassily Leontief in the 1930s. A detailed introduction to input-output technique's application to environmental problems can be found from Leontief (1970) or Miller & Blair (2009). In brief, this "top-down" method tells the environmental impact related to a monetary transaction on a certain sector of the economy (Wiedmann, 2009). The benefits of the EE I-O method are said to be its capability to give an overview of the life-cycle effects of production and consumption of an economy, its lack of problems related to system boundaries and truncation errors, and the repeatability and easiness of calculations once the model is developed (Suh et al., 2004; Tukker & Jansen, 2006).

In this paper we apply EE I-O model called ENVIMAT, which is developed by the Finnish Environmental Institute, University of Oulu's Thule Institute, and the MTT Agrifood Research Centre. ENVIMAT measures the direct and indirect life-cycle environmental impacts caused by the Finnish economy. In this article, we utilized the 2005 consumer-price version of the model, which has 52 commodity groups, classified according to the COICOP classification and the related GHG emission intensity for each sector (emission per monetary amount used per sector). In the consumer-price version of the ENVIMAT model, the intensity tells the amount of direct and indirect emissions caused by a consumed product or service during its life cycle. As mentioned above, the expenditure data also follows the COICOP system, so the model-data fit is excellent. Climate impacts are assessed as CO_2 equivalents for greenhouse gas (GHG) emissions. A detailed description of the model can be found in Seppälä et al. (2011).

We made certain modifications to the input-output model and its straightforward application. Firstly, the original CO_2-intensity of hot water, district heating, or natural gas was modified. The ENVIMAT-model's intensity of 34.6 kgCO2-eq / euro used to be clearly higher than the intensities of other groups that turned out to be a model error. The sector's intensity was corrected to be 4.3 according to the information received from the model developer. Secondly, another issue was the treatment of durables such as cars. The emission burden of one household can grow unfairly compared to another that bought its car before or after the analysed 12-month period. We solved the problem by calculating the average expenditure for the sector "purchase of motor cars" for urban and non-urban households who report to have a car and allocating it to all those owing a car. Thirdly, the expenditure-based estimation of housing's emissions was refined since rental costs vary significantly by place of residence, making EE I-O's homogeneity assumption questionable. We replaced the reported rents, both actual and computed, with the product of the living space and the average rent per square meter (8.81 €) based on Official Statistics Finland (2014d) statistics on dwelling rents.

In this paper, we talk about direct and indirect emissions. Direct compasses two categories: fuels for personal transport and direct housing energy, i.e., electricity, gas, liquid and solid fuels, and heat energy. The indirect, or in other words embedded, emissions consist of five classes: food and non-alcoholic beverages, other housing (except housing energy), all other tangible goods, intangible goods (services such as education, health care, culture, recreation, and restaurants and public transportation. In other words, the direct and indirect categories together comprise all the reported expenditures, as these broad categories contain all the 52 categories of the ENVIMAT model. For example Bin & Dowlatabadi (2005) and Druckman & Jackson (2009) use similar direct-indirect categories.

2.4 Regression analysis

Regression analysis provides the possibility to analyse the relationships between background variables and the dependent variable of interest. As our starting point we use a non-linear exponential relationship between environmental impact and household expenditures (Lenzen et al., 2006; Roca and Serrano, 2007; Kerkhof et al., 2009a; Shammin et al., 2010).

$$Y_i = A^{\beta_0} \times E_i^{\beta_1} \times f_1(D) \times \varepsilon_i \qquad (1.1)$$

where the dependent variable Y is the per-capita carbon footprint, A is a constant, E is per-capita expenditure, and D is dummy variable indicating the dweller type. Here, D is a 3-step variable combining apartment and dweller type: those living in the non-urban surroundings, those living in the apartments built in the 60s or 70s, and those living in the new apartments built in the 21st century.

As usual, a non-linear dependence can be transformed with a suitable operation. The transformed model satisfies the assumptions of a general linear model. We follow the literature and transform the equation (1.1) with a natural logarithm transformation, obtaining the following equation:

$$lnY_i = \beta_0 + \beta_1 ln\, E_i + D + u_i \qquad (1.2)$$

For log-transformed equation (1.2) estimates for β, and partial regression coefficients (ηD) for explanatory dummy variables (D) can be efficiently estimated using the highly developed theory of linear relationships. Coefficients are estimated by minimizing the weighted sum of the squares. Benefit of the model form (1.2), also known as the log-log model, is that the estimate for a continuous explanatory variable, that is expenditure, is the so-called expenditure elasticity of carbon. This value tells how much a relative change in expenditures will affect the relative demand for the dependent variable. In case of dummy variables, the coefficients are interpreted with $p = 100(\exp(\beta) - 1)$, where p is a percentage effect on the original dependent variable, and being in one group is compared to the chosen reference group, which is indicated with brackets (Hardy, 1993, 58).

3. Results

3.1 Comparisons of the sample averages

In the following Table 1 we compare the selected case areas and households. In the first section of the table we compare the background statistics of households, then some socioeconomic statistics are compared and finally we move on to housing related statistics.

Table 1: A comparison of the averages for those having different types of living, standard errors in the parenthesises.

	Households living in urban apartment buildings built in the 60s or 70s	*Households living in urban apartment buildings built in 2000s*	*Non-urban households living in apartment buildings*
Background statics:			
Sample size	*552*	*128*	*169*
Household size	*1.58 (0.04)*	*1.70 (0.09)*	*1.57 (0.07)*
Number of children	*0.19 (0.02)*	*0.17 (0.05)*	*0.21 (0.05)*
Number of cars in the household	*0.54 (0.03)*	*0.70 (0.06)*	*0.68 (0.06)*
Share of carless households	*50 % (0.03)*	*38 % (0.05)*	*44 % (0.05)*
Socio-economic statistics:			
Disposable income per household (€)	*26,277 (1,305)*	*33,318 (1,940)*	*20,247 (886)*
Share of households where the reference person has only primary education	*33 % (0.02)*	*23 % (0.04)*	*36 % (0.04)*
Share of households receiving unemployment benefits	*11 % (0.02)*	*3 % (0.01)*	*13 % (0.03)*
Housing related statistics:			
Living area per capita (sqm)	*42.54 (1.22)*	*39.39 (1.51)*	*39.91 (1.36)*
Number of rooms per household member (including kitchen)	*1.57 (0.05)*	*1.35 (0.07)*	*1.38 (0.06)*
Share of owner occupied dwellings	*51 % (0.03)*	*49 % (0.05)*	*39 % (0.04)*

Table 1 tells us that there both differences and similarities between the compared samples. Surprisingly, the average household size is the smallest in the non-urban areas and when comparing the urban areas we see that the number of household members of households living in the new building stock is the biggest. However, the differences in household size are quite minor and all the households compared in this paper tend to be rather small. The differences in the number of children aren't prominent either.

Carless lifestyle is the most common among households living in urban apartment buildings built in the 60s or 70s. As much as 50 % of these households don't own a car. This is likely to be related to the fact that the suburbs built in the 60s and 70s are typically located closer to the city centres than newer areas, where the share of carless households is 38 %. Another potential explanation is the higher affluence level of the households living in the newer buildings. Comparisons of the share of less educated households and households receiving unemployment benefits tell a similar story as well – there seems to be at least certain level of socio-economic segregation and the wealthier and more educated households tend to cluster to newer areas.

Housing related statistics actually tell slightly a different story. There are no major differences between the variables in the compared sub-samples. Living area is the highest, approximately 43 km^2 per capita, in areas built in the 1960s and 1970s but the differences are rather minor. Share of owner-occupied living is also the highest, 51 % in the areas built in the 60s and 70s. The actual carbon footprints for different apartment dweller types living in either urban or nun-urban areas are compared in Figure 1.

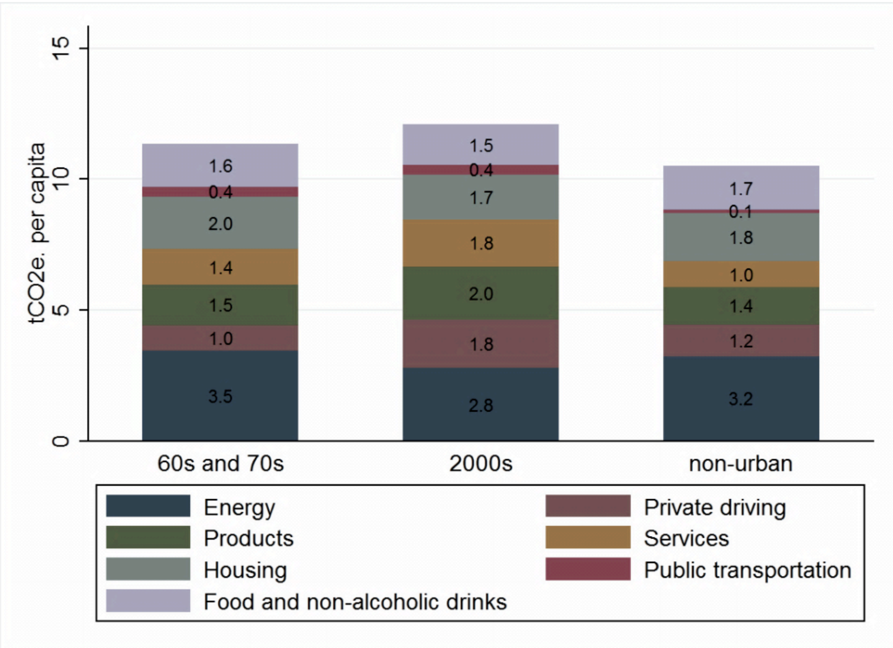

Figure 1: Carbon footprints

The carbon footprints seem to be smallest in the non-urban surroundings where the size of the footprint is 10.5 tCO2eq. For urban apartment dwellers, the average carbon footprint in the areas built in the 60s and 70s is 11.3 tCO2eq and 12.1 tCO2eq in the new areas built in the 2000s. As Figure 1 tells us, there are differences in the emission sources as well. Housing energy causes the most emissions in the 60s and 70s group, whereas the energy related emissions are the lowest in the apartments built in the 2000s due to the stricter energy efficiency requirements. Also expectedly, private driving causes more emissions (1.8 tCO2eq) in the urban areas built in the 2000s than in those built in the 60s and 70s but surprisingly the amount of private driving related emissions is almost equal between non-urban and 60-70s types of living, both significantly outnumbered by the GHGs caused by those living at newest apartments. However, also the number of cars in the household is the highest and the share of carless households is the lowest for those living in these newest apartments. Also, rather surprisingly the amount of emissions from public transport is equal for these two urban types of livings.

The most affluent households living in the newest urban apartments cause the most emissions due to product and service demand, when comparing the three groups. However, their emissions from the category other housing are the lowest probably due to low need for renovations in comparison to the older building stock. Food causes approximately same amount of emissions in each type of living. Finally, it is of importance to notice that indirect emissions, i.e. emission embedded to products, services, housing, public transportation, and food, dominate direct emissions from home energy and private driving in all the three groups compared, highlighting the importance of consumption-based perspective.

3.2 Regression results

Table 2: Regression models 1–3

		model 1	model 2	model 3
VARIABLE		**lnGWP**	**lnGWP**	**lnGWP**
ln(EXPENDITURE)		.779***	.797***	
		(.021)	(.021)	
ln(INCOME)				.596***
				(.024)
AREA				
(non-urban apartment dweller)				
	Urban 60s and 70s		-.050*	-.044
			(.022)	(.032)
	Urban 00s		-.151***	-.126**
			(.029)	(.043)
CONSTANT		-5.082***	-5.196***	-3.360***
		(.197)	(.196)	(.233)
	N	849	849	849
	R2	0.7647	0.7747	0.4812
* p<0.05, ** p<0.01, *** p<0.001.				

Table 2 tells us that expenditure controlled carbon footprints are 5 % lower in the urban areas built in the 1960s and 70s and 15 % lower in the new urban areas than in the non-urban areas. The result remains, but the coefficient on 60s and 70s turns statistically insignificant and the explanatory power of the model diminishes, when using the income instead of expenditure as explanatory variable. Expenditure elasticity of carbon footprints of apartment dwellers is approximately 0.8 meaning that a 10 % rise in the expenditures leads on average to 8 % increase in the carbon footprints.

This result means thus that the GHG consequences of the urban-rural migration (when only the apartment building residents are concerned) depend on the income changes associated with the moving. On an absolute level the emissions are higher in the urban settlements, but urbanization decreases the relative emissions.

4. Discussion

4.1 Discussion

The purpose of this paper was to analyse the GHG consequences of the non-urban-urban migration. The issue is of tremendous importance, but still surprisingly few studies have made attempts to tackle the issue. While our analysis has some clear weaknesses, in the future this kind of approach could be developed further.

Our key finding is that the changes in the level of affluence potentially associated with the migration actually define whether the GHGs decrease or increase as the consequence, at least in the Finnish context. When comparing the averages it seems that moving from non-urban areas increases the footprint. If a non-urban households moves to urban area built in the 60s or 70s its average yearly footprint grows by approximately 0.8 tCO_2eq and if it moves to new urban area it grows by 1.6 tons. However, some of sub-group results are to some extent unexpected. Firstly, if moving from non-urban area to a recently built urban one the emissions from private driving actually grow. This tells that the locations of these new urban areas seem to be inaccessible with public transportation only. If moving from non-urban area to area built in the 1960s or 1970s the private driving's emissions diminish moderately. Secondly, the benefits of smaller home energy emissions in the new areas are compensated in the higher emissions from private driving and demand of products and services. However, the picture changes when expenditure is controlled. Now, emissions of those living in newest areas are the lowest.

An interesting issue in defining the actual carbon footprints is the rebound effect appearing when a certain household increases or reduces its spending on a certain category. For example, if a household spends a lot on housing, the money is away from other consumption and thus hinders the increase in the emissions even if the housing-related emissions were high. An example of that could be a household investing into high energy efficiency and thus reducing the emissions from other consumption thanks to the invested money being away from other consumption. The same applies to private driving as well, and carbon footprints may either increase or decrease when a certain household gives up on private driving, depending on how the saved money is allocated. This type of rebound effect is especially important in the lower income segments where the consumption choices are made under serious budget constraint (see Heinonen et al. 2013b for further discussion).

Total cumulative net migration to urban municipalities is forecasted to be 336 000 persons by 2040, meaning on average 12,500 persons per year (OSF, 2014e). According to this paper the difference between moving to area built in the 60s–70s or a new one is approximately 0.8 tCO_2eq. This difference indicates that GHG emissions could be as much as 268 000 tCO_2eq more or less by the year 2040, depending on the choice of location of the moving households. However, this figure doesn't take into account the GHG-consequences of new construction that would change the results dramatically for the worse (e.g. Minx et al., 2011; Heinonen et al., 2012).

4.2 Limitations

First, there are uncertainties related to EE-IO-LCA's general weaknesses (e.g., Wiedmann, 2009, 176-177; Ferrão & Nhambiu, 2009). To sum up, the main issue is that the sectors are much aggregated and emissions assumed to grow linearly with expenditures. So it is obvious that assuming prices and environmental impacts to be homogeneous at the sector level causes uncertainties to the results and thus they should be interpreted as approximations.

There are also budget survey and other data limitations. It is of general knowledge that people do not fully report all their consumption expenditures in such surveys (see e.g. Kok et al., 2006). Even if we use weights coefficients throughout the paper some uncertainties in the generalization of results remain. Furthermore, we did certain modifications to e.g. reported rents (explained in Section 2.3), but we acknowledge that these modifications do not cover all the issues related to the housing's environmental impacts. Furthermore, we don't take in the account the differences in the housing energy's modes of production that makes differentiating between more clean and less clean sources of energy impossible. Finally, this paper doesn't take into account the carbon spike of new construction (see more e.g. Heinonen et al., 2012) that would significantly grow the emission burden of those moving to new apartments built to accommodate the migrating non-urban people.

In this paper we apply kind of marginal thinking i.e. we assume that the average of households living in a certain type of dwelling projects the impacts of new household moving from non-urban setting to either urban apartment built in the 60–70s or urban apartment built in the 2000s. This kind of thinking has its flaws. For example Fiala (2008) highlights that a new urban dweller typically needs less land than the average land-use for those living in the city is, indicating that looking only at the current averages when planning future land-use can lead to biased results. It is also apparent that there is a whole range of issues that affect the environmental impacts, and for example the distances to working places and public transportation possibilities can differ. In addition to this, it is not obvious that the migration from non-urban to urban surroundings necessary changes consumption habits.

5. Conclusions

The GHG consequences of the urban-rural migration seem to have very interesting and important GHG mitigation policy implications. It seems that even when the existing building stock is assumed to be able to accommodate the migration, the GHG consequences depend on the possible income and expenditure changes associated with the moving. It seems that if the levels of affluence of the migrating households remain on the previous level, urbanization could lead to reduced emissions. However, if the migrating households prosper as a consequence, for example due to higher wage levels in the more urbanized areas, the GHGs might increase along with the move. Another issue, left out from the analysis in this paper, is the impact of the often needed heavy infrastructure (including buildings) development required to accommodate the increasing urban population. If these emissions are taken into account, it seems very unlikely that the migration could lead to reduced emissions. This issue should be taken into account in GHG mitigation policies relying on densification through new infill developments.

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The Relationship Between Corporate Social Responsibility and Company Competitiveness From the Perspective of Construction Industry

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Abstract

Corporate social responsibility (CSR) has evolved to an important agenda for many industries and its scope has been widened from the responsible business to strategic decisions. The increasing importance of CSR affects business relations because organizations tend to choose business partners in consideration of their CSR awareness and activities. Scholars have identified the reasons why companies develop CSR strategies, such as reputation improvement, government regulations, competitive advantage, stakeholder pressures, and top management pressures. Since the construction sector serves infrastructure for other industries and has great supply chain relations in its business process, construction organizations should need to adopt CSR in their business. However, it is hardly a new idea for the construction industry and there is limited research from the perspective of construction industry. This study is a part of the thesis, which aims to understand CSR awareness, implementation, and its relationship with company competitiveness.

Keywords: Corporate social responsibility, construction industry, competitiveness.

1. Introduction

Increased concern about sustainable development and socially responsible business proliferate the concept of corporate social responsibility. Although its origin comes from the idea of contributing to society among economic activities of business organizations (Carroll and Buchholtz, 2006), the emphasis on employing the CSR for increasing competitive advantage (EU, 2010a) turned it a key business driver in today's business. Since the construction industry has great impact on environment, economy and society, it has found itself interested in the concept of CSR (Murray&Dainty, 2009). Most research on CSR has focused on the consequences of CSR implementation—or lack of implementation. (e.g. McWilliams and Siegel, 2000; Margolis and Walsh, 2003; Barnett and Salomon, 2006). Furthermore, the majority of empirical research on CSR applications of business is about developed countries' applications. Also, there seems to be few empirical studies related to the subject in project-based industries such as construction. It has become clear that there is a need to become more aware of the importance of this phenomenon and its impact on company competitiveness in today's highly competitive construction market. Additionally, CSR practices vary not only across industries but also countries as well. In this respect, this paper aims to compare differences on CSR between companies from the UK and Turkey, and provide an overview of the focus on CSR from the UK and Turkish perspective.

This paper is a part of a cross-cultural study, which examines how the construction companies understand and implement CSR in their practices, and present how CSR practices impact their business process and firm competitiveness. It starts with the theoretical background of CSR, and continue with analyses of four different case companies from UK and Turkey by questioning the success criteria and competitiveness strategy processes and the integration of the CSR concept in those processes. So far, the majority of empirical evidence on CSR has been based on western cases, especially from the perspective of UK construction industry (e.g.: Jones et al., 2006; Glass & Simmonds, 2007; Barthorpe, 2009; and Larsen et. al., 2012) and it is rather a new subject for Turkey especially for construction companies. Therefore, small and mid-sized construction companies were selected from both countries to explore the subject from different perspectives and demonstrate the similarities and differences. Research findings intend to increase our understanding of the relationship between the CSR and company competitiveness as well as provide rich content for the companies that intend to adopt CSR in their business.

2. Theoretical background of CSR

Despite the growing importance on the concept of CSR and its long historical background, there is not any single accepted definition of corporate social responsibility. Although different definitions of CSR has been put forward in academic area since 1950's (Bowen, 1953; Davis, 1973; Carroll, 1979; Wood, 1991, Porter and Kramer, 2006), Carroll's part definition of the CSR accepted as a base point in other researchers (e.g: Wartrick and Cochran, 1985; Lewin et al, 1995; Visser, 2007). According to four part definition of CSR: "The social responsibility of business encompasses the economic, legal, ethical, and discretionay expectations that society has of organizations at a given point in time (Carroll, 1979). Economic resposibilities are accepted as primary for doing business because producing a value and selling it with a profit is the underlying reason to make business. This is followed by legal responsibilities, because all organizations are expected to operate complying with laws and regulations. Then, the next step is ethical responsibilities, which means ethical manner should be embedded in business activities. Lastly, organizations have discretionary responsibilities, which refers to voluntary activities and any kind of contribution to society. In short, as stated by Carroll (1991) organizations should be profitable, obey the law, be ethical, and be a good citizenship. However, the meaning of the CSR has developed far beyond of presenting it within hierarchical view later. Therefore, "Three-domain model of CSR" proposed by Schwartz & Carroll (2003) to explain CSR activities, which seems more suitable to explain CSR theory in today's business. This model divides the activities into three domains, which are economic, legal and ethical with embedding philanthropic responsibilities in all domains.

Petrovic-Lazarevic (2008), in her paper on the development of CSR in the Austrlian construction industry, uses CSR as 'a set of principles established by an organization to meet societal expectations of appropriate behaviour and achieve best practice through social benefits and sustainable competetive advantage'. In reference to construction firms, she states, citing Yadong, that some of the common activities undertaken as part of CSR include: 'a moral obligation to be a good citizen; sustainability; reputation; relationship with employees and unions; relationship with suppliers and community representatives; and commitment to reportingon CSR'. Glass and Simmonds (2007) refer to "Considerate Contructors Scheme" which aims to enhance the social and ethical performance of construction companies at the site level.

Besides theoretical improvements on CSR, it has been an important agenda for governmental and international commissions such as European Union, World Business Council for Sustainable, and World Bank. One of the widely accepted definition of CSR was put forward by European Commission as: "a concept whereby companies integrate social and environmental concerns in their business operations and in their interactions with their stakeholders on voluntary basis" (EU, 2010a). Also, many business and non-governmental organizations have produced frameworks, assessment systems to manage and measure corporate social responsibility (BITC CR Index, 1998; AccountAbility1000, 1999; GRI Report, 1997; BRC Project, 2010b; ISO26000, 2010). For instance, BITC CR Index has been published by Business in the Community (non profit organization) as a voluntary benchmark system, which guide organizations while managing their corporate responsibilities in a systematic way. The index defines four management areas such as marketplace, workplace, environment and community (BITC, 1998). *Marketplace activities* refers to the business relations such as stakeholder management, supply chain activities, transparent business transactions. *Workplace activities* are mostly related with employee related issues like continuous improvement, equal opportunities, work-life balance, health&safety. *Environmental activities* means responsible for climate cahnge, carbon foodprint, pollution, waste management, energy efficiency, etc. *Social activities* refers to the philantrophic contributions, voluntary activities, supporting local people and economy and community invetments.

The dominant position in the utilization of CSR adresses these domains independent from the business process. As a result, CSR becomes something that companies does an extra behind their main business operations. However, as stated by Porter and Kramer, "...if corporations were to analyze their prospects for social responsibility using the same frameworks that guide their core business choices, they would discover that CSR can be much more than a cost, a constraint, or a charitable deed it can be a source of opportunity, innovation and competitive advantage (2006)". In order to understand current approach in the construction sector, whether the case companies integrate their CSR activities in their business processes its integration in succcess criteria and competitiveness strategies is questioned.

3. Research methodology

Due to the intention to understand how the concept of CSR is understood in construction industry and question the relationships between CSR activities and company competitiveness, the research focused on qualitative data, and the case study strategy was used to gather in depth understanding with real life examples. The unit of analysis was selected as organization because the research aims to investigate the CSR from organization's perspective. To present more powerful results than a single case study (Yin, 2003) multiple case study methodology was conducted with selection of four cases from UK and Turkey. Case selection was made upon the following criteria; (i) the companies should mention about the CSR subject in their company vision, mission statements, values or strategic plans; (ii) the companies should have a special CSR related sections on the company web pages, which explain their CSR activities; (iii) the companies should use the indexes, assessment tools and standards related to the CSR. (iv) The number of employees and the industry in which they operate. Semi-structured interview was used for data collection and interview questionnaire was developed with the guidance of the literature review. This paper is structered on the last part of the questionnaire which contained questions discussing the relationship between CSR and company competitiveness. The majority of the questions were 'open ended' in order to keep flexibility and depth of information. Data analysis involves organizing qualitative data from interview notes, records, and documents. First, empirical findings were ordered in the structure of the questionnaires as interpretation of interview answers as well as direct quotations from the interviewees' comments. For the next step, the findings found from interview analyses were compared with the theoretical findings and intra-case and cross-case analyses were conducted. Lastly, summary of the findings and recommendation for future work were given in conclusion part.

Table 1: Description of the case companies.

	Case A (MS-UK) Medium size/ UK	***Case B (MS-T) Medium size/Turkey***	***Case C (LS-UK) Large size/ UK***	***Case D (LS-T) Large size/ Turkey***
Foundation	*2000*	*1961*	*1952*	*1963*

year				
Work type	*Refurbishment, Fit-out specialist*	*Residential building*	*Education, justice, retail, social housing construction; fit-out projects; regeneration; support services*	*Building construction; ports and industrial plants construction; transportation projects*
Number of employees	*Between 101-250*	*Between 101-250*	*More than 500*	*More than 500*
Job title of the interviewee	*Owner-Partner*	*Corporate Communications Coordinator*	*Pre-construction Manager*	*Corporate Relations Manager*

Four case companies from two different countries – UK and Turkey- and two different scales – big and SME- were analyzed in detail and compared to each other. Therefore, research findings show the differences between CSR approach of construction companies from high and middle income companies enabling the identification of the factors their decision process. Besides, comparison of the approaches from different sizes enables to understand how the company scale shapes CSR approach of the companies. The companies were asked about what are their success criteria, competitiveness strategies, how they are defined and what are the relationship between CSR activities and those processes. Findings are presented as tables and discussed in the light of theoretical background.

4. Cross-Case Analysis and Conclusions

In order to facilitate a comparative analysis of the case study qualitative data, the case studies were sifted and Tables 2,3,4,5,6,7 and 8 constructed.

Table 2. Company value statements.

Case A (MS-UK)
"Setting up a people-focused business, Creating excellence in construction, Investing in environment, training, and staff development, Creating work-life balance, Contributing to the society."
Case B (MS-T)
"Satisfying the shareholders' expectation, Complying with rules on environment, health & safety, Developing protective systems through determining any kind of risks, Becoming a leading brand, which creates of good quality and modern living projects."
Case C (LS-UK)
Adding continuous value to the clients and shareholders, Contributing the society as a whole, Undertaking the activities in a sustainable and responsible manner, Taking a leadership role in the built environment, Creating human touch, relationship focused approach, Being entrepreneurial and direct, Being visible-well known in the community and industry, Determined the preserve their environment
Case D (LS-T)
Being a corporation where its employees and stakeholders are proud of working with, Respect for human (against discrimination, language, gender, race; healthy and safe workplace; zero occupational accident), Working in responsible, consistent, honest and fairness manner, Sustainable contribution to society, Support economic, cultural, and social development, Minimizing negative impacts on environment, encouraging for conservation and recycling)

Since the concept of CSR and how it is understood in construction is still new subject (Larsen et al., 2012), value statements of the case companies were questioned to examine whether the concept of CSR is referred (Table 2). Although the case companies do not mention about "CSR" directly, when the statements of the case companies are evaluated with CSR domains, ethical domain becomes prominent by all firms. Besides, among CSR types, considerable emphasis was placed upon social activities. Mid-sized companies place much emphasis on ethical domain, whereas large size companies refer to the legal and economic domains as well. The underlying reason could be explained with the business scale and necessities that should be considered and brought along (policies, legislations, stakeholder or financial requirements). It was only the Case A, which explains their aim as differentiating in the sector with the people-focused approach and pays special attention to social activities. This explanation supports the idea that the companies that act in socially responsible manner gain a differentiation in the sector that affect their business affirmatively (Girod & Bryane, 2003). Although all companies acknowledge the use of marketplace related activities throughout the interview, they do not give place the "marketplace activities" directly in their CSR definitions. What needs to be well understood is that the case companies define their company values with the social activities and ethical responsibilities more than other factors; however, when they were asked about CSR in detail they all connect the concept of CSR with economic domain and marketplace activities.

Table 3. Criteria of Business Success

Case A (MS-UK)
- Investment in people **workplace* - Work with well-trained people **workplace* - Production of well-developed and excellent work **marketplace* - Continuous training and development **workplace* - Giving good service to the clients with the things listed above **marketplace*
Case B (MS-T)
- Financial performance **marketplace* - Turn over ratio **marketplace* - Percentage of product realization **marketplace* - Percentage of customer satisfaction **marketplace* - Becoming a leading company in construction industry **marketplace*
Case C (LS-UK)
- High level of repeat work (long lasting business relations) **marketplace* - Low stuff churn **workplace* - High customer satisfaction in pre and post construction **marketplace* - Compliance with 10 Point Sustainable Project Plan **environment* - Turnover and profits in line with budgets **marketplace*
Case D (LS-T)
- Improved economic activities **marketplace* - Increased business activities **marketplace* - New investments and developments in other sectors such as energy and information technology **marketplace* - Increased business volume in construction **marketplace* - Spread business geography **marketplace* - Increased brand recognition **marketplace* - Improved employee satisfaction **workplace*

Next, the case companies were asked to define their criteria for business success (Table 3). When their answers were compared with CSR management areas, marketplace activities come first and it is followed by workplace activities. Answers of the Case A demonstrate the importance of workplace activities and show consistency with their value statements and business philosophies. Case B focused solely on the marketplace activities although they give place environmental and social focus in their value statement. Large size companies give place workplace and environment related criteria along with strength of marketplace activities. It is revealed that case companies do not give place to social activities or CSR in their success criteria, even though they all define themselves with socially responsible business. This finding contradicts the view that firms use CSR as part of their portfolio of business strategies (McElhaney, 2009). It also indicates that CSR activities and company success are treated as unconnected issues.

When the companies were asked about the process of success criteria definition, it seems obvious that there is no single way of organizing a firm's CSR decision-making. While the case firm C prefers a centralized decision-making structure (*"Our chairman would define this at board level")*, others have a de-centralized or a hybrid decision-making structure, depending on their operating features and management style. Long-term targets, economic climate, industry requirements, governmental effects, business cycle, social needs and sustainability requirements are defined as the most important parameters that affect decision criteria definition. These are also the parameters that should be considered in planning CSR activities to get long-term benefits. If companies evaluate their CSR activities in connection with their success criteria, the concept of CSR could easily be embedded into their business strategy and bring long-term benefits.

Table 4. Link between CSR and business success.

Case A (MS-UK)
- Success criteria and CSR activities are linked - CSR should be identified with business principle to get real success. - Differentiation strategy-PR tool
Case B (MS-T)
- CSR and success criteria have to be linked to achieve in long term
Case C (LS-UK)
- CSR targets are part of their success criteria
Case D (LS-T)
- CSR is integrated in their business - CSR is integrated in all success criteria

Following question asks the relationship between company success criteria and CSR (Table 4). The interesting point is that although they did not mention about the concept of CSR while they are defining their company success criteria or its decision process, they all agree on the strength of the CSR–competitiveness relationship . This reveals that some CSR related activities are embedded in their business activities, however, they do not define them as CSR. Case A states that CSR is the main business principle of the company, therefore it is also the success criteria of the company. On the other hand, Case B asserts they produce CSR activities depending on the social needs and company's success criteria. The question emerges here is that whether the CSR concept shapes the success criteria, or it is shaped by the success criteria. Consequently, all companies agree on the idea that success criteria and CSR activities are linked to each other even though they do not make room for the concept of CSR in success criteria statemenets. Thus this finding provides confirming evidence for European Competitiveness Report (2008), which examines the effects of CSR on firm-level competitiveness. One can go further and say that if companies recognise how CSR can contribute to their competitiveness, CSR will not be an extra cost behind the business activity and turn to strategic activity integrated in all business process (Porter &Kramer, 2006).

When companies were asked whether they have a strategy deal with the competitiveness in the construction sector (Table 5). Case A asserts that becoming sustainable in triple bottom line is their strategy to compete in the industry. Their emphasis on the regional development differentiates them from other companies and seems as the critical point in their business success. This legitimizes the growing interest in localized focus in getting sustained competitiveness (Kao et al, 2009; Larsen et al., 2012). Case B states that although they define competitiveness strategies, they do not prefer sharing the strategic decisions with public. However, the interviewee explains their competitiveness perspective as believing in innovation and blue ocean strategies, competing in niche areas and increasing customer satisfaction. Integration with the concept of CSR and sustainability is seen as an innovation and niche advantage for the company. On the other hand, current economic situation and the low-cost strategy impacts Case C's competitiveness strategies. Their main focus turns to compete on price without decreasing their quality, however, low cost strategy can damage responsible business philosophy and the image of construction industry. Case D defines their strategies as long-lasting business relations, relationship with successful partners, work quality, transparency and responsibility in triple bottom line. Also, the interviewee stresses the differentiation impact of their work volume and project characteristics in strategic planning. This supports the view that competitiveness strategies are not generic and they are changing according to localized context (type, size, location and activity areas of the company and current projects) (Kao et al., 2009). Consequently, all competitiveness strategy statements refer to the issues under the scope of CSR theory; however, they are not denominated as CSR. This shows that current approaches to CSR are detached from the organization's business plans and strategies. However, if the companies shape their stance to social responsibility with the same frameworks that guide their core business choices, it can turn to a source of "opportunity, innovation, and competitive advantage' (Porter and Kramer, 2006). Also, if organizations utilize CSR in consideration of companies' conceptual and operational levels, it could be more embedded and manageable in the business process (Ward &Smith, 2006).

Table 5. Competitiveness strategies of the companies.

Case A (MS-UK)
- Becoming more sustainable in triple bottom line. - Increasing their contribution to the regional economy, social welfare and environment.

- Accomplishing periodic goals, aims and objectives of the company. - Doing back casting and defining 3 years business plan for long-term.
Case B (MS-T)
- Being competitive in niche areas. *("…We believe in innovation and blue ocean strategies…")* - Increasing customer satisfaction. - Bringing innovations. (*"…Our company was the first construction company, which closed sales offices, and started to sell building projects online…"*
Case C (LS-UK)
- Market is a balance of quality and price, and emphasis changes among clients and projects. *("…The current trend is price led work....")* - New strategy is to be competitive on price whilst still maintaining the work quality.
Case D (LS-T)
- Establishing long-lasting business relations. - Working with successful business partners. - Quality of the work. - Transparency in business process. - Ensuring responsible behavior in economic, environmental and social areas.

Following question asks the impact of their CSR activities on company competitiveness (Table 6). Although the interviewee of the Case A thinks that CSR does not impact their competitiveness, he states that CSR gives them differentiation, which is one of the Porter's genetic strategies (Porter, 1980). The underlying reason of interviewee's negative evaluation can be explained by domination of low cost strategy in the construction market. Case B mention about the increasing awareness of sustainability and introduction of some governmental regulations in Turkey (i.e. energy efficiency law). Since they are ahead of the game with early CSR integration, they pinpoint the importance of the CSR awareness on the company competitiveness. Case C stresses the negative impact of the current price led work in UK construction sector and stated that if current economic climate proceeds in this direction, the concept of CSR could be damaged. An interesting point emerges in the answer of the Case D, which supports the importance of the CSR awareness in getting financial support to the projects.

Table 6. CSR impacts on competitiveness.

Case A (MS-UK)
" It does not have an effect on being competitive. People believe in money competitiveness. CSR is a differentiator for us. When some clients see that we are engaged with our community, they prefer to work with us."
Case B (MS-T)
"CSR started to create a positive impact for our company. Due to the increasing sustainability awareness and some governmental obligations, people have started to recognize the concept of CSR. The increase in CSR awareness id getting us competitive advantage in the sector."
Case C (LS-UK)
"CSR obviously has a cost to the business, which must at some point be recovered. If the trend for price led work continued and became more widespread it would place pressure upon the CSR policy sector."
Case D (LS-T)
" CSR defines our business standards. We explain our sensitivity in economic, social and environmental impacts of our business with CSR. Our competitiveness strategies include CSR theory in it. For this reason, I could say that it has great impact on our competitiveness. Also, credit unions' positive reactions to our CSR awareness have impact on our competitiveness."

Table 7. CSR engagement with competitiveness strategy.

Case A (MS-UK)
" Yes, they are. How we do our business is also how we compete with others. We have sometimes problems to get the job, because we cost them more than others. The reason is that people are first in our company. We don't cut back expenses of our people to get a project with less budget."
Case B (MS-T)
" These issues are highly connected to each other. As I stated before, our CSR activities creates competitive advantage for our company. For this reason, we consider our business strategies, and then make CSR decisions."
Case C (LS-UK)
" We define our business target as being unique in the sector, and CSR could give us this differentiation. In this situation CSR has direct impact on company competitiveness. However, the current trend in construction is low-cost. CSR obviously has an extra cost to the business, which must at some point be recovered. If the trend for price led work continued and became more widespread it would place pressure upon the CSR policy."
Case D (LS-T)
"Being responsible in all business process is our main strategy for this reason they are related subjects. However we could not state that all our CSR activities are engaged with our competitiveness strategies. For example our social activities such as supporting education, arts & culture and sports are not directly engaged with our competitiveness strategy."

Then, to what extend their CSR activities are engaged with their competitiveness strategies are discussed with the companies (Table 7). Since the Case A bases their business process on the concept of CSR, they found a strong link among their CSR activities and competitiveness strategies. In similar vein, Case B states that they decide their CSR activities considering their business strategies. The difference between the Case A and B is that while the concept of CSR shapes business strategies of Case A, CSR activities are shaped according to the business strategies of Case B. On the other hand, Case C believes that CSR gives them differentiation strategy, however, they are worried about the negative effect of current low cost strategy in construction market. Case D evaluates their CSR activities divergently from their strategies. While they stress the relationship between their CSR activities and company competitiveness in previous question, they stated that social activities are not directly related with their competitiveness strategies. The answers indicate that British case companies precede in relating their CSR activities to their business strategies, CSR and business strategies are still different subjects which have impact on each other from the perspective of Turkish case companies. The reason could be high level of CSR awareness in UK, while it is rather a new subject for Turkey.

Table 8. Ranking the importance of CSR types in getting competitive advantage

	Case A (MS-UK)	Case B (MS-T)	Case C (LS-UK)	Case D (LS-T)
1	Marketplace Activities	Environmental Activities	Marketplace Activities	Social Activities
2	Environmental Activities	Social Activities	Environmental Activities	Environmental Activities
3	Workplace Activities	Marketplace Activities	Workplace Activities	Marketplace Activities
4	Social Activities	Workplace Activities	Social Activities	Workplace Activities

As seen in Table 8 the importance of CSR types in getting competitive advantage changes depending on the country. The reason could be attributed to CSR awareness level in the country, prevailing economic policies (Falck and Heblich, 2007), governmental regulations, and current industry trends. Case A prefers to rank the importance of their CSR activities from the perspective of their customers and because they judge the company with their satisfaction level, marketplaces activities are ranked at the top. Then, because of the increasing environmental sensitivity and the focus on health and safety, the company places them after market place activities and closes with the social activities. Case B prefers to put their environmental activities to top because they use it as a differentiation strategy, which gives them a first mover advantage (Falck and Heblich, 2007) in Turkey. Also, since they see social activities as the way for increasing brand value and reputation, it is placed in second place. The respondent of Case C stresses the importance of marketplace activities in the first place. Then, they pointed that environmental issues have been accepted as key point for long-term success in competitiveness. While they accept workplace activities are prerequisite for business, social activities was placed at the end, and interviewee stressed that clients do not interested in social activities as they are on other types. Case D approaches the competitive advantage from the perspective of getting recognition and reputation. Therefore, the respondent begins with social activities and states that social activities are the kind of activity that companies could reach more people. Then due to the increased interest in environment, he puts the environmental activities in second place. As they see the workplace activities as a priority in conducting their business, he does not support to rank it for competitiveness and puts marketplace activities in the third place. The interviewee assumes the reputation and increased engagement with people as competitiveness. Turkish case companies mention about increasing sustainability awareness inside the country and importance of the social activities in getting brand recognition, therefore places environmental and social activities at the beginning. Also, in British construction industry there are increased awareness of stakeholder engagement and long-lasting business relations, as a result marketplace activities are defined as the most important type of CSR in getting competitive advantage.

Lastly, when interviewees are asked about their personal comments on the concept of CSR, Case D pinpoint the greatness of the construction industry products' involvement in our lives and regards the concept of CSR as a tool to help raising the quality of life. Also, they draw attention to the complexity of CSR integration in construction sector due to the fragmented nature and other industry specific characteristic. However, he asserts that CSR will be an obligation in near future. Case C asserts that CSR is important for the long-term future of construction industry and sees the CSR as a tool to promote the image of construction industry. Case B points to the impact of construction industry on environment and economy and sees CSR as an indispensible element of business process. They support governmental incentives and obligations for increasing the awareness of CSR. Case A is concerned about the future of CSR and states that: *"CSR is seen as an extra thing by our industry. It is not integrated in the business plan. They believe that CSR will fade away and go in the future. My frustration is that not enough companies understand the benefits of engaging CSR."* The underlying reason of this concern is current low cost strategy in the construction sector. It is challenging to receive this comments from the company in which all business system is based on CSR.

5. Conclusion

This study focused on the qualitative comparison and evaluations of CSR applications of the UK and Turkish firms. The results show that although both Turkish and British case companies are found to have consensus about the connection between corporate social responsibility and business success, they do not incorporate CSR into the way they do business. This provides evidence for the view that the companies are still differentiating corporate social responsibility from their business decisions even though CSR as a rapidly developing business strategy is a response to globalization. It is challenging to see that even the companies that base their business philosophy on CSR are concerned about the future of CSR and have confusion about its integration and consequences while there is a growing agenda about the CSR in both academic and professional business environment. For instance, corporate responsibility has been suggested as an alternative discourse for increasing the competitive advantage (Green et al, 2008) and it is proposed as a way for gaining long-term success (Jones et al, 2006; Porter &Kramer, 2006; Larsen et al., 2012). Although the results could not be generalized, it is important to signify that the companies, which see themselves as leaders in CSR awareness in construction industry, failed to accept it as a business philosophy shaping their business. Also, it is revealed that both the concept of CSR and the competitiveness strategies should be evaluated according to the context in which the organization is embedded, rather than application of generic rules, management standards etc. The suggestions for future researches, more companies could be analyzed and more general results could be presented for the construction industry. Also due to the complex structure of the construction industry, CSR could be analyzed in detail according to different parameters such as company scale, business type, and business area – domestic or international-.

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Forecasting cash flow expenditure at pre-tender stage: Case studies in New Zealand construction projects

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Abstract

Construction projects are extremely reliant on cash flow to survive. Cash flows from the client to the contractor and onto the subcontractors through monthly progress payments. Knowing the value of each progress payment in advance is essential for clients to arrange their sources of funding to ensure timely payments. The creation of a cash-flow forecast is a complex process, especially in the pre-tender stage of a project. There have been a number of past studies done in the area of cash-flow forecasts for construction projects at various stages. The 4th degree polynomial and the Logit model have been identified in the literature as the most effective methods of forecasting cash flows at pre-tender stage. However, no significant study has been done in New Zealand to identify the most accurate model to predict cash flow at the pre-tender stage.

This research aims to develop a robust model to effectively forecast cash flows for construction projects in New Zealand at the pre-tender stage. Interim payment valuations in nineteen completed projects were analysed, using Logit model and 4th degree polynomial, to identify the best model to forecast cash flow.

The 4th degree polynomial was identified as the most effective model for modelling cash flows. However, due to the unique nature of construction projects, no standardised curve was identified to represent cash flow forecast. It was discovered that an idiographic approach is needed to forecast cash flows, by adding or subtracting the unique features of the project from the base model. The findings of the research would be of benefit to quantity surveyors and construction clients in predicting cash flow in construction projects at the pre-tender stage.

Keywords: cash flow, construction industry, forecasting, New Zealand, pre-tender stage

1. Introduction

Cash flow plays an important role in construction project financing for both clients and contractors. It flows from the client to the contractor and on to the subcontractors and suppliers. It is beneficial for clients to know the cash flow plan in advance, to arrange funding sources accordingly, and ensure smooth functioning of the project (Kenley, 2003). Similarly, accurate cash flow forecasting is essential for the survival of any contractor at all stages of the work (Banki and Esmaeeli, 2008). Much research has been done on cash flow forecasting for construction projects, with a number of different solutions being offered to address the problem. However, predicting cash flow during the pre-tender stage is considered difficult, due to limited information and time availability.

A number of different statistical approaches have been used to develop cash-flow forecasting models. The majority of cash-flow forecasting models developed have been based on polynomial regression, which was first used by Bromilow and Henderson (1977). They collected data from past projects, modelled into a standard curve using regression. This method was further expanded by Tucker (1986), Kaka and Price (1991), Khosrowshahi (1991) and Ng et al. (2001), by grouping projects into different types, and developing standard curves to match each group/type. All these approaches were nomothetic, and had the belief that a standard curve for a type of project could be found. This approach is challenged by the idiographic approach, which treats each project as unique. Projects are modelled by creating a curve for each project individually. Research has shown the idiographic to be correct (Banki & Esmaeili, 2009; Kaka, 1999; Kaka & Price, 1991; Kenley, 2003; Kenley & Wilson, 1989; Min-Yuan & Andreas, 2010) when tested on completed projects. However, the idiographic approach of modelling is useless for forecasting, as identified by Banki and Esmaeeli (2008), as it can only be used for analysis. A standard curve is needed for forecasting, as grouping the projects according to their different parameters improves the accuracy of the standard curves. However, the accuracy of the standard curves is still not ideal (Kenley, 2003), and they have been proven to be unreliable in forecasting cash-flow expenditure.

Further research is required to improve the standardised curves to provide more accurate results. Furthermore, no significant research has been conducted in a New Zealand context to develop a model to forecast cash flow at the pre-tender stage, which is the focus of this study.

2. Previous research

There are a number of different ways to forecast cash flow for construction projects; these include S-curves, cumulative value and cost-loaded programs. A large amount of research has been done on cash-flow forecasting at various stages of the construction project. The S-curve models were regarded as the fastest and easiest methods to forecast cash flow at the pre-tender stage of a project (Banki & Esmaeeli, 2008). Much research has been done to find S-curve models to represent the cash flow of a project more accurately.

2.1 Bromilow Model

Bromilow developed one of the early models to forecast cash flow in the 1960s at the building research division of the Commonwealth Scientific and Industrial Research Organisation (CSIRO) (Kenley, 2003). Bromilow used polynomial regression to develop the model.

The Bromilow's equation:

$$T = C_0 + C_1 P_1 + C_2 P_2 + C_3 P_3 + C_4 P_4$$

Where T is the percentage of time since the start of construction, P is the percentage of expenditure, and C are the constants.

In developing this model, Bromilow used a very small sample and very little thought was given to the unique characteristics of different project types. This model has been used as the basis for further research by Bromilow and others (Balkau, 1975; Bromilow & Henderson, 1977; Jarrah et al., 2007; Khosrowshahi, 1991; Ng et al., 2001; Skitmore & Ng, 2001; Skitmore & Ng, 2003; Tucker, 1986).

2.2 DHSS model

Hudson (1978) at the British Department of Health and Social Security (DHSS) developed a model to forecast cash flow using polynomial regression, which was later called the in full first time (DHSS) model. However, unlike the Bromilow model, this model used only two constants to define the shape of the curve.

The DHSS model:

$$y = s\left[x + cx^2 - cx - \frac{6x^3 - 9x^2 - 3x}{k}\right]$$

Here c and k are the two parameters that define the model, x is the proportion of contract completed, and S is the contract sum.

Hudson published a range of c and k values for different project types and total project costs. Berny and Howes (1983), have done further work to the DHSS model to address the issues of cost overruns, and came up with a new, extra-exponential equation. Keller and Ashrafi (1984), compared the DHSS model with the Keller-Singh Model; the latter was developed with relatively complex mathematics, including three constants. The comparison concluded that both models performed well in forecasting cash flows for construction projects, however, the DHSS model was preferred over the Keller-Singh Model due to the availability of standard constants. The DHSS model was further tested by Skitmore (1992) for different types of project. The above study recommended the use of the DHSS model to forecast cash flow in different project types, although it was originally developed for hospital projects. This has expanded the use of the DHSS model more than other models to forecast cash flow (Kenley, 2003).

2.3 Logit Model

Instead of the nomothetic approach, the idea of an idiographic approach to find a model was introduced by Kenley and Wilson (1986). Their work was based on the hypothesis that each project is unique and therefore the cash-flow model cannot be developed from grouped data. Kenley and Wilson (1986) used a Lorenz curve in their model, to show the cash flow forecast in cumulative form, which allows progress payments to be identified. The Logit model is used to create the curve. A good-fit test was done using the risk index and the standard deviation of the estimate of Y (SDY). This allows models to be compared with other models to select the best fit, with the lowest SDY.

The Logit model:

$$v=e^{\alpha}\left(\frac{t}{1-t}\right)^{\beta}\Big/\left[1+e^{\alpha}\left(\frac{t}{1-t}\right)^{\beta}\right]$$

(Source: Kenley & Wilson, 1986)

Where v is the value of the contract complete and t is time complete, both expressed as a percentage, and α and β are the constants.

Kaka and Price (1991;1993) reinforced the need for an idiographic approach to cash-flow forecasting, as introduced by Kenley and Wilson (1986). This study used data from 150 completed projects and used the Logit model function to set a best-fit curve. The projects were defined by four distinguishing features; type of project, size of contract, construction company and type of contract. The authors used SDY as the basis to compare the model with the data set to find the best-fit curve. To give a clear representation of the curve's fit, a boxplot was used to graphically represent the data. The ANOVA test was used to identify how different groups affected the shape of the curve, and further identified the fit for the groups. After finding the curve, a test was done to compare the fit of data to that from different groups. Kaka and Price (1993) concluded that the idiographic approach to forecasting cash flow had inherent advantages over standard curves. The drawback of the lack of grouping of data can be overcome by deriving constants for each criterion. This concept was taken further by Banki and Esmaeeli (2008), who agreed with the idiographic approach to forecast cash flow. However, this study emphasised that the idiographic approach can only be used effectively to analyse completed projects, which is a drawback in the methodology. Hence, the study concluded that the nomothetic approach is more suitable to forecast cash flow at the pre-tender stage of a project.

Apart from the above, a number other models have been developed by many researchers to forecast cash flow in construction projects. Boussabaine and Elhag (1999) developed a model using fuzzy logic, which was based on an idiographic approach. It predicts the average outcome of the cash flow at any particular point on the curve. Boussabaine and Elhag (1999) believed that fuzzy logic averaging would be a good compromise to the standard cash-flow curve.

However, there appears to be no published research on developing a model to forecast cash flow in a New Zealand context. The industry currently uses both nomothetic and idiographic cash flow forecasting models, with varying degrees of accuracy, to forecast cash flow in construction projects. The literature suggests the Logit model and 4th degree polynomial as the most common models for forecasting cash flow, in other countries. Hence, this research focuses on selecting the most appropriate model for construction projects in the New Zealand context for forecasting cash flow.

3. Research method

This study aims to identify the most suitable cash-flow forecasting model for the New Zealand construction industry. The data was collected from progress payment valuations in nineteen completed projects; seven supermarket projects and twelve healthcare projects. Since variations are changes to the contract work that cannot be forecast, the total value of variations was excluded from the total interim payment amount in the analysis. Also, the total cost of retention and GST were disregarded, as they can be added later, depending on the requirements of the cash-flow forecast. Along with the total project cost, project duration and project type were also considered in the analysis. The Logit model and 4th degree polynomial, which were identified in the literature as the two main forms of model that forecast cash flow, were tested using Microsoft Excel software to assess the most suitable model in the New Zealand context.

4. Findings and analysis

4.1 Analysis of data using Logit Model

The cumulative percentage of time (t) and cost (v) in all nineteen projects were transformed into Logit values using the Logit transformation equation as follows:

$$Logit = In(z/(1-z)$$

The v and t values were then used to find the alpha and beta values for the Logit equation using linear regression, where alpha is the intercept of the v and t values and beta is the slope (refer to Table 1). After the creation of the curve, the fit of the data to the Logit curves was found by calculating the SDY.

Table 1: Project Alpha, Beta and SDY values

Supermarket Projects	Alpha	Beta	SDY	Healthcare Projects	Alpha	Beta	SDY
1	0.8211	2.0353	3.15%	8	-0.3959	1.4486	2.11%
2	-0.5682	1.5435	3.50%	9	0.6453	2.1027	12.08%
3	-0.1291	1.6625	6.76%	10	0.1402	1.6545	3.59%
4	-0.0359	1.5947	2.00%	11	-0.3494	1.7845	2.67%
5	-0.9745	1.7867	1.98%	12	-0.0765	1.2614	1.59%
6	-0.5402	1.9141	5.54%	13	-0.5183	1.4693	2.79%
7	-0.43	1.4395	2.80%	14	-0.4885	1.3699	1.39%
				15	-0.38	1.41	5.92%
				16	-0.6157	1.4774	4.82%
				17	-0.0672	1.3229	1.81%
				18	-0.2686	1.7363	2.86%
				19	-0.3937	1.5418	2.73%

The projects were then grouped according to their types, and the average Alpha and Beta values were calculated as shown in Table 2.

Table 2: Projects grouped by construction type with average Alpha and Beta values

Project type	Alpha	Beta
Supermarkets	-0.2652	1.7109
Healthcare	-0.149	1.5844

Using the above Alpha and Beta values to form a curve for the project type, each project's original data was modelled back against this curve to find the SDY value, as shown in Table 3.

Table 3: Average SDY for average Alpha and Beta values

Supermarket projects	SDY	Healthcare projects	SDY
1	13.48%	8	3.91%
2	5.96%	9	5.08%
3	5.37%	10	7.32%
4	2.09%	11	4.90%
5	11.11%	12	4.68%
6	8.44%	13	8.27%
7	3.18%	14	6.93%
Average	**7.09%**	15	10.24%
		16	11.77%
		17	4.08%
		18	2.44%
		19	5.95%
		Average	**6.30%**

The SDY values calculated using average alpha and beta values in both supermarket and healthcare projects are considerably higher than SDYs calculated using alpha and beta values in individual projects. Hence, further categorisation of projects has been done using both project type and total project cost, to assess the suitability of the Logit model. Based on the project cost of construction, supermarket projects were divided into three groups: $5-$10 million; $10-15 million; and $15-25 million. Similarly, healthcare projects also divided into four groups; up to $5 million, $5-$10 million, $10-15 million and $15-25 million. After the above categorisation, some groups were disregarded, as they had only one project in the category. Average alpha and beta values of both supermarket and healthcare projects are shown in Table 4.

Table 4: Average Alpha and Beta values

Type of project	***Project cost***	***Alpha***	***Beta***
Supermarket projects	*$5 to 10 million*	*-0.0463*	*1.7459*
	$15 to 25 million	*-0.3487*	*1.603*
Healthcare projects	*$5 to 10 million*	*-0.289*	*1.5736*
	$10 to 15 million	*-0.2305*	*1.4324*
	$15 to 25 million	*-0.1046*	*1.7195*

The projects were modelled against these new curves to find the fit-to-curve using SDY. The values were averaged to find the overall fit of the curve to the data samples, as shown in Table 5.

Table 5: Average SDY based on project cost

Supermarket projects	***SDY***	***Healthcare projects***	***SDY***
$5 to 10 million	*7.36%*	*$5 to 10 million*	*5.99%*
$15 to 25 million	*4.13%*	*$10 to 15 million*	*4.50%*
		$15 to 25 million	*6.19%*

Apart from supermarket projects with a total construction cost from $5 to 10 million, the average SDY values have been reduced slightly, with the further categorisation of projects in the sample based on their total project cost. This indicates that grouping projects based on their characteristics would give better results in forecasting cash flow using the Logit model.

4.2 Analysis of data using 4th Degree Polynomial Model

The 4th degree polynomial curve has four constants that define the shape of the curve, unlike the Logit model. A similar process to the Logit model analysis has been conducted to assess the fit of the data to the 4th degree Polynomial model. The process consists of four steps:

1. Initially, the constants were calculated for individual projects and SDYs were calculated to assess the fit of the data to the model, as shown in Table 6.

Table 6: SDY values of individual projects using 4th degree Polynomial model

Supermarket projects	***SDY***	***Healthcare projects***	***SDY***
1	*1.89%*	*8*	*0.86%*
2	*2.40%*	*9*	*2.74%*
3	*1.49%*	*10*	*1.76%*
4	*1.59%*	*11*	*1.84%*
5	*1.64%*	*12*	*1.18%*
6	*2.40%*	*13*	*1.48%*
7	*1.66%*	*14*	*1.16%*
Average	***1.87%***	*15*	*1.94%*
		16	*2.15%*
		17	*1.18%*
		18	*2.03%*
		19	*1.94%*
		Average	***1.69%***

2. Secondly, the average values of constants were calculated separately for healthcare projects and supermarket projects and SDYs calculated to assess the fit of the data to the model, as shown in Table 7.

Table 7: Average SDYs of healthcare and supermarket projects

Project type	***SDY***
Supermarkets	*6.55%*
Healthcare	*5.23%*

3. Thirdly, projects were further grouped based on their type and total project cost and the average value of constants calculated.

4. Finally, SDYs were calculated for each group, to assess the fit of the data to the model, as shown in Table 8.

Table 8: Average SDYs based on project type and project cost

Supermarket projects	SDY	Healthcare projects	SDY
$5 to 10 million	7.09%	$5 to 10 million	4.74%
$15 to 25 million	3.93%	$10 to 15 million	4.66%
		$15 to 25 million	5.81%

It is interesting to note in these results that the 4th degree polynomial model always provides low SDY values when compared with the Logit model. Hence, the 4th degree polynomial was identified as the best model for representing cash flow in New Zealand construction projects. After identifying the 4th degree polynomial as the most effective model to forecast cash flow, the analysis moved on to finding a standard curve, by grouping the projects. The groups were formed based on construction type and project cost. Figures 1 and 2 show the standard curves developed for supermarket and healthcare project groups respectively.

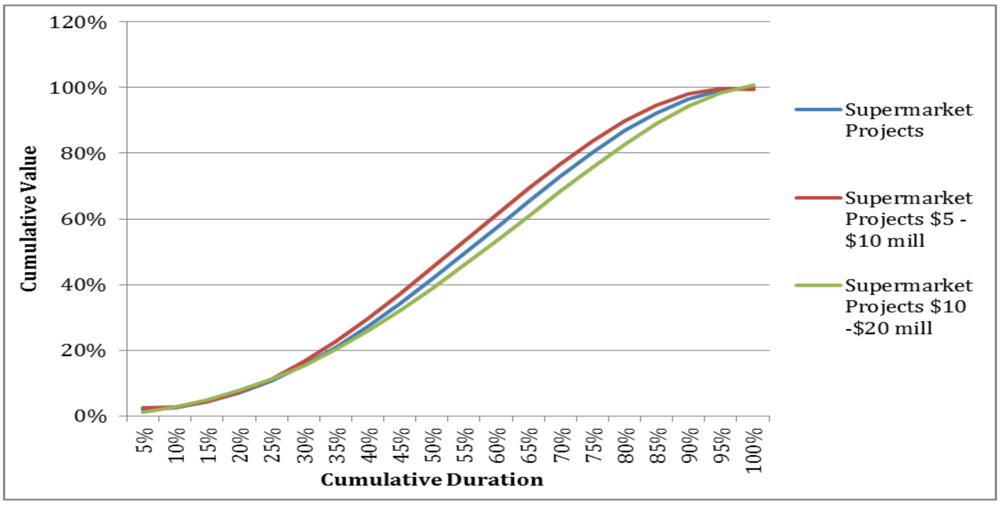

Figure 1: The 4th degree polynomial curves of the supermarket project groups

The graph illustrates that supermarket projects with a lower value have a steeper curve than projects with higher values. Interestingly, healthcare project curves are completely opposite to the supermarket projects; here projects with a high value have a much steeper curve than projects with a low value.

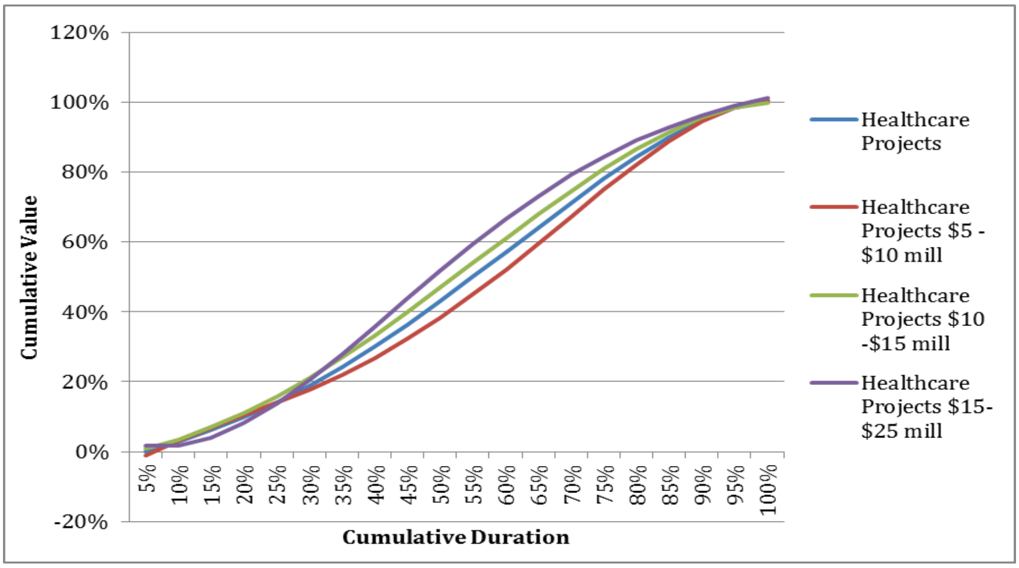

Figure 2: The 4th degree polynomial curves of the healthcare project

The aforesaid findings clearly indicate that developing a standard curve is difficult, due to unique nature of construction projects. However, further categorisation of projects based on their own characteristics would produce a better curve fit to the data. This is where the idiographic approach to forecasting is needed, as the great inaccuracies of standard curves do not provide accurate cash flow forecasts. Previous research on the idiographic approach by Kenley (2003) used the Logit model, however, the 4^{th} degree polynomial proves a better fit to the data when modelled individually; this was further confirmed by the findings in this research. It is also important to draw the attention of users to the aforementioned drawbacks in the polynomial model, to use it effectively by taking mitigation measures to minimise errors during the practical application of the model.

5. Conclusions

This research aimed to identify the best model to predict cash flow in construction projects, using existing models in the literature. The 4^{th} degree polynomial model was identified as the most suitable model to predict cash flow at the pre-tender stage of construction projects in NZ. With every construction being unique, it was concluded that no standardised curve could accurately be used to forecast cash flow. This research gives some insight into a complex problem, and provides industry professionals in New Zealand with a basis for forecasting cash flow. However, further research is required to group projects with more specific parameters that affect cash flows, to find precise models to alleviate the risk of inaccurate forecasts. It also opens up some already existing concepts, such as the idiographic approach, for further investigation.

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5D Building Information Modelling In The New Zealand Quantity Surveying Profession

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Abstract

Building Information Modelling (BIM) is a 3D building model represented by intelligent objects that reflect different elements of a building, and the data related to each of these objects. This data can be reused to simulate the construction of a building (4D BIM) or to provide quantities for cost estimating, frequently referred to as 5D BIM. BIM is having a profound effect on the construction industry, with an ever-intensifying focus on the profession of quantity surveying. As the capabilities of BIM appear to mimic the perceptions of quantity surveyors' (QSs) work, many have speculated that the growth of BIM will be the downfall of the quantity surveying profession.

This research paper examines perspectives on present and future uses of 5D Building Information Modelling in the quantity surveying profession in New Zealand; and by means of a postal questionnaire, investigates the norm in the New Zealand construction industry regarding the use of 5D BIM among QSs; understanding the use of 5D BIM within the quantity surveying profession; and barriers and recommendations to improve the use of 5D BIM among New Zealand QSs. It was found that New Zealand is very much at the beginning stages of utilising BIM to generate cost data, with a promising possibility of increasing BIM use in the future. Results also indicate that the cost data generated through BIM cannot be fully trusted without a quantity surveyor managing it and thus, BIM cannot take over the role of a quantity surveyor. They also highlighted the importance of new or amended forms of construction contract to provide assurances for any uncertainties over ownership of data, to increase the use of 5D BIM among QSs in New Zealand.

Keywords: 5D, Building Information Modelling, New Zealand, Quantity Surveying

1. Introduction

Technology is forever evolving; it is continually fixing problems or enhancing current functionality. A product of these technological advances is a process known as building information modelling (BIM). BIM is "a model composed of objects that represent the different elements of a building, and data related to each object" (Forgues et al., 2012: p.779). It essentially evolved from a conceptual 3D model of a building at a particular point in time, into a model of a building which is not only able to evolve as the physical building on site, but also predict and understand possible changes to a building before these changes are adopted onsite. Eastman (2011) also stresses that:

> *"BIM is not just a technology change, but also a process change. By enabling a building to be represented by intelligent objects that carry detailed information about themselves and also understand their relationships with other objects in the building model. BIM not only changes how building drawings and visualisations are created, but also dramatically alters all of their key processes involved in putting a building together" (p. vii)*

Moreover, the data in a BIM model could be reused to simulate the construction of the building (4D BIM) or to provide quantities in real time for cost estimating; frequently referred to as 5D BIM (Forgues et al., 2012).

5D BIM is the term used to describe generating cost data via the BIM process. In essence, the term '5D' can incorporate a variety of interpolarity levels in cost data generation through the use of a BIM model. 5D BIM is having a profound effect on the construction industry, with an ever- increasing focus on the profession of Quantity Surveying. As the capabilities of BIM appear to mimic the perceptions of a QS's work, many have speculated that the rise of BIM will be the downfall of Quantity Surveying. Further, the unique nature of the New Zealand construction industry, due to its small size, effects a lack of regular clientele and also government initiatives to mandate the implementation of BIM within construction projects. This research paper offers a perspective on the present and future use of 5D Building Information Modelling in Quantity Surveying in NZ.

2. Research methodology

Firstly, a comprehensive literature review was conducted, to explore the use of 5D BIM among QSs world-wide including New Zealand; the impact of 5D BIM on the quantity surveying profession; and barriers to the use of 5D BIM. The literature review mainly aimed to explore the knowledge base published in the current literature, and to establish a firm foundation for this study. Secondly, a web-based questionnaire was devised using Survey Monkey, with the following four main sections: participant demographics; the use of 5D BIM among QSs in New Zealand; the role of 5D BIM in the quantity surveying profession; and barriers to and recommendations for adopting 5D BIM. The questionnaire consists of both closed and open-ended questions, with the view of obtaining straightforward answers with further clarification where necessary. The questionnaire was disseminated throughout New Zealand to QSs who are registered members of the New Zealand Institute of Quantity Surveyors (NZIQS). Altogether, a hundred questionnaires were sent out and 20 questionnaires were received, a 20 per cent response rate. Data collected were stored electronically in two places; in a computer (where management of the data was performed) and an external hard drive (to serve as a back-up device). The statistical data gathered were analysed using basic descriptive analysis, considering respondent counts and percentages. Qualitative data were analysed using content analysis.

3. Literature review

3.1 5D BIM

5D BIM is the term given to the costaspect of Building Information Modelling (Forgues et al., 2012; Liddle, 2012; Boon, 2009).The literature indicates that BIM does not provide full capabilities for handling cost data as opposed to a spreadsheet or estimating package (Whatmore, 2012; Eastman, 2011). Hence, a number of interoperable capabilities have to be considered when using BIM for its 5D aspect. In doing so, Eastman (2011) suggested three primary options: (1) export building-object quantities to estimating software; (2) use a BIM quantity take-off tool; or (3) link the BIM tool directly to the estimating software. A similar approach was highlighted by Whatmore (2012), explaining the process being undertaken in the company Rider Levett Bucknall, in which a BIM model is loaded into a measurement platform, which is then linked to a cost plan allowing re-costing to occur instantaneously as the model evolves. Boon and Prigg (2012) confirm that a similar process is followed in a New Zealand context for costing with BIM, where costing takes place outside of the core BIM software, using 3rd party assistance. However, Forgues et al. (2012, p. 780) make specific mention of these options as "offering little or no interoperability capabilities to automate the exchange of data between the model and the BIM-based estimating," suggesting that true 5D occurs in the core BIM software. Eastman (2011) and Taylor and Bailey (2011) agree with Forgues et al. (2012), but also recognised that the level of 5D BIM interoperability as outlined earlier is necessary for the development of 5D BIM. Furthermore, Forgues et al. (2012) identified that the concept of 5D BIM can only be made possible with the use of a 4D model that takes time into account. Hence, the absolute necessity of 4D BIM for accurate cost data should be considered.

3.2 Use of 5D BIM in the Quantity Surveying profession

Many studies highlighted that BIM use is continuing to grow; Bernstein and Jones (2012) reported that there was a 45 per cent growth from 2009 to 2012 in North America. According to Malleson (2013), a similar increase has also been seen in the United Kingdom (UK), where use and awareness of BIM among construction professionals increased from 13 per cent in 2010 to 39 per cent in 2012. Furthermore, the UK government (2011, p.14) has mandated that "fully collaborative 3D BIM (with all project and asset information, documentation and data being electronic) will be the minimum by 2016.” Similarly to other countries in the world, BIM usage is rapidly growing in New Zealand. According to Huber (2013), awareness and usage of BIM among construction professionals increased from 34 per cent in 2012 to 57 per cent in 2013, which is a significant growth.

Among the surveys that assessed the usage of BIM among construction professionals, the BCIS survey (2011) went a step further, focusing only on BIM usage among QSs in the UK. The survey reported that 10 per cent of QSs use BIM regularly, while 29 per cent of QSs had only a limited engagement with BIM. Moreover, it was reported that among the QSs who used BIM over 12-month period, 14 per cent frequently used BIM for construction scheduling (4D) and 8 per cent frequently used BIM for extracting quantities (5D).

The literature suggests that extraction of quantities using the BIM model is the most influential factor on the quantity-surveying profession (Eastman, 2008; McCuen, 2008). Some studies argue that this is the beginning of the downfall of the profession (Hannon, 2007), while some studies argued the use of 5D BIM will aid the profession, by saving QS time to apply knowledge and intelligence to generating more savings and efficiency (Mitchell , 2013). A number of researchers (Firat, 2010; Taylor & Bailey, 2011; Boon & Prigg, 2012) agree with Mitchell (2013). However, findings from these studies stressed that full automation of building quantities extraction could be unreliable and therefore still require a significant amount of human involvement, to exercise judgement on the information extracted from a BIM when estimating.

3.3 Advantages of 5D BIM

Forgues et al. (2012, p. 778), states that the use of BIM “enables a faster and more cost-effective project delivery process, higher quality buildings, increased control and predictability for the owner.” Similar advantages were also discussed by Cho et al, (2012), and BELLC (2010), claiming opportunities existed to increase the efficiency of construction projects by using BIM. These studies also suggest that BIM leads for higher productivity by reducing the use of materials, time, and money in construction projects. Snjiders (2009) and Sacks et al. (2010) also stressed that BIM increases efficiency by decreasing downtime, and potential large expenses incurred on site, by identifying potential threats before they actually occur. The findings of Azar et al. (2012) showed that the accuracy of BIM-based estimates were within 3 per cent, with an up to 80 per cent time reduction in generating estimates. This helps to reduce the risk of investment in construction projects for clients (Liu & Hsieh, 2012). Forgues et al. (2012) suggest the reason for the efficacy of BIM is due to its expanded range of possibilities in managing an immense amount of information, which can be encapsulated and later extracted from the digital model.

3.4 Barriers, and recommendations to improve usage of 5D BIM

A study conducted by McCartney (2010) mentioned that some main contractors were nervous about embedding cost data into 5D models and were hesitant to move away from traditional estimating methods. Lack of trust of the BIM process was also mentioned by Tran et al. (2012) and Tiwari et al. (2009), highlighting the need for a cultural shift to increase the use of BIM. The latter study also suggests that this trust could be improved by sufficient training, to ensure all information produced is accurate. Providing necessary training to ensure accuracy in using BIM is also mentioned by Forgues et al. (2012), where they realised that integration between 3D, 4D and 5D could be misleading, as one is highly likely to experience missing data or anomalies in the 3D model, affecting the accuracy of quantities of an estimate. Lack of training and application interfaces between BIM systems, lack of client demand and lack of standards were identified by the BCIS (2011) survey as other major barriers to implementing 5D BIM. In the New Zealand context, reluctance to change, and a perception of limited benefit from the use of BIM among the users, were identified as major barriers that lower BIM uptake (Boon and Prigg, 2012).

In order to promote BIM usage, BELLC (2010) & Whitmore (2012) make specific mention of the importance of developing contractual frameworks and standards that allow for collaborative work, while reducing risk, responsibilities and liabilities. For example, the ability to map objects extracted from the BIM model, via the use of standards, to the estimating database would not only reduce risk and responsibilities but also liabilities concerning the object in question. While Tran et al. (2012) also agree with the above suggestions, they go further, with specific mention of New Zealand’s construction industry, stating that there needs to be more research on the best ways of using BIM, in order to increase BIM usage.

4. Survey findings

4.1 Norm of 5D BIM usage among NZ Quantity Surveyors

The following graph illustrates the percentages of Quantity Surveying firms in New Zealand using BIM to generate cost data. Results show that there is an even split between Auckland quantity surveying firms using or not using BIM to generate cost data.

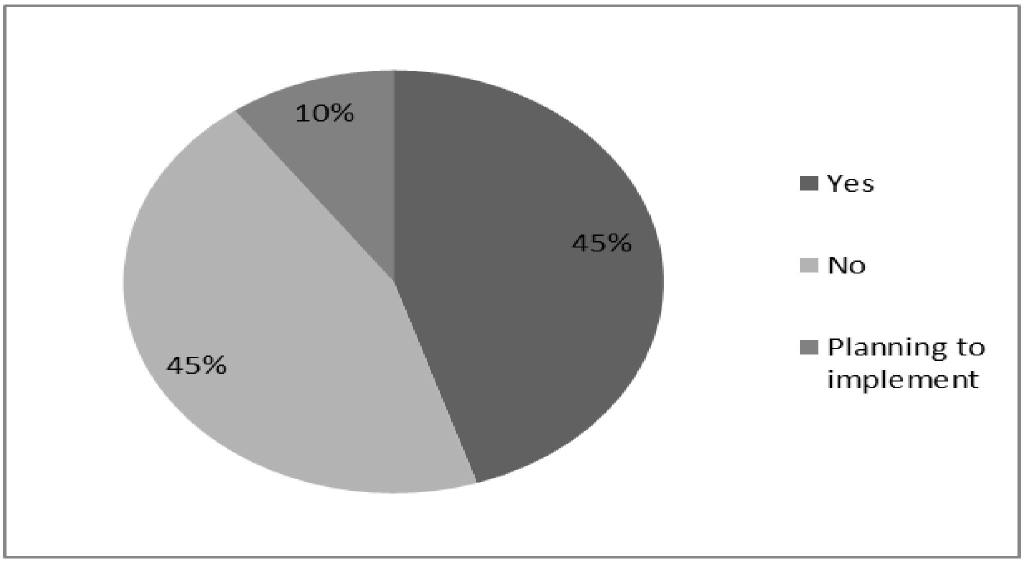

Figure 1: Use of BIM to generate cost data

In order to gain a clear view of the extent of 5D BIM usage in New Zealand projects, respondents who have reported using 5D BIM were asked to select the number of projects they worked on, using 5D BIM, within the last five years. Almost all the respondents stated that they had not used 5D BIM in more than five projects. This clearly indicates that New Zealand is still at the very beginning of 5D BIM usage. However, the majority of QSs (95%) believed that the use of BIM to generate cost data is very important. Moreover, around half of the respondents (45%) are currently undergoing BIM training, indicating a future steady growth of the use of BIM.

4.2 5D BIM use among New Zealand Quantity Surveyors

Informants' responses in regard to the extent of their use of 5D BIM features in generating cost data are summarised in Figure 2, which shows that none of the quantity surveyors have used BIM to generate cost automatically. Indeed, the majority of the respondents (65%) acknowledged they have either extracted quantities from the BIM model and linked live to a third-party software system to develop cost data instantaneously, or have extracted quantities from the BIM model via a take-off tool. However, 35 per cent of the respondents mentioned that they have not used BIM in any way to provide cost data.

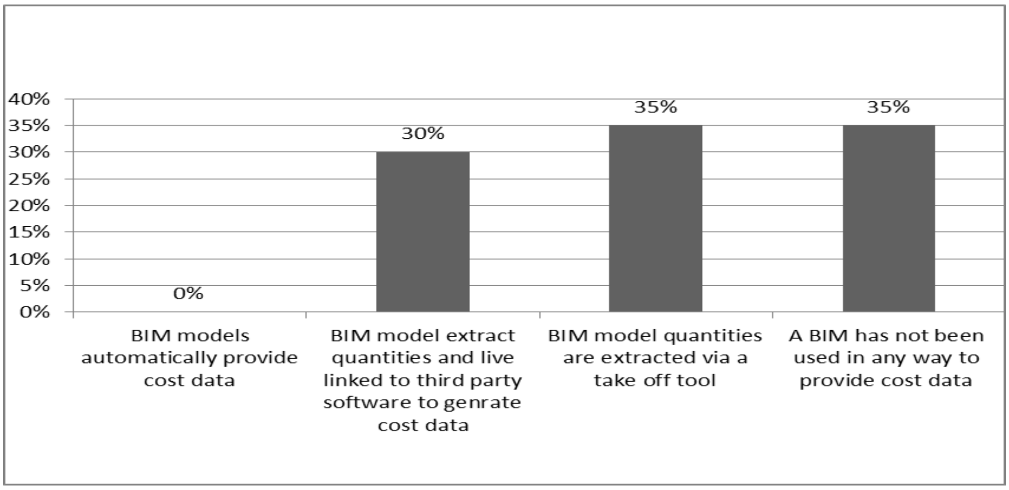

Figure 2: Use of BIM to generate cost data

Furthermore, this study has attempted to investigate the BIM's influence on the QS profession. As shown in Figure 3, 85 per cent of respondents believed that cost data gathered from a BIM model could only be used effectively where there is a quantity surveyor to manage it. Almost all the respondents (95%) agreed that BIM provides the 'heavy lifting' of calculating the majority of quantities, allowing the QS additional time to apply their knowledge to generating savings and other efficiencies. Therefore, respondents strongly believed that the automatic generation of cost data with 5D BIM will not affect the role of a quantity surveyor. Interestingly, the aforesaid findings are in line with the findings of many recent research studies, such as Mitchell (2013) and Boon and Prigg (2012). Therefore, they are completely opposed to the argument by Hannon (2007), which emphasised that the rise of BIM could be the downfall of the QS profession.

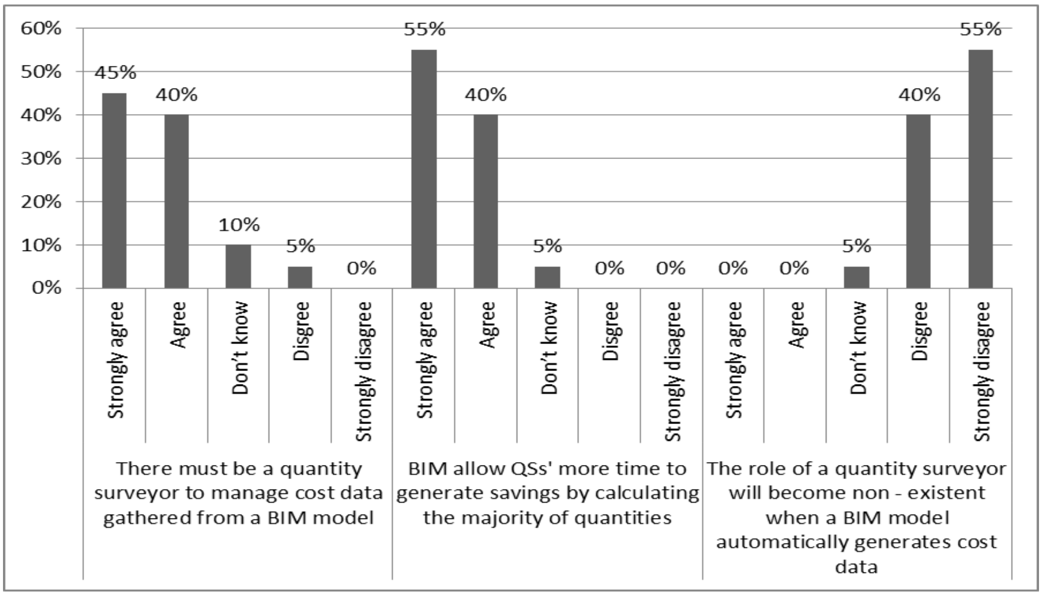

Figure 3: Influence of 5D BIM on the profession of Quantity Surveying

4.3 Barriers to and recommendations for improving 5D BIM

As shown in Figure 4, there are a number of barriers that slow down the progress of uptake of BIM in producing cost data in New Zealand. According to the findings, ‘lack of new or amended forms of construction contracts’ was accorded as the most significant barrier that slowed the adaptation of 5D BIM in producing cost data. Additionally, half of the respondents believed that ‘uncertainties over ownership of data and responsibilities’ is another major barrier, while 30 per cent of respondents reported that ‘lack of BIM training’; ‘lack of government intervention’; and ‘lack of client demand’ often affects the uptake of 5D BIM among QSs in New Zealand. However, only few (15%) respondents believed that ‘lack of IT infrastructure’ is a major barrier to increasing the use of BIM for generating cost data in construction projects.

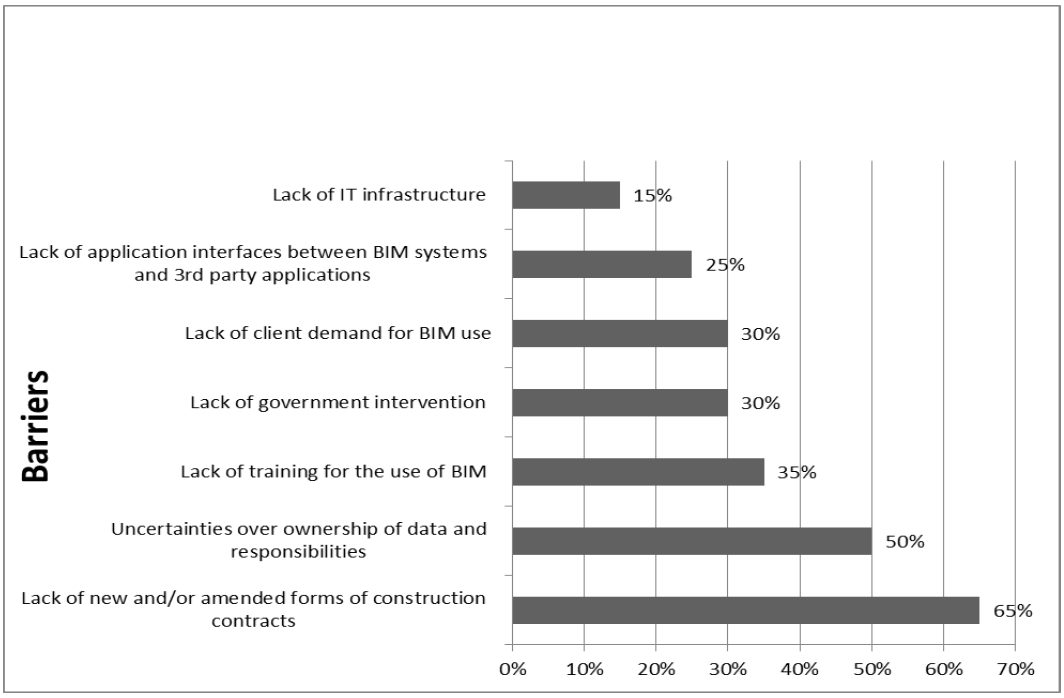

Figure 4: Barriers to implementing 5D BIM among New Zealand QSs

Conversely, a number of recommendations were made by the respondents for increasing the adoption of 5D BIM among QSs in New Zealand. The majority suggested the necessity of ‘providing new or amended forms of construction contracts to provide assurances for any uncertainties over ownership of data and responsibilities’ to increase the adaptation of BIM for cost estimation. Respondents strongly believed that this could bring the required cultural change among QS professionals, by increasing trust in embedding cost data into 5D models. Moreover, informants highlighted the need for BIM training programmes for QSs, to increase their level of awareness and understanding of BIM use and the advantages of using it to manage cost data. Apart from the above, respondents recommended ‘more government intervention to promote the use of BIM', as this increases awareness of BIM among construction professionals, which could eventually motivate clients to use BIM in their projects.

5. Conclusions

The aim of this paper was to examine perspectives on the present and future use of 5D BIM in Quantity Surveying in New Zealand. The findings revealed that the use of 5D BIM by quantity surveyors in the New Zealand construction industry is still at the "infant" stage, with a promise of steady growth in future. According to these results, the concerns raised by some research studies about the possibility of the decline of quantity surveying due to an increase in BIM use is a myth. Instead, the results indicated that the use of 5D BIM enhances the value of the profession by allowing people to perform more specific tasks rather than spending much time on 'take-off' quantities. It also stresses that for BIM to truly be useful within Quantity Surveying in New Zealand, the most important step would be to provide new and or amended forms of construction contract, in order to provide assurances over any uncertainties about ownership of data and responsibilities.

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A Comparison of the Determinants of Carbon Footprints in California and in the U.S.

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Abstract

The traditional production-based greenhouse gas (GHG) assessments tend to point fingers at the less urbanized areas where agriculture and the most GHG intensive production are often located and where transit distances are longer than in more dense settlements. This, however, may give a very biased basis for decision-making, since the consumption-intensive lifestyles and the heavy emissions from infrastructure development following rapid urbanization in the more affluent urban settlements may actually result in higher emissions caused by urban residents. In this study we tackle this issue by developing a hybrid life cycle assessment (LCA) model for assessing the consumption-based carbon footprints of the residents of the U.S. and the state of California. We utilize the most recent U.S. Consumer Expenditure Survey data of the Bureau of Labor Statistics and amend the model with several external data sources. Compared to the earlier assessments with similar methods and geographic scopes, our assessment includes a couple of advancements. Firstly, we utilize significantly more recent and more disaggregated input data. In addition, traditionally the carbon footprint assessments have not been able to sufficiently capture the GHG impacts of buildings and infrastructure development as well as purchases of certain long-term durable goods. In the developed model we propose a new way to incorporate these impacts into the assessment. With our assessment we depict how the carbon footprints in California appear as significantly lower than in the rest of the country due to lower power generation emission intensities and traffic-related emissions. We also discuss how this

type of analysis could later be used in designing more effective GHG mitigation strategies and more sustainable urban societies.

Keywords: carbon footprint, life cycle assessment, greenhouse gas, urbanization, carbon footprint, consumption, construction

1. Introduction

Rapid and significant greenhouse gas (GHG) emission reductions are needed to mitigate climate change to an adaptable level (IPCC, 2007). Unlike many pollutants, carbon emissions cause the same amount of harm regardless of where they are emitted. However, many assessments of the carbon footprints of regions or individuals focus only on the carbon that is emitted locally (Kyoto Protocol type of production-based assessments). Moreover, the irrelevance of the location of the emissions does not imply that a resident's location is of no importance. People living in different countries or different communities adopt different lifestyles due to the surrounding urban structure, and, by extension, make different consumption choices. Thus the production-based approach disproportionately penalizes regions that export products produced to meet demand in other regions (see e.g. Hoornweg et al. 2011 for a wider discussion).

Within a certain country, production-based assessments tend to point the fingers at the less urbanized areas where agriculture and the most GHG intensive production are often located and where transit distances are longer than in more dense settlements. This, however, may give a very biased basis for decision-making, since the majority of the production is actually caused by the demand of the more affluent urban consumers (Heinonen et al. 2013a; Minx et al. 2013). The consumption-intensive lifestyles and the heavy emissions from infrastructure development following rapid urbanization lead to a situation where the emissions caused by the urban residents may actually easily exceed those caused by the residents of the blamed agricultural and industrial areas or less dense rural settlements.

This kind of "consumer responsibility" perspective considers the emissions caused by the manufacture of a product to be embedded in the product, and that the consumer purchasing the product is responsible for its manufacture (see e.g. Baynes and Wiedmann 2012; Lenzen et al. 2007 for further discussion). The consumption-based approach to carbon footprinting makes it possible to include both direct and embedded emissions, and to analyze how total emissions associated with varying lifestyles differ across space. Consumption-based assessments are not meant to replace, but rather to complement the production-based approaches by offering a way to analyze emissions based on the demand for and use of goods and services by consumers.

Environmentally extended input–output life cycle assessment (EE IO-LCA) is the method most commonly used for carbon footprinting (Baynes and Wiedmann 2012). The method has been widely used for assessments on different geographic levels since it provides a good basis for such assessments due to the comprehensiveness in the inclusion of the indirect or embodied emissions of a certain product (Suh et al. 2004; Matthews et al. 2008). The techniques are still evolving, however, as there are certain inherent problems in the available models. Currently the majority of the available assessment models are based on a certain national economy, which brings about problems in the accuracy of the assessments as imports are assumed the same per monetary unit emissions as domestic production (e.g. Suh et al 2004). This “domestic technology assumption” also hinders the scalability of the assessments since the production technologies can vary significantly even within a certain country. The emergence of multi-region models will in time help to resolve this problem.

In this study we develop a hybrid life cycle assessment (LCA) model for assessing the consumption-based carbon footprints of the residents of the U.S. and the state of California. We utilize the most recent U.S. Consumer Expenditure Survey data of the Bureau of Labor Statistics and amend the model with several external data sources. Compared to the earlier assessments with the same method and geographic scope (Weber and Matthews 2008; Jones and Kammen 2011) we utilize significantly more recent and more disaggregated input data. In addition, traditionally the carbon footprint assessments have not been able to sufficiently capture the GHG impacts of buildings and infrastructure development, especially those of new residential construction, as well as purchases of certain long-term durable goods, due to them being weakly reflected in consumer expenditures. In the developed model we propose an alternative way to incorporate these impacts into the assessment. With our assessment we depict how the carbon footprints in California appear as significantly lower than in the rest of the country due to lower power generation emission intensities and traffic-related emissions. We also discuss how this type of analysis could later be used in designing more effective GHG mitigation strategies and more sustainable urban societies.

The paper proceeds so that in the next section we present a short literature review on consumption-based carbon footprint assessments, in Section 3 the method and data are described, Section 4 presents the assessment results and in Section 5 the results are discussed and positioned with regard to the previous studies. Section 6 presents some policy implications as well as issues for further research.

2. Background

Linking lifestyles to the environmental burden is not a new idea. Already in 1989 Schipper et al. attempted to explain the relationship between income and (direct) American energy consumption by looking at lifestyles. Since then, EE IO-LCA based methods have become a popular tool to assess the environmental impacts of entities ranging from neighborhoods to nations. Unlike methods that measure only direct emissions from fuel combustion and indirect emissions from electricity use, EE IO-LCA based methods enable the assessment of the entirety of the emissions caused by consumption, including emissions embedded in products manufactured outside the geographic unit under study. The methods can thus capture the so called "carbon leakage" phenomenon, whereby the manufacturing and production of polluting industries are concentrated in different locations than their consumption. Such research has shown how a significant share, up to 90%, of the emissions associated with consumption can occur outside the geographic unit being considered (Schultz 2007; Nijdam et al., 2005; Erickson et al., 2012; Peters and Hertwich 2008). Regarding the United States, Weber and Matthews

(2008) reported a share of 29% of the consumption-based emissions occurring outside the country borders, whereas Peters and Hertwich (2008) found 16% of the GHGs caused by consumption to be emitted abroad. Davis and Caldeira (2010) ended up with an even lower figure in their study. They found that approximately 11% of emissions embedded in products consumed in the United States were imported from other countries in this manner.

More recently sub-national carbon footprinting has become a widely studied topic. One key direction of this research is the city level, for which different approaches have been developed (Newman, 2006; Ramaswami et al. 2008; Heinonen and Junnila 2011a, 2011b; Sovacool and Brown 2010; Minx et al. 2013). The city level has been seen important since it is obvious that smaller units under study allow higher potential for carbon leakage.

One direction of this research has used EE IO-LCA for evaluating the claim that urban living is less carbon-intensive on a per-capita basis than suburban or rural living. Hoornweg et al. (2011) found that the strength of this claim depends heavily on whether you consider the embedded emissions in imported products – when embedded emissions are included, the differences nearly disappear. Baur et al. (2013) evaluated 134 European cities and in overall found a weak relationship between density and emissions, but within a single nation population density would seem to be stronger indicator. In Finland Heinonen et al. (2013a, 2013b) concluded that the current higher level of affluence of the Finnish urban residents leads to them having the highest carbon footprints, but if only the middle income segment is taken into account, the city residents have on average slightly lower carbon footprints. Affluence and overall expenditures, rather than urban density, have actually been shown to drive an individual's carbon footprint elsewhere as well. This finding has been replicated in Canada (Hoornweg et al., 2011), the United States (Weber & Matthews 2007), the United Kingdom (Baiocchi et al. 2010; Minx et al. 2013), Australia (Wiedenhofer et al. 2013), the Netherlands (Kerkhof et al. 2008), European cities (Baur et al. 2013), and nations overall (Hertwich and Peters 2009).

On the methodology level, one important direction of development have been hybrid models that combine process LCAs with EE IO-LCAs. E.g. Suh et al. (2004) describe how some of the inherent shortcomings of the EE IO-LCAs can be overcome with hybridization of the assessment model. Wiedmann and Minx (2008) suggest the hybrid methods as the best way to calculate the carbon footprints. Multi-region IO models (MRIO) are another direction of rapid development. In general the environmentally extended EIO-LCA provides less reliable results when the geographic level of analysis falls below that of a nation because the method calculates emissions based on national averages, but at the same time even on a national level the national economy based models cannot capture the emissions embodied in the foreign trade.

A perspective that has received significantly less attention is how the urban structure affects the lifestyles and the resulting GHG emissions. Focusing only on transportation and/or housing energy, emissions strongly correlate with population density with the most dense regions having the lowest emissions (Brown et al. 2009; Glaeser and Kahn 2008). There would thus seem to be a discrepancy between these studies and those having found affluence to drive emissions when the overall carbon footprints are considered. It seems that while we might understand relatively well how transportation patterns change along with the urban structure, there is a significant gap in understanding how other consumption patterns are related to the surrounding structure and how the emissions change as the consumption patterns change.

3. Research design

3.1 Methodology

LCAs can be categorized to bottom-up and top-down approaches (e.g. Wiedmann and Minx 2008). Bottom-up approaches are based on process analysis which allocates the emissions to the entity under study process by process. In theory the method is accurate, but it inherently suffers from truncation error, as the system boundary needs to be set somewhere (e.g. Matthews et al. 2008; Suh et al. 2004). These errors can be significant (e.g. Lenzen 2001; Matthews et al. 2008). Top-down approaches, namely IO-LCAs, employ input-output tables that produce the emissions occurring through the production and supply chain as the result of a monetary transaction within a certain economic sector. These methods offer in theory an infinite coverage and thus don't suffer from the truncation error, but include other inherent problems. Of these some of the most important are aggregation error and homogeneity and linearity assumptions. Aggregation error means that the IO tables can describe wrongly the emissions associated with a certain good due to each sector in the IO tables including several actual economic sectors with varying GHG intensities. On the other hand, the homogeneity and linearity assumptions mean the simplistic assumptions inherent in all IO tables that all the products within a certain product category would have the same associated emissions and that higher expenditure would mean linearly more emissions. Since most IO tables are based on national economies, this boundary brings an additional error source that could be called "domestic technology assumption".

In this study we utilized a streamlined EE IO-LCA based hybrid LCA. Any environmental burdens can be analysed with LCAs, but our approach can be called streamlined since we focus only on GHGs (Crawford 2011). The specific EE IO-LCA model we employ as the basis of the hybrid model is the 2002 U.S. Benchmark Purchaser Price Economic Input-Output Life-Cycle Assessment (EIO-LCA) model from Carnegie Mellon University's Green Design Institute (CMU Green Design Institute 2010). The EIO-LCA groups economic activities into 428 sectors derived from the North American Industry Classification System (NAICS) and relates economic activity in each sector to the greenhouse gas emissions, energy use, toxic releases, and hazardous waste creation. The purchaser price model means that the sectoral emission outputs are adjusted to actual prices paid by the customers.

The primary type of hybridization we used is the tiered hybrid LCA (e.g. Suh et al. 2004). More specifically we replace the first tier emission in the EIO-LCA with local or more recent process data to increase the accuracy of the assessment. The sectors and exact hybridization methods are described in Section 3.3.

3.2 Research material

As the primary input data we use the most recent U.S. Consumer Expenditure Survey (CEX) from 2012, administered annually by the U.S. Bureau of Labor Statistics (U.S. Bureau of Labor Statistics 2013). In addition to its annual frequency, the 2012 CEX data is robust along two dimensions; it covers roughly 120,000 respondents throughout the United States over approximately 700 consumption categories that correspond to the Universal Classification Code (UCC). The data also includes a wide variety of background variables that can be used for sampling purposes.

The survey is divided into two parts: the interview and the diary. Of these, the interview part covers all the other categories of personal consumption except groceries, which are covered with the diary part. The interview data is collected on a quarterly basis and includes the household expenditures for each respondent. Each interview covers the consumption expenditures for the respondent's household in the three months preceding the interview. The respondents can remain in the survey over several quarters or change during a year, but the reliability of the samples is maintained by keeping the number of respondents in each quarter above a minimum threshold. The diary data includes quarterly one- and two-week diaries from the respondents mainly on their grocery purchases. The respondents in the diary part can be the same or different from the respondents of the interview part.

Due to the shortcoming of the CEX data (discussed in Section 5), we complement the data with construction statistics from two sources. Building permits were used to approximate the annual construction activity, since no better data was available. The California data was taken from the Construction Industry Research Board (CIRB), a non-profit that collects permit data from over 500 California permit offices. National data come from the US Census.

3.3 Research process

The research process included the following steps:

1. Calculating the consumption profiles for the average USA and California residents.
2. Converting the consumption data into 2002 dollars.
3. Matching the consumption data with the EIO-LCA sectors.
4. Calculating the first screening LCA.
5. Building the hybrid model and re-calculating the carbon footprints.
6. Analyzing the results.

In the first phase we extracted from the CEX micro data all relevant expenditure variables. The interview data is available on quarterly basis, each sample including data from interviews made during that quarter. The 2012 data include five quarterly files – 2012 Q1-2103 Q1 – since all they include responses regarding purchases in 2012. Because we were interested in average expenditures over a 12-month period, we restricted our sample to only four quarters by keeping the survey responses collected between 2012 Q2 and 2013 Q1. Responses recorded in 2013 Q1 contain data for 2013 Q1 in addition to 2012 Q4, but the overall result is an average expenditure over a 12-month period. The quarterly sample sizes remain rather constant varying only from 5,965 to 6,029 households in the whole data and from 722 to 748 households for California.

The diary responses are split into four quarterly files for 2012. The one- and two-week diaries were simply extrapolated to represent quarterly averages (i.e., 13-week consumption data). The sample sizes are significantly smaller in the diary part of the survey varying from 1,599 to 1,655 in the whole data and from 169 to 205 for California.

To calculate the annual expenditure profiles we created quarterly, rather than annual, datasets for the US and for California to avoid biasing averages toward households that participated in the survey in several quarters. Furthermore, after the sampling the household-level expenditures within each quarter were divided by the family size to reach the per capita level that was chosen as the functional unit of analysis. The quarterly averages were then summed for the annual consumption profiles.

As the second step, because the model year is 2002 and the CEX data is from 2012, we used the BLS Consumer Price Indices (CPI) for All Urban Consumers (CPI-U) to convert the expenditures to 2002 dollars. The CPI factors follow a very similar sectoral breakdown to CEX and thus a detailed sectoral deflating was possible.

In the third phase we matched the expenditure categories with the EIO-LCA sectors. In general the CEX expenditure categories are much more disaggregated and comprehensive (~700 categories) than the EIO-LCA model (~430 sectors). Furthermore, a significant share of the EIO-LCA sectors are primary production or business-to-business service sectors, so some matching decisions necessarily sacrifice granularity in the consumption data. Still, 138 different EIO-LCA sectors found to match with the expenditure data.

During the matching process, a couple of changes for the expenditure data were made. Firstly, the CEX data on rental payments of residences include utility payments whenever they are paid along with the rent. The shares of the utilities should be separated from the actual rent since their GHG intensities differ significantly. The CEX data includes information on who of the respondents have paid certain utilities within their rents, but not the dollar amounts of these utility payments (which are likely unknown to the renter). We approximated these by assuming that if a certain utility payment was embedded in the rent, it was as large as the particular utility payment on average when paid separately. These average utility payments were then subtracted from the combined rental payment.

Secondly, the emissions associated with building construction activities are not well-represented by expenditure surveys because consumers typically pay the construction cost over a long time-period through loans, and emissions are easily underestimated if these payments are used in the assessment (e.g. Heinonen et al. 2012). We thus omitted the principal payments of housing loans from the input data and assessed the construction related emissions using residential construction permit values for our reference year 2012. For the emissions intensity we used the residential construction sector from the *2002 producer price model* of EIO-LCA and for dollar value conversion the construction cost index. Unfortunately, the US Census only reports on permit data for new construction, whereas CIRB also reports on permits for alterations and renovations to existing stock. To reconcile the two data sets, we assumed that the ratio of renovations to new construction in California is representative for the United States as a whole. Finally, for vehicle purchases we also omitted the vehicle loan principal payments and down payments made in 2012 since they give a poor basis for approximation of the emissions from vehicle manufacturing. Instead, we extracted the vehicle values from the CEX data for the new vehicles purchased in 2012 to approximate the vehicle manufacturing related emissions, and for the values of used vehicles purchased in 2012 to add the retail emissions related to their sales.

At this point we calculated the first screening LCA. Based on this, the model was chosen to be amended with external data on the GHG emissions from energy production. The emission factors for the full life cycle were taken from Horvath and Stokes (2011) for California and for the US and the EIO-LCA sector for power generation was replaced with these. Additionally, the EIO-LCA only assigns purchases of fuels (such as petroleum for cars and natural gas for home heating) with emissions associated with their extraction, production, and transportation. We therefore added process-based combustion emissions to create a more reliable and realistic tiered hybrid LCA model. The fuel price data for the U.S. and California was retrieved from the U.S. Energy Information Administration (2013a for motor fuels, 2013b for household fuels, 2013c for electricity). The U.S. emission factors are from the U.S. Environmental Protection Agency (2008a for motor fuels, 2008b for household fuels).

Finally, we re-calculated the carbon footprints and aggregated the consumption sectors into a six sector breakdown of apparel & services, food, healthcare, housing, transportation and other. The results are presented in the next section.

4. Results

California is often recognized for its environmental stewardship, in particular its promotion of low-carbon policies well before the rest of the country. Thus it is not surprising that the average annual per capita carbon footprint in California is somewhat lower than in the rest of the country. As **Error! Reference source not found.** illustrates, the difference is about 4 tonnes of carbon dioxide equivalents (CO_2e) per person; approximately 13 tons CO_2e/a in California compared to 16.6 tons CO_2e/a in the rest of the country.

The figure shows how California's advantage derives primarily from housing-related emissions. Within these the difference is largely explained by the better emissions intensity in power generation in California. Also, probably due to climatic and price reasons, less electricity is purchased in California than in the U.S. on average. Another reason for lower purchases is the larger average household size in California. In our samples the household size in California is close to three, but only 2.5 in the rest of the country. This economies-of-scale advantage shows especially in shareable goods categories like housing and transportation. Residential natural gas combustion is another important source of emissions, but no significant differences are found

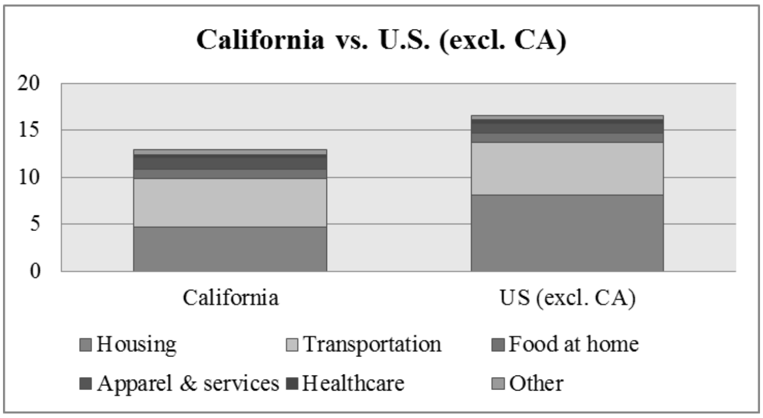

Figure 1: Per capita carbon footprints in 2012, California vs. United States (excluding California), tons CO_2e/a

between California and the rest of the country. Construction activity was on a relatively low level in the whole country in 2012 and thus the emissions per capita, while somewhat lower in California, only create a very small share of the overall emissions; 0.26 tons CO_2e/a in California vs. 0.36 tons CO_2e/a in the rest of the country.

Transportation is the second largest source of emissions in overall. The differences in the gasoline use related emissions are actually relatively small, varying only from 3.3 tons CO_2e/a in California to 3.5 tons CO_2e/a in the rest of the U.S., but fewer new vehicles were purchased in California in 2012 and thus the emissions from vehicle manufacturing are smaller for the average Californian. Vehicle purchases, and thus the emissions from vehicle manufacturing, actually form quite a significant share of the overall emissions, from slightly over one ton in California to 1.5 tons CO_2e/a in the rest of the U.S., even though 2012 was not among the top years in vehicle sales.

The rest of the categories form approximately a three tons share of the overall emissions in both two groups. The average Californian seems to consume slightly more services, especially eating out, but otherwise there are no significant differences between the groups.

5. Discussion

5.1 Interpretation of results

The purpose of this paper was to develop a hybrid LCA model for assessing the consumption-based carbon footprints of the residents of the USA and the state of California. Further, we aimed for some improvements in the IO-LCA based assessment techniques especially regarding durable goods like buildings and vehicles, where the private expenditure data cannot often be used for assessing the emissions related to the production of these goods.

In the paper we depicted how the average Californian has approximately 25% lower carbon footprint at 13 tons CO_2e/a compared to the U.S. average (excl. CA) at 16.6 tons CO_2e/a. Two primary reasons were found for the difference. Firstly and the most importantly, the significantly lower GHG intensity of power generation in California explains the difference. Calculated based on Horvath and Stokes (2011), the life cycle emissions are approximately 560 g/kWh in California, but as much as 750 g/kWh in the rest of the country. The economies-of-scale advantage from larger household sizes in California contributes to the difference as well. The impact of higher electricity prices in California (0.15 $/kWh to 0.12 $/kWh in the U.S. on average) is impossible to assess within this study, but it inevitably affects as well.

Private driving appeared as the second most important source of emissions, as was anticipated based on earlier research. Interestingly, no clear differences were found from the emissions from fuel combustion, but the share of vehicle manufacturing was found as relatively important and the dominant source of differences as well. The vehicle sales market is a highly fluctuating market and thus the emissions can vary annually quite a lot. It is also possible that Californians spend less on vehicles than people in other US states due to California's outsize expenditures on public transportation, but confirming this would need much more data over a longer time-period. In any case, the share of the manufacturing phase emissions is so high even for an average consumer, that a change of vehicle even to the most fuel efficient one only leads to GHG reduction after somewhat long time period.

The rest of the categories together account for approximately three tons of CO_2/a out of the average carbon footprints of both the California and the U.S. resident. While their overall share is rather significant, relatively small variations were found between the two groups. Eating out is more frequent in California, or at least more money is spent on eating out, leading to higher emissions in our assessment. Probably the very wide geographic scopes in the assessment reduce the differences in these other categories. More restricted samples could lead to more significant lifestyle variations within these as well.

Compared to the earlier assessments with the same method and geographic scope (Weber and Matthews 2008; Jones and Kammen 2011), our assessment includes a couple of advancements. Firstly, our 2012 CEX data is more recent and better reflects current lifestyles. Secondly, we use a wider selection of EIO-LCA sectors with 138 different sectors and thus also more disaggregated input data. We also convert the expenditures into 2002 dollars by sector, so as not to hide the huge variations in the sectoral inflation between 2002 and 2012. In addition, we consider our way of allocating the construction phase emissions to the residents an improvement in the sense that it truly allocates the emissions to the residents of the areas where construction takes place. In the setting of this study the construction phase emissions played a minor role, but when smaller units are analyzed similarly, the role of construction could change dramatically (as shown by Heinonen et al. (2012) in the case of a new residential area). The same applies to private vehicles to some extent. They are often paid through loans over a long period and thus the expenditure data gives a poor basis for the emissions approximation. In this study we allocated manufacturing related emissions only for those having purchased new vehicles during our reference year, and approximated the emissions with the vehicle values rather than with the payments in the reference year.

Our results comply relatively well with the above mentioned earlier assessments. Jones and Kammen (2011) report a carbon footprint of 48 tons CO_2e/a for an average U.S. household, and Weber and Matthews 50 tons CO_2e/a (without foreign trade), which are somewhat higher than our 42 tons CO2e/a if converted to a household level, but easily explained with the more recent input data and some differences in the assessment approaches. Furthermore, the U.S. 16.6 tons CO2e/a is in line with the U.S. production-based carbon footprint of approximately 17.5 tons CO_2e/a (U.S. Energy Information Administration 2013d) taken that not all the emissions are included in our assessment. On the other hand, several authors have depicted that the carbon footprints in the U.S. increase when foreign trade is taken into account (which is a limitation of the EIO-LCA model and thus of our assessment as well).

5.2 Limitations and uncertainties

There are certain limitations and uncertainties associated in this kind of study. These can be divided into three broad categories: those arising from the method, those related to the data and those related to the interpretation.

Firstly, the IO-based LCA method includes some inherent weaknesses. Of these, we already mentioned aggregation error and homogeneity and linearity assumptions in Section 3. Even though the EIO-LCA 2002 with its 428 sectors is one of the most disaggregated model available, all the sectors are comprised of many industries. Further, we were able to use only 138 sectors, and even while it is more than most of the earlier authors have utilized, aggregation error exists. Basically this means that some EIO-LCA sectors may under- or overestimate the emissions due to them including many industries which might have significantly varying emission intensities. Hybridization of the model reduces this problem, but only regarding the hybridized sectors. The linearity and homogeneity assumptions are present in all IO-LCAs as well. Especially the homogeneity assumption might somewhat bias the results, since the cost of living appears to be much higher in California than in the U.S. on average (C2ER 2011). Thus the California estimate might be biased upwards since higher housing prices don’t indicate higher emissions as such. However, especially the housing prices are significantly higher in California on average, and regarding these the method of extracting the utilities and replacing the housing loan principal payments with the separate construction phase emissions assessment reduces the bias. Anyway in the future taking the living costs into account would be an important development step. The linearity assumption should not bias the results, since the disposable income is relatively equal between the two groups.

The CEX data is a potential source of errors from at least two perspectives. Firstly, the accuracy of input data is questionable especially regarding less frequently purchased goods. The BLS CEX data is gathered via interviews and diary entries, and it is difficult to verify the accuracy of expenditures reported by all individuals. The reliability of per capita carbon intensity calculations could in the future be improved by using multiple years of BLS CEX data. It is possible that the respondents do not form a representative demographic sample of the entire population of a certain geographic area sampled (e.g., for factors such as age, race, geography, etc.). It is also possible that people who were too busy to respond to the survey share some important characteristic (e.g., low or high income earner) and that their exclusion thus influences national averages (discussed in Heinonen et al. 2013a, among others). There are weighting multipliers included in the CEX data to correct these biases, but they are only applicable to the whole country level. To assess whether the data suffers from significant non-response bias, we compared statistics for several characteristics of CEX-sampled households to figures reported by the American Community Survey (ACS). We found that there may be a slight bias in the BLS CEX towards lower-income households. The US mean per capita income in the BLS CEX is approximately 6% lower and the California per capita income approximately 13% lower than the value reported by the ACS for the same population. Furthermore, in the CEX data the difference between the household sizes of California and the rest of the country is slightly higher than in the ACS data. Together these might somewhat affect the results, but presumably not very significantly.

An issue relating both to the data and to the EIO-LCA model is the sectoral fit. Predominantly this fit is good, but the categorization is still not the same in the two. We conducted a sensitivity analysis for those CEX categories that are not well described by an EIO-LCA sector to determine the importance of this expenditure on our footprint result. According to this analysis, the questionable sector choices don't significantly affect the results.

6. Conclusions

In this paper we have shown how the average per capita carbon in California is quite significantly lower than that of the residents elsewhere in the U.S.. It would seem that the difference is related almost solely to power generation and transportation; sectors where the state affluence is potentially strong in guiding the use and production towards more GHG efficient fuels, vehicles and technologies. California has therefore achieved a lower per capita carbon footprint than the rest of the United States by substantially reducing emissions in two of the three most carbon-intensive sectors. However, even in California over two thirds of the overall GHGs still come from these two sectors. This means that the majority of the emissions are generated within California, and thus that the state policies can still have a very significant impact.

Given the many uncertainties the assessment includes, more work is needed before this type of assessment could be used to truly support public decision-making. For example, in the future the average consumption profiles could be calculated as averages over multiple years, which would significantly reduce the uncertainties related to less frequently used goods. However, even this screening LCA has been successful in identifying both the most important sources of GHG emissions and potential ways to reduce them. Our assessment was also a purely attributional in nature, but in the future the same framework could be used for consequential analyses, which provide an additional important perspective when designing GHG mitigation strategies at different levels. The advantages of this type of assessments would show especially in geographically more restricted analyses. For example, analyses on the GHG consequences of urbanization would be one interesting direction for future research.

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Stakeholders' Preference towards the Use of Conflict Management Styles in Dual Concern Theory in Post Contract Stage

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Abstract

Conflicts often act as obstacles to the project success by wasting time, money and energy of the construction stakeholders; resulting numerous harmful effects to the project. Having conflicts is a natural phenomenon which is inevitable due to the unbreakable bond between the nature of the construction industry and the sources of conflicts. It is identified that the tendency of having conflicts is enormously high, especially in post contract stage of any construction project. Even though the conflict management found to be existing in the construction sector, still the construction stakeholders often have to face many unmanaged conflicts which subsequently convert into disputes, demanding expensive and time consuming dispute resolution. Therefore, the requirement of an effective conflict management should receive a prior importance. It was verified that the effective conflict management can be derived from the opinions of construction stakeholders since they are the personnel who create and experience the conflict situations. Therefore, the aim of this study was to develop a stakeholder preferred framework for effective usage of dual concern theory for conflict management in post contract stage. Case study was selected as the most suitable research approach due to the qualitative nature of the study. Twelve semi structured interviews were conducted; selecting three stakeholders representing each case. The collected data was analyzed using content analysis and conclusions were drawn and recommendations were put forward. The findings of this study proved that effective conflict management is a broad spectrum which should be fully followed from the commencement of the project till the end. Moreover, it was recognized that the main reason for increment of having conflicts is that the construction stakeholders ignore to follow the entire conflict management spectrum. Furthermore, the findings confirmed that inclusion of dual concern theory which manages conflict situations by providing consideration for both self and others at the same time yet in different degrees in the conflict management spectrum will provide more effective results. Hence, this study proposed a framework for effective conflict management with the usage of dual concern theory for post contract stage.

Keywords: Conflict, Construction Industry, Conflict Management, Dual Concern Theory, Post Contract Stage

1. Background

Construction industry is one of the largest industries in the world yet distinct from the other industries due to its inherent quality of complexity (Yousefi, Hipel, & Hegazy, 2010). The complexity of construction is successfully dealt by dividing the entire project into several sub projects, which are then let or sublet to several contractors and subcontractors (Chua & Song, 2003). It was recently evidenced that the tendency of having conflicts is extremely high due to the complexity in relations, lengthy process of construction and multidisciplinary involvement in the construction project (Jaffar, Tharim, & Shuib, 2011). Lee (2008) defined conflict as a situation where the interests and ideas of two or more individuals operating in one unit appear to be irreconcilable. Similarly, Fisher (2000) defined conflict as "an incompatibility of goals or values between two or more parties in a relationship, combined with attempts to control each other and antagonistic feelings towards each other" (p.1). Tjosvold (2006) argued that conflicts are not always destructive and they can be constructive as well if they are well managed. Further to author, neither conflicts just happen nor escalate by themselves. It is the choices which made by the people who involve in the conflict escalate conflict or lead to more constructive outcomes.

The success of a construction project is closely related to the effectiveness of the stakeholders who involve in post contract stage where the actual work of the project is accomplished (Alzahrani & Emsley, 2012). According to Kumaraswamy (1998), conflicts are arising due to the multidisciplinary involvement with different cultures, interests and diverse objectives which can be highly seen in post contract stage. The conflicts that can be seen in the pre contract period probably can be seen in the post contract stage since the design is continuously changing due to reasons such as impracticability, design errors and changes in client's requirements (Ng & Skitmore, 2000). Therefore, it is very important to have a clear idea about the effective management of those conflicts in post contract stage as they directly provide harmful effects to the project success (Awakul & Ogunlana, 2002). Hence, an effective conflict management technique should be introduced to any construction project (Huan & Yazdanifard, 2012).

Dual concern theory is one of the most effective conflict management techniques use around the world (Lee, 2008). It argues that conflict management can be effectively done by providing a simultaneous consideration for both self and the other party who involved in the conflict, however, in different degrees (Chou & Yeh, 2007). According to Popovic and Hocenski (2009), the principle of conflict management is not making effort to eliminate conflicts yet investigating how to manage them and decrease the probability of non-productive escalation.

Thalgodapitiya (2010) and Howe (2013) emphasized that the amount of having unmanaged conflicts is significantly increasing annually and subsequently generate more and more disputes, demanding dispute resolution. According to Howe (2013), the annual cost and time consumption for dispute resolution has increased with an alarming rate. Hence, there is a strong requirement of effective conflict management during post contract stage of any construction project.

2. Literature review

2.1 Conflict management

Generally, management can be defined as "the process of dealing with or controlling things or people" (Oxford Dictionary, 2013). Therefore, conflict management can be defined as the process of dealing with or controlling conflicts. According to Verma (1998), proper conflict management includes three major steps. First step is preparing for the conflict by expecting the conflict and planning to face the conflict. Second step is facing the conflict by understanding its real nature and the third step is managing the conflict according to the plan with necessary changes. Therefore, it is very important to recognize and understand the conflict before starts the management. However, conflict management only focuses on eliminating the harm caused by the conflict so that the project can be successfully completed within allocated time and cost (Popovic & Hocenski, 2009). It never meant to eliminate the conflict as it is practically impossible (Acharya, Lee, & Im, 2006).

2.2 Conflict management in the post contract stage

In post contract stage, many professionals and parties are involved in the construction that have their own values, beliefs, interests, education and needs. Therefore, the tendency of having conflicts is more when compared to pre contract period. According to Kumaraswamy (1998), conflicts are arising because of the involvement of more stakeholders with different cultures, disciplines and diverse objectives which can be highly seen in post contract stage. Furthermore, Appelbaum, Shapiro and Elbaz (1998) mentioned that due to the globalization of the industry and advancement of technology, diverse task groups with different racial and ethnic backgrounds will need to work together. Further to author, conflicts are easily generated in such kind of environment which saturated with diversity such as the post contract stage of any construction project. Therefore, it can be said that construction industry fulfils all requirements that should be needed for creating conflict situations easily.

The ultimate result of unmanaged conflicts will be disputes which require expensive dispute resolution with immense wastage of time, money and energy. Yiu and Cheung (2005) explained that if the level of conflicts escalates continuously, it may become psychological struggles between the contracting parties and manifests as disputes and the unfortunate outcomes will be loss of productivity and increase in cost of construction. Similarly, Thalgodapitiya (2010) stated that dispute resolution with lawyers, judges/arbitrators, and jury members will bring the project cost far away from the estimated project cost, along with excessive wastage of time and lot of aggravation. It can be seen that a third party has to be involved in the process of dispute resolution and he has to be paid. In addition, considerable time have to be spent for the dispute resolution procedure so that it will consume the time allocated for construction. By the end of the dispute resolution, all related parties will be frustrated and tired. This will decrease their efficiency and willingness to work.

2.3 Dual concern theory

The dual concern theory, proposed by Pruitt and Rubin (1986), is the most often cited theory in conflict management literature (Chou & Yeh, 2007). However, according to Desivilya, Somech, and Lidgoster (2010), the conceptual foundation of dual concern theory was laid by Blake and Mouton (1964). The dual concern theory argues that conflict management can be effectively done by considering the behaviour; as a meaning of high or low concern for self, combined with high or low concern for others (Chou & Yeh, 2007). The effective usage of conflict management styles in dual concern theory means that the degree to which dual concern theory is successfully used to control and decrease conflicts in such a way that they never become a disturbance to the project success. According to Chou and Yeh, (2007), there are five conflict management styles in dual concern theory namely; problem solving style, obliging style, forcing style, avoiding style and compromising style. They are further described in table 1.

Table 1: Conflict Management Styles in Dual Concern Theory

Style	***Description***
Problem-solving style	*High concern for self and others. A win-win approach. This style treats the conflict as a problem that should be solved by examining alternatives.*
Obliging style	*High concern for others and low concern for self. A lose-win approach. This style is used when one party is more factually strong and has more experience, power and good reputation than the other party.*
Forcing style	*High concern for self and low concern for others. A win-lose approach. This style pushes one party's viewpoint towards the other party that the latter party have no other option to be selected.*
Avoiding style	*Low concern for self and others. This can be either win-win approach or lose-lose approach. This style can be used when the conflict is irrelevant to the project.*
Compromising style	*Moderate concern for both self and others. A partially win-win approach. This style searches solutions and bargains for solutions that bring some degree of satisfaction to all parties.*

Source: Cheung and Chuah (1999); Chou and Yeh, (2007); Friedman, Tidd, Currall, and Tsai, (2000); Fisher (2000); Verma (1998)

2.4 Research problem

It can be seen that conflicts in post contract stage in construction projects have a tendency to increase due to number of reasons. Even though the industry uses conflict management styles such as dual concern theory, still there is no sign of decreasing conflicts which subsequently convert into disputes. According to the aforementioned literature findings, dual concern theory is the most effective and most commonly used management style all over the world yet failed to completely manage conflict situations in construction projects. Therefore, conflicts and disputes are increasing day by day. The failure to manage the conflicts effectively reveals the fact that the prevailing conflict management system has many weaknesses. It can be predicted that these weaknesses are either in the conflict management styles or in the stakeholders who use them. Thus, the requirement of finding out the weaknesses and put forward the remedies to overcome the weaknesses should receive a prior consideration. Furthermore, the damage caused by the unmanaged conflicts is more critical in the post contract stage of any construction project. Since conflict management is very subjective, stakeholders' preference for a particular conflict management system is very important. Therefore, the research problem of this study is "how to build a stakeholder preferred framework for effective usage of dual concern theory for conflict management in post contract stage?".

3. Research methodology

Since the study obtains qualitative characteristics, data collection was done via case study approach. The population of the study was the professionals involved in construction projects which are in post contract stage and having conflict management. A sample was taken from the aforementioned population. Since this study required the opinion of construction professionals in diverse disciplines and groups, stratified random sampling was selected. Accordingly, the population was divided into mutually exclusive sets and drew simple random samples from each set. In order to saturate data, four cases were selected. Semi structured face to face interviews were selected for the study. The interviews were carried out with three participants from each construction project; representing the client, consultant and contractor. Content analysis was used to analyze data and to understand the relationships between findings. NVIVO (version 10) was used to conduct the content analysis.

4. Data analysis and research findings

4.1 Profile of the cases

Four building projects in Sri Lankan construction industry were selected as the cases and all of them were adopting the measure and pay procurement arrangement. Case 1 and 2 were selected from private projects and case 3 and 4 were selected from the government projects. Case 1, 2 and 3 were recently completed and case 4 is nearly completed. Case study 1 is 8 storied luxury multi purposive building which was completed within 30 months, spending Rs. 0.33 Billion. Case study 2 is 14 storied super luxury hospital building which was completed within 26 months, spending Rs. 1.85 Billion. Case study 3 is 14 storied semi luxury office complex building which was completed within 30 months, spending Rs. 3.00 Billion. Case study 4 is 5 storied administrative building which is expected to be completed within 18 months, spending Rs. 0.11 Billion.

4.2 Analysis of collected data

According to the research findings, conflict management can be defined as the process of maintaining the conflict situations properly by converting it to a source of motivation, mode of taking attention and way of upholding the concentration over the project without letting the destructive stage of conflicts to be raised. In advance, it includes a large spectrum of avoiding the circumstances of having conflicts, preparation for potential conflicts by considering past experiences, early identification of conflicts, utilize the constructive part of the conflicts, conflict management by using management techniques, dispute avoidance and maintaining a record for future use.

The findings revealed that four conflict management styles in dual concern theory are currently practicing in the Sri Lankan construction industry. From the interviews conducted with 12 respondents, it was found that 44% of conflicts are managed through negotiating while 32% of conflicts are managed via using authority. 16% of conflicts are managed using obliging style whereas 8% of conflicts were managed by avoiding them. However, the degree of succession of this prevailing system is very low with respect to the effort taken to manage the conflicts. The main reason for the above stated failure is that majority of Sri Lankan construction stakeholders do not give a specific consideration for conflict management. It was found that 66.67% of projects do not specifically consider about conflict management whereas only 33.33% of projects use proper conflict management.

Respondent 3 of case 3 explains this non-consideration by mentioning "*No. We didn't consider about conflict management separately as a concept such as risk management, value management, etc. But I think we considered about avoiding conflicts from our common sense*". Furthermore, the respondent 2of case 1 stated that "*There was no specific thing called conflict management for which a separate staff was assigned. However, it was always there in the project*". These explanations visualize that the Sri Lankan constriction stakeholders consider conflict management as an aspect which should be done by common sense. It is true that common sense is required up to some extent to carry out the conflict management. Nevertheless, there is broader identification for conflict management rather than using common sense to seal the harmful situation.

In Sri Lanka, the stakeholders recognized conflict management as a process which should be carried out to settle the conflict. However, there is no proper preparation for potential conflicts, utilization of constructive part of the conflicts and proper record keeping for future use. Nevertheless, avoiding the circumstances which create conflicts can be randomly seen in the industry. Even though the stakeholders implement a considerably broad conflict management procedure in their organizations, they do not consider about conflict management techniques and utilization of the constructive part of the conflicts, therefore do not follow the entire conflict management spectrum. Therefore, it can be concluded that Sri Lankan construction industry do not follow the entire conflict management spectrum. This will be one reason to the increment of conflicts.

Moreover, the respondents identified another probable reason for the failure in current system as in most of the conflicting situations, the parties use wrong conflict management technique with regard to the situation. Respondent 2 of case 4 clearly explained this phenomenon by stating "*Most of the time, the client use his authority to manage problems. But I don't think it's good because he should listen to the other two parties who know much about the construction*". Furthermore, the respondent 1 of case 2 confirmed the aforementioned statement quoting "*Most of the times, the Contractor agreed with us unwillingly. So I think the reason for not giving full satisfaction can be wrong technique as well characteristics of people*". By adhering to the aforementioned opinions, it can be accepted the fact that the degree of succession of using prevailing system for conflict management in the Sri Lankan construction industry is low.

There is another reason for not maintaining a successful conflict management by using the prevailing techniques. Respondent 1 of case 2 revealed that "*The problem is that once a conflict occurs, it is very hard to manage it in a way that it will provide full satisfaction to both parties because the way of thinking about that particular conflicting situation by both parties is different. You know, it is very hard to change the other persons' minds, especially when they are well educated*". Therefore, rigid and cold characteristics and different attitudes of Sri Lankan stakeholders will be another reason to lessen the success. However, the reasons for having a low succession can be listed out as follows.

- The industry is not following the full conflict management spectrum
- Using wrong conflict management technique for the wrong conflict situation
- Rigid and cold characteristics and attitudes of the parties

With regard to the aforementioned opinions of the respondents, it is obvious that the degree of succession of prevailing conflict management techniques in Sri Lanka is considerably low and therefore, maintains the increment of having conflicts. Since the tendency of having conflicts is high in the post contract stage, the situation will be more critical if an efficient and effective conflict management is not performed. Therefore, it is highly required to identify a proper and effective conflict management procedure than the prevailing process.

By considering the aforementioned factors, the study proposes the most effective conflict management system that can be adopted to eliminate the prevailing weaknesses. It is demonstrated in figure 1. This framework is specifically developed for the post contract stage of Sri Lankan construction industry. According to figure 1, conflict management is a broad spectrum which identifies each and every precaution that can be taken to successfully manage the conflict. The process commenced by considering the ways of mitigating the situations where conflicts are likely to be occurred. However, despite of every effort to avoid the conflict situations, at least few conflicts will be occurred during post contract stage. These conflicts will become favourable for the construction project within a limited period of time since having conflicts will up to certain extent assist the project success. However, these conflicts should be identified at their initial stage and properly utilized. Improperly utilized or unutilized conflicts will then develop into their destructive stage demanding conflict management techniques to manage them appropriately. Proper conflict management will avoid disputes saving a valuable experience to the project team.

However, the most effective way of managing a conflict is to identify the root of the conflict and then treat the root. It can be effectively done by using the subsequent procedure shown in figure 1. Accordingly, whenever a destructive conflict occurs, identifying the conflict type and the respective sources can be done by using the given conflict types and sources in the framework. Then analyse whether it can have multiple solutions, is one party more factually strong, fair and reasonable than the other party, the authority and power gained by each party, the degree of relevancy of the conflict to the project and whether it obtains more than one of aforementioned factors. Then, both parties can identify their position with respect to the conflict with the correct conflict management style to be used.

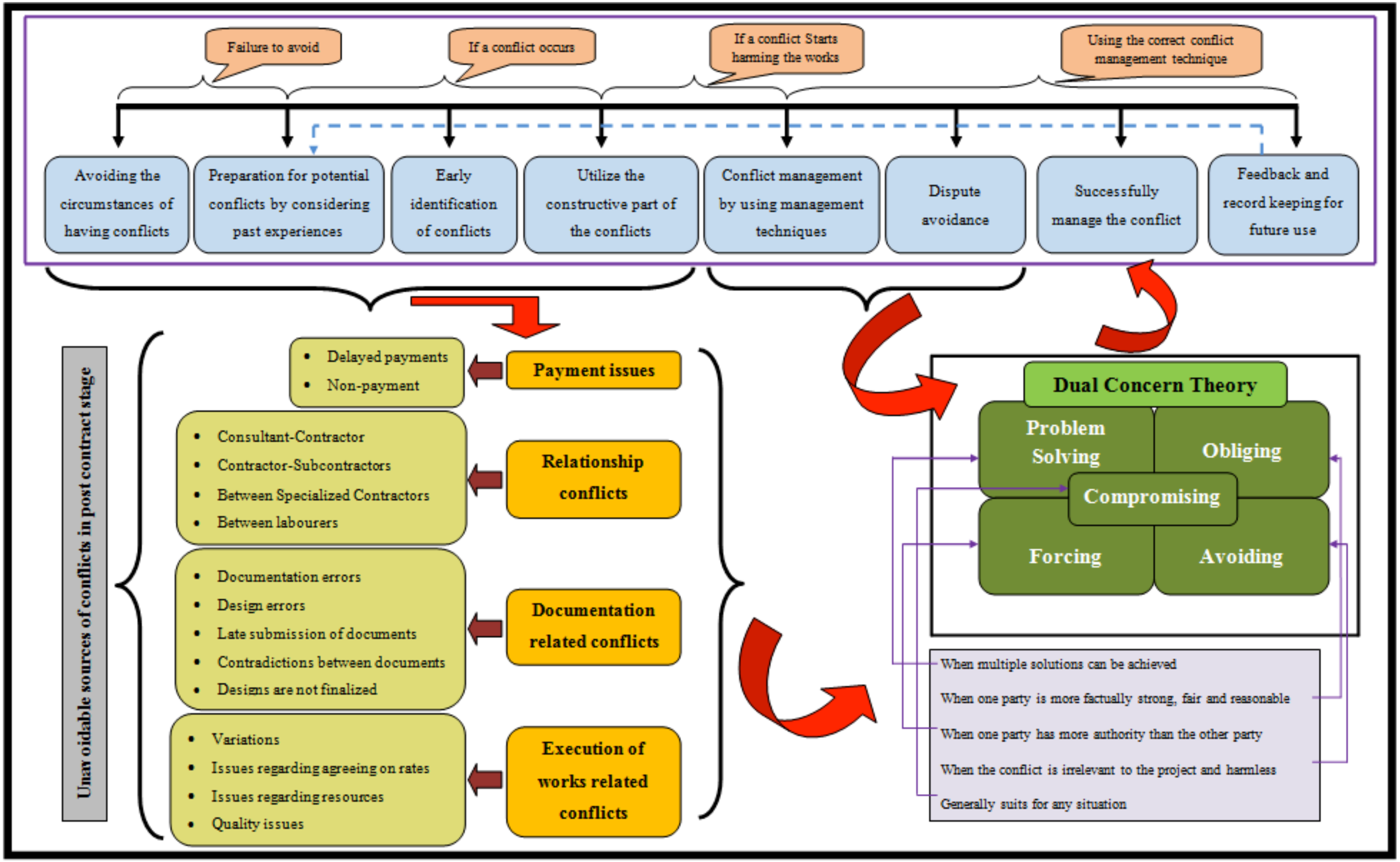

Figure 1: Framework for effective conflict management in Dual Concern Theory in post contract stage

For example, if there is a delayed payment by the client to the contractor and it has created a conflict between the parties, in such situation, as the contractor, he initially should understand his position regarding the matter. It can be understood that there is no possibility of having multiple solution for this conflict; hence, problem solving style cannot be used. Since the contractor stays below compared to the client, he is not in a position to use forcing style. This conflict cannot be avoided since it is a serious issue for the contractor by which his cash flow can be critically affected. Considering about all aforementioned factors, it can be decided that the contractor can obtain either obliging style or compromising style or combination of both styles. If the client has fair and reasonable facts to defend himself and contractor has no serious financial requirement, obliging style can be used. If the contractor is in a serious financial matter due to this conflict, the best method that can be used to manage the situation is compromising. Likewise, using proper conflict management style is very important for the effective conflict management.

5. Discussion

The research findings identified that the dual concern theory is already used by almost all the stakeholders in the construction industry; yet in a different manner. In addition, majority of the stakeholders have used it without knowing that it is a specific theory. However, according to Chou and Yeh, (2007), dual concern theory is the most commonly used conflict management theory all over the world. Nevertheless, Sri Lankan construction industry did not recognize it as a universal theory. According to the analysis, it was identified that dual concern theory is not using in Sri Lankan construction industry as what it intends to be. The stakeholders are only considering about the style; not about the spirit of the theory. According to Sorenson, Morse, and Savage (1999), the dual concern theory lies on the basis of high or low concern given to both self and others so that it is the spirit of the theory. However, Sri Lankan construction stakeholders lack the consideration given to other party. They only follow a specific conflict management style to manage the situation for sake of their respective parties not the opposing party. Moreover, dual concern theory can be successfully used only if the complete conflict management spectrum is followed. Therefore, the prevailing techniques in Sri Lankan construction industry cannot identify as following dual concern theory for effective conflict management.

The study focuses on the stakeholders' preference towards the conflict management styles in dual concern theory. The preference is considered due to the fact that successful conflict management is totally depending on the people factors. Accordingly, Dreu, Evers, Beersma, Kluwer, and Nauta (2001) stated that individual's conflict management apprehension is more stable so that it is very important to consider the preference of the individuals who related to the conflict when taking steps to manage the particular conflict. Research findings identified that the compromising and problem solving styles in dual concern theory were highly preferred by the Sri Lankan stakeholders. The main reason for the aforementioned preference, as in lined with the research findings of Verma (1998) is that both techniques provide a win-win solution, yet in different degrees. In addition, these two techniques are the only techniques which preserve the good relationship between the parties. Other than the aforementioned techniques, the remaining three techniques are considered to be strictly situational. Research findings indicate similar results of the researches conducted by both Verma

(1998) and Rahim (2002) that these techniques should be carefully used to the right conflict situation, otherwise create more harm by developing additional conflicts or increasing the remaining conflict. Therefore, it can be concluded that application of dual concern theory for Sri Lankan construction industry should be done by considering the suitability of each management style and the stakeholders' preference towards the styles.

6. Conclusion and recommendations

The magnitude of having conflicts in Sri Lankan construction industry is continuously increasing with time. It can be clearly seen that the tendency of having conflicts is high in the post contract stage. Since this increment will generate harmful consequences, it is very important to manage the conflicts. Unfortunately, even though conflicts create many harmful effects to the project, Sri Lankan construction industry has not yet given a high consideration to achieve a proper and effective conflict management procedure. Hence, the study proposed a suitable framework for effective conflict management using dual concern theory. The framework indicates the correct and appropriate method of managing a conflict by adhering to the entire conflict management spectrum.

This study recommends to establish a proper conflict management system in every construction project during its commencement. It further suggests that the stakeholders should always follow the entire conflict management spectrum without just trying to seal the conflict situation in an ad-hoc manner. According to the study, it is better to use conflict management styles in dual concern theory considering the correct situation since it thinks about both self welfare and the good will of the others. Moreover, the study proved that patience is important in conflict management in order to protect the professional relationships, therefore dual concern theory is ideal for the conflict management procedure. Finally, the study thoroughly recommends to adhere to the proposed framework in order to achieve proper conflict management.

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Profit, risk and value: the role of business model fit in the value creation in REC sector

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Abstract

This paper suggests that the identified challenges of REC sector to deliver end-user value and sustainability over the life of buildings may lay in the poor configurational fit between REC sector business models. The purpose of the research is to analyse how companies within REC sector value network see their contribution to the overall value creation of a buildings life cycle, and how their related business models are aligned in terms of customer value creation (value proposition) and their own value capture. A single case study was chosen as research approach. The case analysed is Northern Europe's largest PPP project, the Nya Karolinska Sjukhuset, a 30-year concession of a new university hospital in Stockholm, Sweden. Trough analysing the configurational fit of business models of companies participating to the network, we test the applicability of the approach. At the end we are also able to draw preliminary conclusions compared to value creation and capture alignment in project network compared to a standard market practice.

Through a series of interviews and documentation analysis the value creation and value capture of the project networks is analyzed from the perspective of profitability, sustainability and innovation. The analysis resulted six key value drivers within the case project: 1) Ability to implement, 2) Risk management, 3) Operational efficiency, 4) Financial optimisation over the life cycle, 5) Functionality and 6) Innovations.

It could be concluded there was a high configurational fit between the value creation drivers and value capture mechanism of project network participating companies. According to the interviewees, the project is expected to have higher-than-standard-market-practice profitability, supporting Storbacka's (2012) suggestion that effective business models are characterized by the configurational fit of their elements. Risk management and risk taking capability of the project network was the most visible value creation driver linked to the value capture mechanisms of the project. This seems to be different compared to the standard industry practices and calls for further research.

Keywords: Business model, configuration, value creation, value capture, risk

1. Introduction

The real estate and construction (REC) sector is central to the search of economically viable alternatives for advancing ecological and social sustainability. Despite the investments on R&D, the REC sector has been poor capturing its potential. As (Teece, 2010) states, in addition to investing in technological development, REC sector should also develop its business models that enable companies to capture value from providing new products and services, making the new operational and technical innovations sustainable in the long term and enable changing the market practices. Due to the increased complexity of building technology and increasing customer demand, the REC sector actors are becoming more inter-dependent and networked. The locus of value creation is no longer perceived to reside within firm boundaries, rather it is co-created between actors in a network (Dyer & Singh 1998, Storbacka K & A., 2012). This means not only developing the business models of individual firms but also the business models over the whole life cycle of buildings and systems.

Teece (2010) states that "a business model articulates the logic and provides data and other evidence that demonstrates how a business creates and delivers value to customers. It also outlines the architecture of revenues, costs, and profits associated with the business enterprise delivering that value". Without a well-functioning, profitable business model, a firm ceases to exist. There are various views on what comprises a business model (see for instance Amit & Zott 2001, Chesbrough & Rosenbloom, 2002, Magretta, 2002, Osterwalder, 2005 Teece, 2010, Zott & Amit, 2010; Zott, Amit, & Massa, 2011), as business model research has only started to emerge in the literature relatively recently no universally agreed definition exists.

In their review of business model definitions, (Nenonen & Storbacka, 2010) identified specific similarities in terms of design elements. First, the majority of the business model definitions include customer value creation as a core element. Second, the business model should also explain the economic performance of the actor, both in terms of how the actor generates a profit from its operations, and in terms of how it creates returns for various stakeholder groups, including shareholders, described in terms of "earnings logic" or "value capture". Third, a business model definition should illuminate the relationships that the actor has with other actors in its value network. Fourth, several business model definitions discuss resource and capability base of the actor and the practices the actor engages in terms of "core competence" or "capabilities" or "resources". Finally, the majority of the reviewed business model definitions discuss strategic decisions, choices or principles.

In his analysis of value co-creation in networks, Storbacka 2012 concludes that effective business models are characterized by the configurational fit of their elements. Miller (1996, p. 509) suggests that a configuration "can be defined as the degree to which an organization's elements are orchestrated and connected by a single theme" (such as value creation or value capture). A key objective of configurations is to create harmony, consonance or fit between the elements (Meyer et al., 1993; Miller, 1996; Normann, 2001). A configuration with many elements reinforcing one another can be said to have a high degree of configurational fit (Siggelkow, 2002).

The concept of business model could applied not only at a focal firm level, but also apply to a network of firms contributing to a value creation to the end-user. Indeed, Zott and Amit (2008), suggest that business models represent a broader conceptualization of value creation that captures the shift towards networked value creation. Each of the companies has their own business model, but all contribute to the overall value stream of a buildings life cycle. Thus the business model of the network could be taken as the perspective, under which the configurational fit or participants' business models can be analysed (Storbacka 2012). In networks, actors have to achieve both intra-actor configurational fit (alignment between various business model elements and practices) and interactor configurational fit (alignment between its own and other actors' business models and practices) (Storbacka 2012).

This paper suggests that the identified challenges of REC sector to deliver end-user value and sustainability over the life of buildings may lay in the poor configurational fit between REC sector business models. In practice this may emerge in e.g. the lack of incentives for contractors to provide solutions that optimize the life-cycle costs of the building. This paper presents the findings of the case analysis focusing on the two key business model key components: value creation and value capture. The specific research questions of the study were: *how each of the companies within the project value network see their contribution to the overall value creation of a buildings life cycle, and how their related business models are aligned in terms of customer value creation (value proposition) and their own value capture.*

Trough analysing of the configurational fit of business models of companies participating in a highly integrated solutions delivery (PFI), we test the applicability of the approach. As a result, we identify key value drivers within the case project and analyse their dynamics in relation to the value capturing logic of the companies. At the end we are also able to draw preliminary conclusions compared to value creation and capture alignment in project network compared to a standard market practice.

2. Research approach and methodology

2.1 Research design

A case study method is utilized to examine the configurational fit of business models of REC sector companies within a value network. The case study approach is argued to be appropriate since the focus is on a contemporary phenomenon within its real-life context, and the boundaries between the phenomenon and the context are unclear (Yin, 1994). The case was selected on the grounds that it is an extreme exemplar (Eisenhardt and Graebner, 2007). We had an opportunity to analyse the value network of an exemplary case of an integrated solutions delivery with several companies. The case deals with a highly integrated hospital project including design-build as well as operational responsibility and financial arrangements, covering a full technical life cycle of 30 years.

Primary data contains six in-depth, semi-structured interviews of each company representatives from senior management with direct commercial responsibility of the project, and the end users/client of the project were conducted during autumn 2013. The interviews were structured around key themes of business model design components found in literature, focusing on value creation, value capture, network, capabilities and resources. In addition specific themes of profitability, market development and building life-cycle were discussed. The interviewees were asked to discuss from their perspective as a partner in a case project network but also give their insights as experienced professionals in the REC sector. Each interview lasted 1-1,5 hours. They were recorded, and later transcribed and coded using qualitative content analysis software Atlas.ti. The data was coded travelling frequently between data and the literature to identify the value creation and value capture drivers and their dynamics between network actors. Some secondary data was also used containing project presentations materials and project website (www.nyakarolinskasolna.com) and site visits.

2.2 Nya Karolinska Solna (NKS) project

The Nya Karolinska Solna (NKS) university hospital is currently the largest PPP-project (Public Private Partnership) in Scandinavia, being built in Solna (Stockholm County), Sweden. The new hospital complex is approx. 320,000 m2 consisting of several buildings to be handed over in different phases during the construction period 2012-2017. The projects PPP-structure creates a complex constellation of different companies and their business models (see Figure 1).

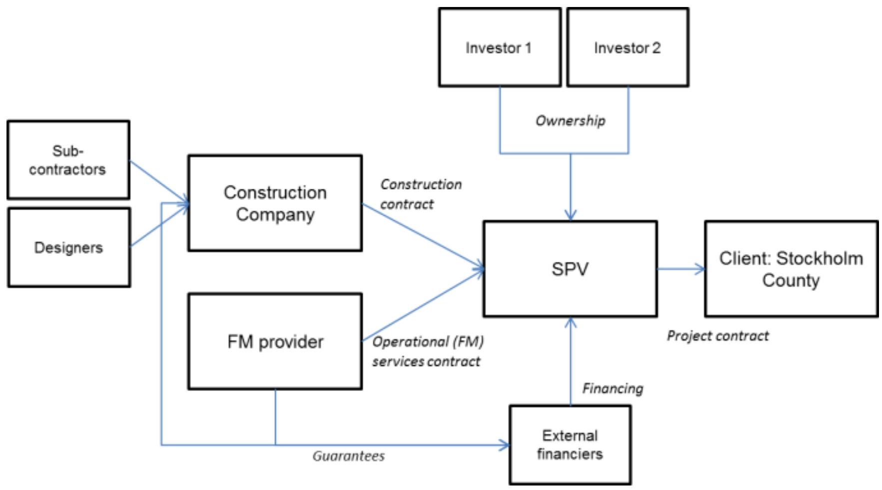

Figure 1. NKS project constellation

As a PPP-project, a Special Purpose Vehicle (SPV) was established to contractually manage design, construction, financing, FM operations and maintenance, and life cycle replacements until the year 2040. The Client (Stockholm County) has signed the PPP-contract with the SPV, thus transferring the risk to the private consortium. Thus the project company undertakes the risk of maintaining available and functioning premises for health care during the concession and handing over a well maintained hospital facility in 2040. SPV is owned by two investors, of which one is a part of the same parent company as the contractor, Construction Company.

SPV Company has subcontracted the contractor to manage construction of the hospital at a fixed price and fixed time. Construction Company thus attains the risk of completing the construction against SPV. In addition it has guaranteed a non-defect period after completion of 5 years. The other subcontracted company in the consortia is the FM provider, which will be responsible for undertaking service delivery in both hard and soft FM operations. Therefore, if certain premises are not available for health care activities, the client will make a deduction in the service payment which will be transferred down to the FM service provider. Even though, SPV has transferred the construction and FM service risk down to their subcontractors they still manage the life cycle responsibility of the project, through raising and maintaining a life-cycle fund, and thus facilitate and steer the development so that contractual criteria are met during the concession.

The contracts construction investment is about 1,5 billion euros, which includes design, construction, credit costs, and demolition of old structures. The investment cost does not include medical technology equipment. In a traditional PPP-project the client would start the service payments when operations in the facility can start; however, the PPP-contractual structure is amended so that the client will pay half of the investment costs during the design and construction phase. During the operational phase from 2017 the client will pay an annual service fee of approx. 150 million euros. This annual payment covers investment costs, financing, risk transfer, FM services, operation and maintenance, and life cycle replacements.

3. Results

The following results section of this paper is divided into three chapters. First, the identified value drivers are presented and their significance to the network participants is assessed. Secondly, the value capture mechanisms of network participants are described. Thirdly, we analyse the dynamics of the identified value drivers and their mutual fit within the project network members' value capturing logic and the value received by the client.

3.1 Value creation & delivery

The analysis resulted seven key themes that describe the respondent's perception of the value created within the NSK project network. The themes were identified through several rounds of coding and discussions with the researchers. The themes are described in the *Table 1*.

1. *The ability to implement* the project was seen as the key driver for the client to utilize a large scale PPP approach in the NKS investment. The mere size of the hospital operations in need for new facilities was leading to realizing the new investments in several phases over the next 10-15 years. This was seen impossible due to the operational, quality and logistic challenges during the investment phase to run a university hospital in temporary locations. In addition, the political process was seen too volatile and risky for the project. The County also did not trust that the traditional public procurement process and investment management approach would have been able to implement the project in time and within budget.

The Construction Company provided the ability to implement to the client, by having the capabilities to arrange a financial and contractual consortium for the project through its sub-division, having the construction resources and the financial capacity to guarantee the project budget and schedule through a fixed price & time contract (Construction Company). In addition FM provider had the experience and resources to guarantee the costs and functionality of operational services during the concession period.

Table 1. Identified value drivers and their descriptions

Value drivers	*Description of the theme*
1. Ability to implement	The project type allowed placing the management of the operational phase of the project outside the politically steered organization of Stockholm county, thus preventing "fiddling with the budget" and enabling more optimized maintenance. In addition The county would not have been able to realize the project in one phase, would there have not been the outside project implementation and financial capacity. Sub themes: Outside politics, Resources, Financial capacity
2. Functionality	Customer concentrating on its core business, the ability of premises to be in the conditions, to allow end-user's uninterrupted operations. Sub themes: concentration on core business, easiness
3. Optimisation over the life cycle	Balancing investments and operations to gain an optimal life cycle cost of the building and maintaining agreed residual value Sub themes: life cycle management, balancing capex and operational costs, residual value
4. Innovations	New solutions providing added value to the end-user operations, increased efficiency or sustainability Sub themes: energy, sustainability
5. Risk management	As a value creator, risk management refers to the value related to avoiding risk or using risk as leverage. Sub themes: risk, risk bearing capacity, risk allocation and transfer, predictability
6. Operational efficiency	Direct savings gained through efficient operations, minimizing customer work and related investment & design strategies Sub themes: efficiency, service costs, total solutions

2. *Functionality* was seen as a major value gained through the NKS project for the client. It was addressed various ways, such as easiness, simplicity and ability to concentrate on core business i.e. providing health care. *"We only want it to function"*. It was also used as a key theme in in the contract, as functionality was used as the basis of payments, allowing the project network to design solutions improving the functionality and to plan investments and maintenance against the demands of the core business. As the need for life-cycle optimization, the requirement of functionality was seen to be sometimes contradicting with the Contractor's value drivers of efficiency and risk management. To ensure the functionality of the premises and thus the payments of FM provider, Construction Company had to ensure the life-cycle effects and impacts on functionality of solutions with FM provider, unlike in traditional contracting project.

3. *Optimisation over the life-cycle was* one of the very visible values that were recognized to be delivered to the client through an integrated solutions approach . The client perceived this as improved environmental performance, linked to innovations, but for the Construction Company and FM provider the life-cycle costs and improved technical residual value of the building were seen as one of the major sources of value to the client. However, the optimization over the life cycle, even prominent, was not seen as being the client's key driver in the project. One interviewee even pointed out, that "*I don't think that's why they chose PPP. It's not the main reason to choose PPP, it's supplementary. They talk about the financial costs and the ability to stretch the financing over thirty years, you never see them talking about the lifecycle.*"

   Unlike in typical construction projects, FM provider participated actively in to the design phase of the building, providing solutions that would enhance the cost efficiency of the premises during the operational phase. This did not always confirm with the demand for efficiency during the operational phase of the building, resulting a need for negotiating optimal design and investment solutions that would not compromise the value for the client but also not undermine the profitability of the construction or FM business. From the Contractors perspective, the negotiation processes were partly a source of uncertainty and operational inefficiency, which did not bring value to Construction Company.

   From the perspective of Swedish Hospital Partners, the life-cycle optimization, resulting from the dialogue between Construction Company and FM provider, was a key source of value. SPV had an obligation to keep the buildings in agreed technical condition, but at the same time ensuring the life-cycle fund remained at a level that allowed it to fulfil its financial obligations. Without a well-sized life-cycle fund, the company would not be an attractive investment object, preventing the investors to divest and thus capture a major portion of the profit from the project.

4. *Multiple Innovations* were brought to the client by the integrated solutions approach of NKS project . However, these innovations were produces already during the bidding phase of the project. The client had prepared a "reference design", to which the prospective solution providers could suggest changes. The client perceived that because of the bidding approach, the client *"got a much better hospital that we could have ever done ourselves"*, in terms of operational efficiency, sustainability and functionality. Also FM provider and Construction Company identified innovations during the bidding process, Construction Company's and FM provider's suggestions to change the reference design, to promote better life-cycle value of the buildings and customer's ability to concentrate on core business.

   However, due to the contractual structure, which highlights predictability of costs and schedule, there are fewer innovations during the construction phase of the project, once the fixed term contract has been signed. Construction Company has a high risk position, amplified by the debt financing structure of the project, which makes the construction process more conservative and risk-aversive in terms of new solutions, technology or processes. *"In this type of projects we cannot take any risk in lifecycle. If we put in something that does not work, we need to change it, get a non-availability penalty, so the model is very very dangerous."*

For FM provider, the innovations during the operational phase of the project are a source of value. There were incentives to innovate, in order to improve FM provider's own operational efficiency, or to develop and invest in technical solutions, due to the long contract period. These innovations could then be distributed to other operations of FM provider.

5. *Risk management* was seen to create value at multiple levels of the value stream. The ability of efficient risk management and risk taking capability was mentioned directly by SPV, Construction Company and FM provider, as part of describing their value creation and value capturing logic. For the client, the value created by the large risk taking capability of network partners came out indirectly when describing the value received through the project.

   For the client, transferring the risk of completion on time & on budget gave the project predictability, which made possible for it to be politically accepted. In addition, the client wanted to focus on its core business – health care – and avoid the risks related to technical or operational functioning of the facilities. Unless the facilities were not meeting agreed functional requirements, the client would not pay for those facilities. This arrangement freed also the client from needing to debate the maintenance budget in a political process, likely to result degrading technical qualities of the building. Finally the client also saw the arrangement to bring simplicity to the contract management and eliminate the risk related to unbundled purchasing strategy of having "grey areas" between multiple contracts, helping the client to focus on its core business. *"All risks are transferred away from us*".

   On the other hand, taking over project and operational risks from the client, the service providers, Construction Company and FM provider are able to utilise their core competencies to gain additional financial and strategic value from the project. In addition, they provide a secure position of SPV, by providing guarantees to cover the project risks. By taking extremely high risks through fixed time & price Design-build contract, Construction Company is able to gain higher than average margins through excellent operational and risk management. For FM provider, the risk taking is balanced with a with a long term service contract, a combination that provides a strong incentive to innovate and invest in new technology to gain efficiency benefits. These innovations are seen to be then applied in other services, for other clients, which otherwise would not allow product development due to short contract periods.

6. *Operational efficiency of the network* created value for the client during the investment phase by ensuring a predictable, speedy process of construction. Operational efficiency was not identified as a key value driver for the Client during the operational phase of the project. This was probably due to the contractual arrangements that linked directly the payment level of the project to the functionality of the premises and the fixed investment contract. Thus, the Client needed not be concerned on the operational costs of running the building or the construction costs development during the project.

   However, the operational efficiency was a key value driver for the participants of project delivery network. The higher than average margins expected from the construction contract, were only available given that Construction Company was able to minimize its operational and component costs and manage its subcontractors and designers to meet targets in set time and price.

For FM provider the operational efficiency was key, due to the incentive for good margins, but also due to the demand that it should regularly benchmark its service price against general FM market price development for similar services. The operational efficiency during construction phase did not always confirm with the demand for efficiency during the operational phase of the building, resulting a need for negotiating optimal design and investment solutions that would not compromise the value for the client but also not undermine the profitability of the construction or FM business.

3.2 Value capture

In addition to value creation and delivery, a sustainable business model needs to have a mechanism by which it receives revenues and turns them into profit (Teece 2010). The value capturing mechanism explains the core logic of this dyad. Without a profitable value creation – value capture setting, companies would not remain in the value networks.

Construction Company's development sub-division is a co-owner of SPV. Their value capture is based on cash flow received from the monthly fees from the Client and from divestment of their share of the SPV after two years of completion of the NKS investment phase. The profitability of this arrangement is based on the SPV's ability to manage the risks of the project during its bidding and construction phase. The major risks are transferred trough back-to-back contracts and guarantees to Construction Company and FM provider and SPV is managing the risk related to life-cycle funding. The divestment of shares is profitable, because at the time of the sale, NKS project has been stripped from construction and maintenance risks enabling the divestment of SPV shares to an investor that favours low risk profile, long term steady cash flow, with significantly lower yield requirements.

The value capture logic of SPV is based on the monthly service fee it receives from the client against fulfilled functional criteria of the premises. The profitability of the arrangement is based on professional management of financial, investment and operational phase risks through contractual management, correct pricing of risks and optimal management of the life cycle fund of NKS. After completion of the project development and construction phases the risk profile of SPV is significantly reduced, providing an opportunity of favourable refinancing arrangements.

FM provider's value capture is based on monthly fees from the client, given that the functional requirements of the premises are being met. The higher than average profitability of the arrangement is based on the long term contract, which allows developing the operational efficiency of FM and negotiating the use of life-cycle funds with SPV to maintain sufficient technical conditions. In addition, FM provider is able to capture value through utilizing the innovations and new technologies in other client contracts. Also, FM provider sees the arrangement to be a potential source for additional value capture through expanding its service scope within NKS.

The value capture of Construction Company is based on fixed price contract of the completion of the project in time. The higher than average margins expected from the construction contract, were only available given that Construction Company was able to estimate and price the its project risks correctly and to minimize its operational and component costs and manage its subcontractors and designers to meet targets in set time and price.

3.3 The fit of value creation and value capture components within the project network

The Figure 2 outlines the relation of identified value drivers as contributors to the client's perceived value and the network participant's value capture logic.

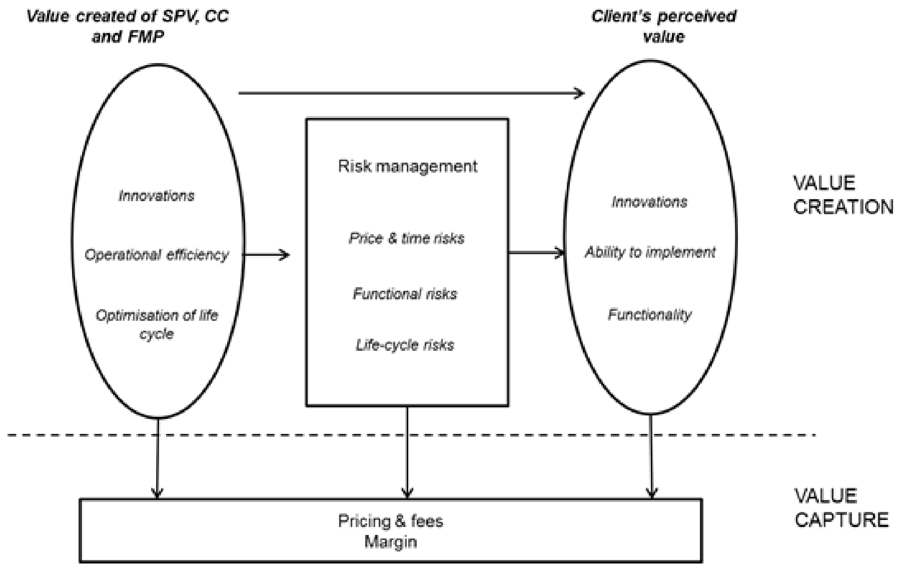

Figure 2. The relation of identified value drivers, customer's perceived value and value capturing logic

Key values that the client received through the NKS project was the ability to implement the project in the first phase, and the ability to concentrate on its core business through a purchasing arrangement that allowed it to purchase functionality instead of walls or services. This value creation was possible, by SPV, Construction Company and FM provider taking the risk of construction time and price, operational risks related to the functionality of premises and the funding of life-cycle costs needed to maintain the building at a high technical quality level. In addition, the client perceived to have received innovations through which it was able to get improved functionality, environmental performance and operational efficiency.

The themes Risk management, Operational efficiency, Optimisation, over the life cycle, Functionality, and Innovations were present in the value proposition to the client trough the operations of FM provider and in line with its own value capturing logic. Risk management was the key enabler for FM provider to take risk over the functionality of the premises. The contradiction between Construction Company's and FM providers value capturing logics and the contractual setting between Construction Company and FM provider forced them to debate over the optimal balance between investment and operational costs when designing the building, resulting "a healthy debate" and allegedly more optimised life-cycle costs. Innovations were a strategy to provide competitive advantage of the consortium during the bidding process and at operational stage again, to improve the operational efficiency of FM, thus supporting both customer value creation and the profitability of FM provider's own value capture.

For SPV the same value drivers as FM provider were present. SPV manages the life-cycle risks of the project, through deciding over the use of life-cycle fund aimed at investments on maintaining the buildings technical conditions at agreed level. For them, innovations and operational efficiency provide more optimized use of the life-cycle funds that is resulting an improved economic position of the company. This is obviously important factor for the value capturing logic of SPVs owners, Construction Company and infrastructure funds.

The value proposition of Construction Company was heavily concentrated on managing risk related to completing in price and on time. This value driver was directly related to the clients' perceived value "having the ability to implement". To be able to deliver that value however, the company was highly focused on operational efficiency. This combination of risk taking and efficiency formed the core of Construction Company's value capturing logic. They saw the additional value drivers of life-cycle optimization and innovations somewhat contradicting with their value capturing logic and also outside their core capabilities. On the other hand, to create a profitable business model for the service providing companies, value drivers of operational efficiency and life-cycle optimization were needed. This contradiction was however identified, as the requirement to get FM provider's approval on material and component choices were included into the construction contract.

4. Discussion and conclusions

In his analysis of value co-creation in networks, Storbacka (2011) concludes that effective business models are characterized by the configurational fit of their elements. In networks, actors have to achieve both intra-actor configurational fit (alignment between various business model elements and practices) and inter-actor configurational fit (alignment between its own and other actors' business models and practices) (Storbacka 2011). This paper suggests that the identified challenges of REC sector to deliver end-user value and sustainability over the life of buildings may lay in the poor configurational fit between REC sector business models. This study has focused on the two most central elements of business models: value creation and value capture. The specific research questions of the study were: *how each of the companies within the project value network sees their contribution to the overall value creation of a buildings life cycle, and* how *their related business models are aligned in terms of customer value creation (value proposition) and their own value capture.*

The analysis of primary data resulted six key themes that describe the respondent's perception of the value created within the NSK project network. The value drivers identified were: 1) Ability to implement, 2) Risk management, 3) Operational efficiency, 4) Financial optimisation over the life cycle, 5) Functionality and 6) Innovations. In addition, we analysed the relation of these value drivers to the relevant value capturing logic of network participants, SPV, Construction Company and FM provider and the mutual reinforcement mechanisms on the value drivers. Of these value drivers, ability to implement, functionality and innovations were identified as value drivers for the client, i.e. the client's perceived value. Other value drivers, visible in all business models of SPV, Construction Company and FM provider were reinforcing these three value drivers either directly or indirectly.

The most visible value creation driver in NKS project is risk management and risk taking capability of the project network. The risk management was the link of value created by the network of companies to the value experienced by the client. Creating functionality or fixed time and price of the investment would not have been possible without SPV, Construction Company and FM provider taking the risk of construction time and price, operational risks related to the functionality of premises and the funding of life-cycle. Taking such a high risk position in the project was balanced with a value capture mechanism that rewarded the project network participants with higher-than-standard-market-practice margins, given that the companies could manage the risks efficiently.

The profitability of the project constellation was dependent on the constellations joint ability to identify, price and manage risks, but also on the division of risk positions and related opportunities (incentives) among the network members based on their core capabilities. As an exchange of the risk-free position purchased by the client, they also gave in their control over the operational implementation of delivering the building and operational services. This required that the client had clearly understood the key capabilities of the network and that the customer and intra-network relationship was based on high levels of trust and informal co-operation, in addition to careful contractual arrangements. The significant role of risk management in PPP was not an unexpected result in this study. However, the central role of risk taking capability, risk positions and risk management as the key connecting theme in the NKS project value creation and capture and a source of business model effectiveness was unexpected. Values such as social sustainability or quality were not on the value agenda of interviewees, an even the life-cycle costs received less attention, whereas the "ability to implement" and risk bearing capacity were dominant.

This seems to be very different compared to the standard industry practices, where its traditional value creation and capturing strategy is to minimize own's risk position and back this up with layered quality control, supervision and checking. This approach creates inefficiency, minimizes the value delivered to the client, creates friction among project network participants and decreased the life-cycle value of the buildings.

The identified value drivers between SPV, Construction Company and FM provider, were supporting risk management through operational efficiency, optimization of the life cycle and innovations. Thus, it could be concluded there was a high configurational fit between the value creation drivers and value capture mechanism of SPV, Construction Company and FM provider. According to the interviewees, the project is expected to have higher-than-standard-market-practice profitability, supporting Storbacka's (2012) suggestion that effective business models are characterized by the configurational fit of their elements.

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On-Site Process Variability and Common Practices: a Case in Asphalt Compaction

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Abstract

Due to changing contracts, sometimes including design and maintenance, it becomes increasingly important for contractors to improve process and quality control during on-site construction. Improving on-site process control, however, requires understanding about current practices. This understanding is mainly lacking, because current practices lean heavily on the on-site experience and craftsmanship of operators and hardly any technologies are used during the on-site process for performance enhancement. Also, the guidelines for on-site operations are vague or even lacking. Therefore, it is near impossible for contractors to distinguish poor and good operational practices.

To develop a deeper insight into the on-site construction processes, the on-site operations need to be made explicit. This paper takes the asphalt construction industry as an example, where the on-site operations of 29 projects in the Netherlands are explicated using technologies, such as D-GPS, a laser linescanner and infrared cameras.

The results show there is substantial variability in key parameters and on-site operations, such as the roller types used for compaction, the number of roller passes undertaken and the time and temperature windows in which these passes are conducted, which are all key for the final asphalt quality. Also, a method is demonstrated to extract common compaction practices from this kind of data-set.

The results are a stepping stone for a structured and systematic design of the on-site process including improved guidelines for on-site operations rather than current experience-based ad-hoc working methods. This is a starting point to distinguish good and poor operational practice and reduce process variability. This will help contractors to improve their understanding about on-site construction processes in order to improve process and quality control.

Keywords: Common practices, innovative technologies, operational strategies, process control, process variability.

1 Introduction

Process and quality control during on-site construction is becoming increasingly important. This is caused by changing roles between contractors and clients. Agencies shift towards service level agreements with lengthy guarantee periods, sometimes including design and maintenance. Within these new roles and contracts, the contractors are directly confronted with shortcomings in quality during the guarantee period creating more pressure on process and quality control during on-site construction.

In the current technological age, one might expect contractors to embrace the new ICT-opportunities, which become increasingly available and affordable, for process improvement and performance enhancement. In reality however, the construction process still mainly is carried out without the use of (high-tech) instruments to monitor key process parameters and to map the on-site construction process (Miller, 2010). Additionally, in many domains of the construction industry traditional working practices lean heavily on the on-site experience and craftsmanship (tacit knowledge) of operators and teams. Operators may implicitly learn based on experience from previous construction projects, but this is based on limited observations and data, resulting in slow process improvement and individualised lengthy learning. It is therefore near impossible for contractors to understand what transpired during on-site construction, assess the quality of the on-site operations and thus trace back what poor and good operational practice is.

To develop a deeper insight into on-site processes, a first step is to make current process variability and the common practices explicit, which are based on years of experience and craftsmanship of operators. When process variability and common practices are explicit, it becomes possible to distinguish good and poor practices under more controlled circumstances in the laboratory. Also, a change can be instigated towards explicit method-based learning as previously described by Bijleveld and Dorée (2013). This paper takes the asphalt paving industry as an example and makes process variability and common practices explicit, especially regarding asphalt compaction. Asphalt compaction is the final stage of the asphalt road construction process and still is a muddy box regarding process and quality control. Although the asphalt technologist put substantial effort into creating a mix with intended characteristics, once delivered on-site the actual compaction sequence primarily depends on experience and gut feeling of the roller operators without clear guidelines. This unknown element in the process and in quality control is bothering the contractors more than ever before due to increasing pressure in service level agreements. The search is on for proper compaction guidelines. From 29 monitored projects on-site operations are explicated and this paper focuses on the process variability and common practices regarding compaction.

The paper is structured as follows: The next section of the paper hones in on the asphalt compaction process, followed by the aims and research methods of this study. Next, process variability within the monitored projects will be discussed, followed by the extraction of common operational compaction strategies. Finally, the main conclusions and directions for future research for the paving industry specifically and the construction industry in general will be discussed.

2 Asphalt construction domain and asphalt compaction

The focus in this paper is on the asphalt compaction phase, which is one of the most relevant operations for the asphalt quality. The Asphalt-Institute (2007) defines compaction as the process of compressing a given volume of asphalt into a smaller volume. The result is a certain density of the asphalt mixture. Achieving the target density will influence the desired mixture characteristics including strength, durability, and resistance against deformation, cracking and moisture (Decker, 2006). If the mixture is over-compacted, the mixture becomes overfilled and can lose its essential stability. If the mixture is under-compacted, deformation of the asphalt mixture during usage of the road can occur and rutting can be the result.

The asphalt compaction process takes place through loading the mixture, in practice executed by rollers. The total compaction process by rollers generally can be divided into three phases from both material as operational perspective (Ter Huerne, 2004; Asphalt-Institute, 2007; Miller, 2010): (1) breakdown rolling, where particles will be be arranged and air need to be expelled, (2) intermediate rolling, where the asphalt mixture behaves differently due to increasing stiffness and elastic behaviour of the mixture, and (3) finish rolling, where the mixture need to be compressed further until its target density. From an operational perspective, these phases can be characterized by the type of roller and the time and asphalt temperature windows for compaction. Usually the machinery for compaction consists of several types of rollers, each with individual roles during the process, for example, squeezing, kneading or smoothing the surface. The challenge of the on-site compaction process is to decide when and how to compact in order to reduce the void content to a certain level and to reach an even surface (Ter Huerne, 2004).

Both researchers and practitioners acknowledge that the temperature of the asphalt mixture during compaction is important for the final quality of the pavement (Timm et al. 2001; Willoughby, 2003; Cho et al. 2012). If the material temperature is too low during compaction, the bitumen can no longer lubricate the mixture, resulting in an open surface and higher risks for ravelling. The same prevails for the maximum temperature: if the binder is too fluid and the resulting aggregate structure is weak (at high placement temperatures), the roller loads will simply displace or shove the material rather than compact it and cracks may originate behind the roll. So, the theory points to an optimal compaction temperature frame to compact the asphalt mixture, logically resulting in an optimal compaction time frame because of cooling of the asphalt mixture. If the asphalt mixture is compacted within these frames, from experience it is known that the intended design properties of the asphalt mixture will be achieved. If the mixture is compacted outside this temperature window there are high risks to negatively influence the final quality of the asphalt construction.

Significant research effort is put into intelligent compaction and automated monitoring of road construction operations to give roller operators more information during the process (Navon and Shpatnitsky, 2005; Beainy et al. 2012). Such systems includes GPS receivers, an integrated computer system to analyse roller information, accelerometers, and temperature information (Gallivan et al. 2011). Typical outputs of such systems are color-coded displays with the number of roller passes and the asphalt temperature. A workflow for clear visual data representation for operators on-site integrating various technologies is outlined by Vasenev et al. (2011). It is envisioned that research in intelligent compaction will capture many of the relevant variables in real-time (Bahia et al. 2006).

To effectively use these innovative technologies on-site in real-time, clear instructions for roller operators are needed regarding the number of roller passes and the asphalt temperatures for compaction. In current practices, roller operators mainly estimate the number of roller passes and temperature of the asphalt mixture throughout the process based on previously gained experience and craftsmanship. It is, however, generally unknown if the previously gained experience can also be applied to a new practical setting. In addition, the guidelines given in various textbooks (Shell, 1990; NAPA, 1996; Asphalt-Institute, 2007) provide general instructions especially about what not to do and about rolling patterns. However, clear instructions about the number of roller passes and temperatures in these textbooks are vague or even lacking. Examples are: "*Start rolling as soon as possible without causing undue displacement of the material, and to continue until all the roller marks had been removed*", "*Intermediate rolling should closely follow breakdown rolling, while the mix is still plastic and at a temperature that will result in maximum density*", "*Finish rolling should be accomplished while the material is warm enough for the removal of roller marks*". Methods or procedures to determine the number of roller passes and temperature windows for compaction are also lacking. This is normally determined by various test-sections and trial-and-error on-site which is very ineffective and uncertain.

So, the on-site compaction process of asphalt is a versatile task. The set of information for roller operators to make decisions include: the cooling rate of the mixture, the previously executed roller passes and patterns, and the roller passes conducted by colleagues. Many vital changing variables, such as the ambient temperature, the temperature of the underlying surface, the layer thickness, wind speed and rain, make on-site asphalt compaction even more difficult. Based on these parameters, operational choices for the roller operator, mainly based on experience, include choosing the type of rollers, the number of roller passes, when to start and finish rolling, and within which temperature windows these roller passes should be executed.

3 Aims and research methods

Little research effort is put onto systematic mapping and analysing on-site construction processes. It is therefore near impossible to know what operations transpired on-site and how these were carried out, making it difficult to distinguish good and poor practices. The textbooks are also unclear about guidelines for on-site processes. In the quest towards improved process and quality control, on-site operations need to be explicated and analysed.

The aim of this paper is firstly to make operational practices in asphalt construction explicit and to demonstrate the degree of variability in key parameters and compaction operations, such as the number of roller passes and the time and temperature windows for compaction, based on actual monitored projects. Secondly, this paper aims to determine common practices regarding asphalt compaction. When more insight is gained into the variability and common practices in on-site construction operations, it becomes possible to analyse the effects of different observed compaction strategies on the final quality of the road under more controlled circumstances in the laboratory.

To systematically monitor and map on-site construction operations, a previously developed framework is adopted. This framework, initially developed by Miller (2010), explicitly and systematically works towards more insight and process improvements and is called Process Quality improvement (PQi). The aim of the PQi-framework is the improvement of the process quality by closely monitoring asphalt construction works, and making operational behaviour explicit by introducing new technologies in the current process. Then, the explicit monitored process is made available to the asphalt team so that they can reflect on their work, discuss and analyse the results and propose improvements to their working methods and operational strategies for future projects. This should lead to a cycle of continuous process improvement.

The technologies that are introduced in the PQi-framework are three-fold: (1) D-GPS to monitor the movements of machinery, (2) a laser linescanner, infrared cameras and thermocouples to monitor the initial lay-down asphalt temperature and asphalt temperature throughout the process, and (3) a density gauge to monitor the density progression during the compaction process. These are important parameters in determining asphalt quality. In order to better understand and contextualise this data, weather data is collected and analysed and a logbook records all the (important) events during the process. More information about the technologies that were used in working with this framework and the systematic way in which data were collected, analysed and mapped are described in Miller (2010).

After a testing period of four years, this framework was broadly implemented in the Dutch industry and 11 contractors committed themselves to monitor two projects per year for a period of four years. Researchers at the university formalised the process using manuals and procedures to use the equipment and analyse the data. Two-day courses were held to educate the contractors to use the equipment and analyse the data themselves. To date, 29 projects were monitored by the contractors using this framework and systematically stored in a structured database. This data is used as a basis to analyse process variability and common compaction practices.

4 Monitored process variability in compaction operations

During the cooling process of the asphalt mixture roller passes are conducted on site by several types of rollers having a different effect on the density and mechanical properties. Data is gathered regarding the roller type, number of roller passes during certain temperatures and the density progression of the asphalt after every roller pass. This is visualized in a graph combining the cooling curve and the density progression – an example is shown in Figure 1. The impact of the different rollers are clearly visible: Firstly breakdown rolling using a tired roller until approximately 98% degree of compaction, then a tandem roller until 100-101% compaction and finally a 3-drum roller to erase unevenness's, but hardly influencing the density. Also, the time and temperature windows for the different roller types become visible in these graphs. In this example, the tired roller conducts 3 roller passes within 145 and 135 °C in 4 minutes, next the tandem roller conducts 4 roller passes within 135 and 107 °C in 7 minutes and finally a 3-drum roller than conducts 4 roller passes within 102 and 83 °C in 7 minutes.

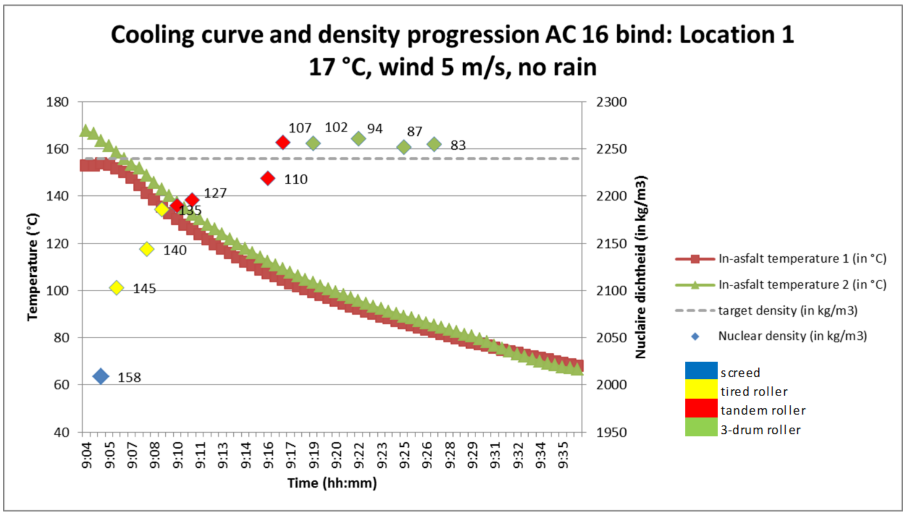

Figure 1: Visualization of the cooling curve and the density progression for 1 location

It is however difficult to determine a reliable relationship between the impact of certain roller passes at a certain temperature under various conditions, because of the many changing variables. The monitored projects demonstrated the extend of the many changing variables and the different operational strategies for asphalt construction. An example of the many changing variables in operational rolling strategies is shown in Table 1. For the construction of three provincial roads an AC 22 base (80 mm thick) mixture was constructed and monitored, where the following variability is highlighted:

- In three different projects, three different sets of rollers are used: (1) tandem roller + 3-drum roller, (2) combi-roller (pneumatic tires at the front and steel wheel at the rear) + small tandem roller for the joints and (3) tired roller + tandem roller. Also in the first project, the sequence of the rollers has changed twice. At locations 1-4, the roller sequence was first the tandem roller and then the 3-drum roller, where at location 5 first the 3-drum roller started and then the tandem roller. At location 6 they only used the 3-drum roller.

- The total number of roller passes in all projects ranges from 8 to 28 roller passes at one location (using different sets of rollers). Also within the same project using the same set of rollers, the total number of roller passes varies significantly. For instance, in project 1 this varies from 10 to 17 passes for the 3-drum roller and 7 to 11 passes for the tandem roller.
- The time and temperature windows in which the roller passes were conducted varies considerably. For example, the total compaction time of the 3-drum roller in project 1 ranges from 53 until 90 minutes. Also, the temperature window in which the roller passes of the tandem roller were conducted varies from 145-100 °C to 120-65 °C.
- The first roller pass behind the paver (and with that the temperature of the mixture at the first roller pass) varies substantially. For instance in the first project, the tandem roller starts rolling between 2-9 minutes after the paver placed the mix and the 3-drum roller starts between 10-19 minutes after the paver placed the mix. Relating this difference in time to the cooling curve, the difference of compacting after 2 minutes or after 9 minutes behind the paver can make a difference of approximately 25 °C for only the first roller pass.
- At almost all the projects roller passes were conducted after the target density was reached to make the surface even. This varies from 1 roller pass after the target density was reached up to 9 roller passes conducted after the target density was reached. This difference will not significantly influence the density, but its significance for mechanical properties is unclear.

Table 1: Variability in compaction operations for the same asphalt mixture

Mixture and weather condition	*Loca-tion*	*Roller type and sequence*	*Number of passes*	*Compaction time*	*Compaction temperatures*	*Time between paver and 1st pass*
Mix: HMA - AC 22 base (80 mm) Weather: 15-17 °C, solar 100-200 W/m^2, wind 8-13 km/hr	*1*	*tandem*	*10*	*38*	*130-85*	*5*
		3-drum	*15*	*53*	*115-60*	*14*
	2	*tandem*	*11*	*30*	*145-100*	*2*
		3-drum	*17*	*62*	*120-65*	*19*
	3	*tandem*	*7*	*43*	*120-75*	*7*
		3-drum	*17*	*90*	*110-70*	*10*
	4	*tandem*	*7*	*43*	*120-65*	*9*
		3-drum	*15*	*54*	*110-65*	*17*
	5	*3-drum*	*10*	*65*	*140-70*	*10*
		tandem	*11*	*30*	*125-60*	*32*
	6	*3-drum*	*14*	*65*	*140-65*	*5*
Mix: HMA - AC 22 base (80 mm) Weather: 5-10 °C, wind 5-8 km/hr, rain	*1*	*combi*	*8*	*30*	*130-90*	*8*
		small tandem	*joints*			
	2	*combi*	*12*	*35*	*110-60*	*15*
		small tandem	*joints*			
Mix: HMA - AC 22 base (80 mm) Weather: 15-25 °C, solar 200-700 W/m^2, wind 0-1 km/hr, clear & dry	*1*	*tired*	*6*	*11*	*150-125*	*2*
		tandem	*11*	*35*	*125-80*	*16*
	2	*tired*	*6*	*6*	*155-140*	*1*
		tandem	*9*	*27*	*140-90*	*7*
	3	*tired*	*6*	*11*	*155-120*	*2*
		tandem	*11*	*35*	*120-80*	*17*
	4	*tired*	*5*	*4*	*130-100*	*1*
		tandem	*8*	*29*	*100-75*	*8*

At the locations where the cooling and density progression was monitored, also cores were extracted determining the lab-density to compare this with the on-site measured density. However, at for example thin surfacings this is not desirable. The differences between the on-site measured density and the density determined in the lab is shown in Table 2 based on 130 cores from 23 projects.

The relationship between the measured density on-site and the core density determined in the laboratory is very weak. This relationship differs from project to project, but also within one project. The differences vary from +137 to -213 kg/m^3. During the WMA-projects only a negative relation was observed, which means that the nuclear density was always higher than the core density, but still varies from -7 to -213 kg/m^3. The measurements on-site are highly influenced by the underlying layer (asphalt or foundation), the circumstances (especially rain), the measurement device (the same device provides different results) and the operator who measures (how does the operator place the device at the asphalt mixture). The on-site measurement devices seem useful to determine whether density progression is achieved or not. However, in determining the absolute density the current devices are imprecise and show a lot of variability in results and are therefore difficult to use. This is one of the reasons to re-evaluate the density measurements on-site and possibly search for alternatives.

Table 2: Relationship between on-site density and lab-density based on 130 cores (in kg/m^3)

Difference nuclear and lab-density (in kg/m^3)	*base/bind 80 mm*	*base/bind 50-60mm*	*WMA 60-80 mm*	*Surf 40-50 mm*	*Surf 30-35 mm*
average difference	*-27*	*-1*	*-61*	*-24*	*13*
minimum difference	*-81*	*-76*	*-213*	*-120*	*-102*
maximum difference	*55*	*93*	*-7*	*41*	*137*
standard deviation	*38*	*53*	*39*	*46*	*59*

* A negative number means that the on-site density is higher than the core density determined in the lab

The conclusion drawn is that there is significant variability in key parameters and construction operations. Although at all locations generally the target density was reached, the compaction operations to achieve this target density are significantly different. However, how this variability in compaction operations influences the final mechanical properties is still unclear. The second goal was then to extract common practices regarding asphalt compaction in order to distinguish good and poor operational practice and to give improved instructions to roller operators. The common compaction practices are described in the next section.

5 Common operational practices for asphalt compaction

From the monitored projects the operational strategies of the rollers per project were extracted. The combinations of roller types per asphalt mixture were firstly determined and these are shown in Table 3.

Table 3: Variability in chosen roller types for asphalt compaction

base/bind 80 mm (3 projects)	*base/bind 50-60mm (12 projects)*	*WMA 60-80 mm (4 projects)*	*Surf 40-50 mm (3 projects)*	*Surf 30-35 mm (7 projects)*
• *tandem, 3drum* • *combi, small tandem* • *tired, tandem*	• *tired, tandem, 3drum (3x)* • *tandem, 3drum (3x)* • *3drum, tandem,* • *tandem* • *tired, tandem* • *combi, tandem* • *tandem, tandem* • *small-tandem, tandem*	• *tandem, 3drum (2x)* • *3drum, tandem* • *small tandem, tandem*	• *small tandem, tandem (2x)* • *3drum, tandem*	• *3drum, tandem (6x)* • *tandem, 3drum*

** The number in brackets corresponds to the frequency of monitored roller combinations*

This data demonstrates that the same asphalt mixtures are compacted using different sets of rollers. Most extreme are the AC base/bind (80 mm) mixture, where 3 projects were monitored and 3 different strategies were used and the AC base/bind (50-60 mm) mixture, where 12 projects were monitored and 8 different compaction strategies were used. The most visible and explicit commonly used roller strategy is for the Surf (30-35 mm) mixture, where on 6 of the 7 monitored projects, first a 3-drumm roller and then a tandem roller was used. Therefore, this roller strategy is appointed as common practice and analysed more in detail.

Based on the temperature and density measurements, and the machine movements, (1) the total number of roller passes, (2) the total compaction time, (3) the starting temperature for compaction and (4) the finishing temperature for compaction were determined per roller and used for analyses. For these parameters, the frequencies were determined and visualized in histograms. These histograms are shown in Figure 2 for the 3-drum roller and Figure 3 for the tandem roller for the compaction of an Surf (30-35 mm) mixture.

From the histograms, common roller strategies for an Surf (30-35 mm) were extracted, based on the frequency of occurrence in the monitored projects. Common practices of compacting an Surf (30-35 mm) based on the monitored projects are:

- The 3-drum roller conducts between 4 and 8 roller passes (sometimes 12) in 10-20 minutes, starting the compaction process at approximately 160-130 °C en finishes around 100-90 °C.
- The tandem roller conducts between 6 and 8 roller passes, starting the compaction process between 110-80 °C and finishes around 60-50 °C. The compaction time mainly depends on the cooling curve and thus on the weather conditions.

Applying this common roller strategy at this specific asphalt mixture does not necessarily mean that the target density will be achieved. However, at all the monitored projects target density was achieved and it is assumed that the roller strategy is based on years of experience of operators. Of course, the rolling strategy will also vary based on the weather and project conditions, but this strategy is based on limited data of 7 different projects with 19 measurement points regarding roller passes and asphalt mix temperature. If more projects are monitored and more data collected, rolling strategies can be determined for different weather and project conditions using the same method.

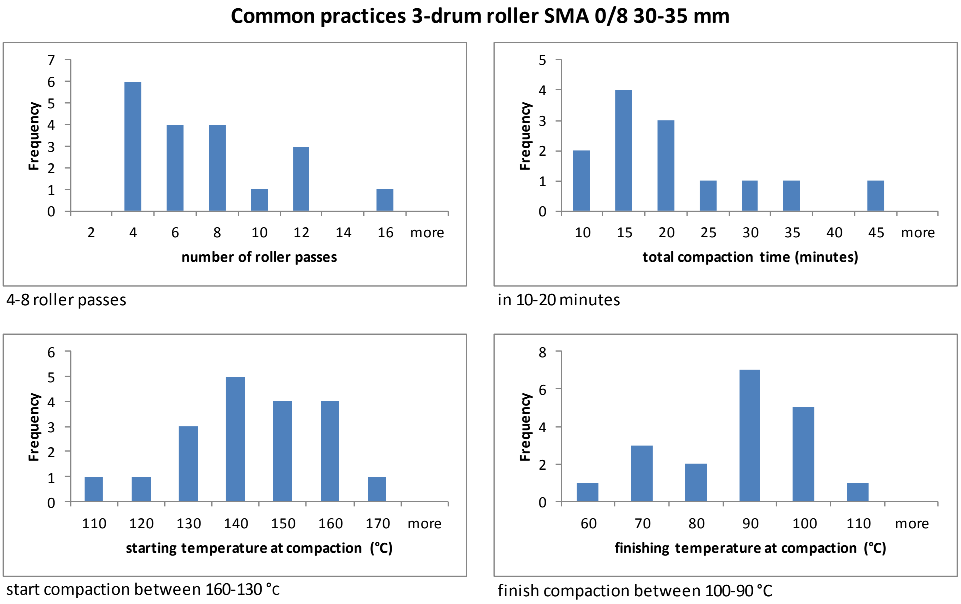

Figure 2: Common practices compaction 3-drum roller for a Surf 30-35 mm

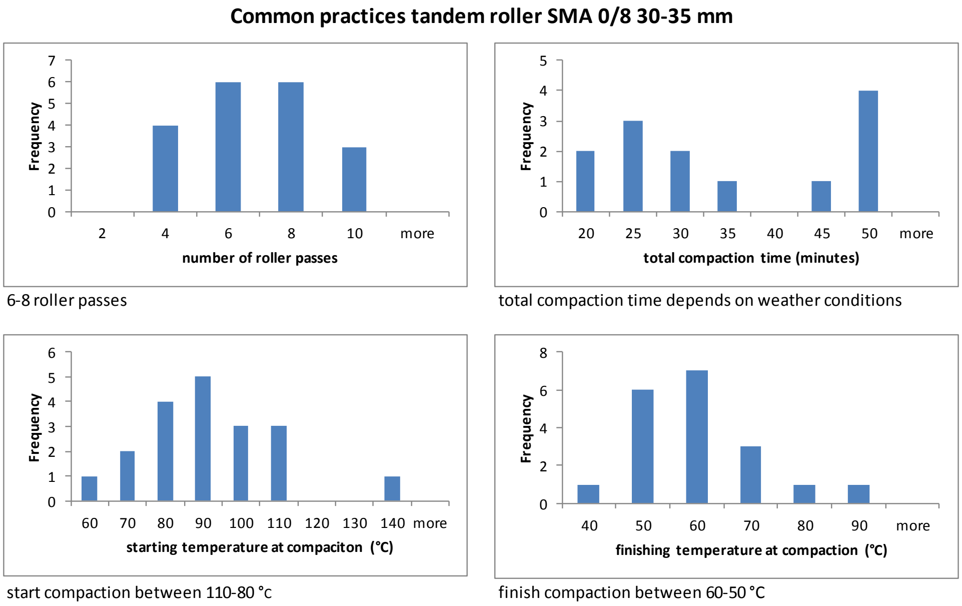

Figure 3: Common practices compaction tandem roller for a Surf 30-35 mm

6 Discussion and conclusion

In current contracts and agreements it is becoming increasingly important for contractors to improve process and quality control during on-site construction. In the current technological age one might expect contractors to embrace the technology-opportunities for performance enhancement. However the actual construction process still is mainly carried out without (high-tech) instruments and little research effort is put onto the systematic mapping and analysing of on-site construction operations. Therefore, it is hard for contractors to trace back what poor and good operational practice is and to improve process and quality control.

This paper adopted a previously developed framework for process quality improvement (Miller, 2010) to make on-site construction processes in the asphalt paving industry explicit. Twenty-nine asphalt construction projects were monitored using this framework and process variability was demonstrated and common practices for compaction were extracted. This framework is applicable for broad implementation in the industry and relevant for making current practices explicit in order to improve process control. Also, the technologies used in this framework are helpful to explicate on-site construction processes, process variability and common practices.

A substantial degree of process variability became clear from the monitored and analysed projects. First, the compaction process very often is executed using different sets of rollers. Also, the number of roller passes and the time and temperature windows in which these roller passes are conducted vary considerably. For one asphalt mixture (Surf 30-35 mm), a common compaction practice could be extracted from the monitored projects. When more projects will be monitored and more data will be gathered, this method can also be used to extract more common operational strategies for other asphalt mixtures under varying conditions. The process variability and common practices lead to an improved understanding about the construction process from an operational perspective and the underlying corresponding difficulties.

The results provide information and methods to move towards method-based learning and improving as described by Bijleveld and Dorée (2013) rather than current variable experience-based and ad-hoc working practices. The results also help to start a discussion with the operators of the asphalt team about the on-site construction process and to extract common practices that can be used in training and education of (new) operators. This can be the input for a virtual construction site for training and education, as described by Vasenev et al. (2013). After demonstrating this substantial process variability, it must also be acknowledged that the relationships between process variability and the resulting quality variability is under-researched and mainly unclear. Further research is being conducted to imitate the various strategies observed on construction sites under controlled circumstances in the laboratory and to determine its influence on quality characteristics (Bijleveld et al. 2012). Moreover, the structured way of monitoring actual construction projects and mapping the information in a database will be continued, creating increasingly more information about on-site process variability and common practices.

Similarly as in the asphalt industry, many domains in the construction industry lean on the on-site experience of operators. The approaches to make process variability and common practices explicit may also be applicable to other traditional experience-driven practices in the construction industry. Lessons learned are the importance of simultaneously introducing new technologies in the process and at the same time explicating current practices. This helps to demonstrate the value of using available technologies and hence of breaking down barriers to technology adoption. Also, having data gathered in a structured and systematic way and synthesised with the needs of the practitioners, proved helpful to adopt the technologies. Altogether this will help to create more understanding about on-site processes and bring the on-site process closer to the other processes in the chain, such as the design, planning and preparation phases. It will also help to fill the gap between current individualised lengthy learning and slow process improvement, and the quest for improved process and quality control on-site.

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The Influence of Organisation and Management in Promoting Innovation in Social Housing in UK

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Abstract

The Government has set an ambitious target to cut the UK's carbon emissions by 80% by year 2050. While working towards zero carbon new homes, refurbishment of the existing housing stock to advanced, low-carbon standards is essential as 27% of the UK's CO_2 emissions come from energy use in homes. In this process, the involvement of all stakeholders at all levels is important to achieve significant results. The issues are not only technical and socio-economic but also organisational and managerial. Organisations and their structure have a major influence in the innovation process. Developing a culture of innovation in organisations and industry appears to be vital in triggering innovation. The combination of attitudes towards risk and a wariness of innovative solutions result in organisational barriers to the wider uptake of low carbon technologies. This paper will present results from a number of research studies carried out in the social housing sector over a decade (2000-2010) to highlight key issues that are important in implementing innovative technologies in sustainable refurbishment. The research methodology was based on case study monitoring, action research and consultation workshops and identified barriers and drivers in achieving sustainability targets. The results illustrate that challenging leadership, organisational structure and management, commitment of all parties, a changed mind-set and better communications at all levels are crucial to drive the sustainability actions. Knowledge transfer, sharing of best practice, training of personnel are essential to make the initiatives successful. The paper will also present the findings of a research study into the level of perceived organisational sustainability, attitudes to risk and innovation amongst social housing providers. A survey was carried out to establish the level of sustainability that was achieved and attitudes towards risk of the responding organisation along with their experiences of sustainable refurbishment of their housing stock. The results identified a range of leadership and organisational characteristics that are needed to drive innovation. It concluded that it is possible to profile UK social housing providers and develop management instruments to accelerate their journey along the sustainable innovation path that in turn will accelerate the uptake of sustainable refurbishment programmes.

Keywords: Organisation & management, Social housing, Innovation, Low carbon homes, Sustainable refurbishment

1. Introduction

The UK government has set a challenging 80% reduction in Carbon Dioxide (CO_2) emissions by 2050. The residential sector accounts for around 30% of the total final energy use and produces 157.2 $MTCO_2e$ per year, which accounts for 27% of the total UK CO_2 level by end-user sector (DECC, 2012). According to the Department of Communities and Local Government the average English home produces 5.8 TCO_2 per year (DCLG, 2012). Notwithstanding the government's plan to increase the UK housing stock by 240,000 homes a year, approximately 80% of today's dwellings will still be standing in 2050 (Boardman, 2008). Improving the energy efficiency of UK existing housing stock has been made a priority within the UK government's Energy White Papers (DTI 2003 & 2007) as an effective, clean, safe and cost effective approach to meet the carbon reduction targets (Gaterell et al 2005, Power 2006). However, the uptake of effective energy efficient strategies within the UK is currently not sufficient to achieve the necessary CO_2 reduction targets (DECC 2009, SDC 2005). In this process, the involvement of all stakeholders at all levels is important to achieve significant results. In the social housing sector, the issues faced are not only technical and socio-economic but also organisational and managerial and require innovation in thinking and technology to face the challenges.

Innovation in the current context has to incorporate issues of social, environmental and economic sustainability and organisations and their structure have a major influence in this process. Developing a culture of innovation in organisations and industry appears to be vital in triggering innovation. The main driving forces are the ideas of stakeholders: customers, management, marketing personnel and production personnel, as they focus on problem fixing and developing new ideas. The lack of proper qualifications, training, access to cutting edge knowledge and technology, fear of taking risks, the culture and mind-sets of the particular organisation could all be contributing factors. For an organisation to be competitive specialist skills, consultancy services and professional expertise are needed. Forward thinking, considering whole life values rather than short-term demands, profits and balancing books are essential in this process. This new way of thinking can be stimulated by research and development within the organisation or externally, exposure to innovative technology and projects, promoting best practice and specialist training. While some European countries, especially Scandinavian, move forward by bringing their sustainability agenda to the public sector, up until recently the UK seems to have been slow in embracing these ideas. A number of reviews of the construction industry provided waves of re-structuring and re-inventing, but long-term sustainability in improved products and processes for better performance, efficiency and mainstreaming of innovative application of renewable and low carbon technology serving the built environment is yet to come. While funding remains a major constraint there are many other issues that directly or indirectly influence this process (Kaluarachchi et al 2007a). The combination of attitudes towards risk and a wariness of innovative solutions result in organisational barriers to the wider uptake of low carbon technologies. Another key factor in this process is the 'Innovation capability of an organisation', which locates and develops potential innovations that can be transferred into the mainstream (Lawson et al 2001).

This paper presents the results from a number of research studies carried out in the social housing sector over a decade (2000-2010) to highlight key issues that are important in organisational and managerial terms in organisations in implementing innovative technologies in sustainable refurbishment. The research methodology was based on case study monitoring, action research, consultation workshops and in-depth survey of related stakeholders. The aim was to identify barriers and drivers that influence organisations in achieving sustainability targets. The paper will also present the findings of a research study into the level of perceived organisational sustainability, attitudes to risk and innovation amongst social housing providers. A detailed survey was carried out to establish the level of sustainability that was achieved and attitudes towards risk of the responding organisation along with the experiences of sustainable refurbishment of their housing stock.

2. Organisational capability to innovate

Cohen and Levinthal (1990) argue that industrial research and development (R&D) not only generate new information but also improve the ability of firms to absorb knowledge developed outside the firm. The type of staff employed provides an indication of a firm's capability to develop, manage and utilise new technical knowledge. Other issues equally important are; organizational structure and culture, the nature of internal and external communications, coordination and feedback mechanisms, the ability to codify knowledge and the type and use of information and communications technologies (Cohendet et al, 2000). Companies associated with fast-moving science and technology sectors usually invest more intensively in R&D than most construction organizations. By other industries' standards investment by government and construction firms in R&D is very low, particularly in the UK; this is not the case in some other countries such as France, Japan and Scandinavia (Gann 2001). It follows from the argument that lack of internal R&D capability in construction indicates that many firms are unlikely to have the capability to absorb the results of academic research or work published in journal articles (Cohendet et al, 2000). Technological progress across the sector is therefore likely to be slow. When faced with the prospects of technological change, the majority of construction firms are recipients of innovation first exploited in other sectors, or by a few construction market leaders. Even when a firm has the technical competence to absorb new ideas, it may not have the internal structure, systems and cultural attributes necessary to capitalize on research results.

3. Organisational structure and communication

Organisations and their structure have a major influence in the innovation process. Visionaries who have corporate influence can drive innovation and influence the market growth, but will need support from other organisations in stabilising the process and creating the demand that is needed to establish the market. The monitoring of Amphion consortium of Register Social Landlords (RSLs) (2001-2004) to establish high quality housing designed and procured in line with a new procurement agreement illustrate how organisational structure and communication have a marked influence on innovation projects. In this arrangement a strategic partnering contract was set up with a single contractor who developed an award winning modern pre-fabricated timber frame housing system. The RSLs agreed to procure 2000 new house units over a four-year period and the research project exploited the opportunity to study a major innovation programme and identify what key lessons could be learnt. The main aim of the research was to set, monitor and compare the Key Performance Indicators (KPIs) and map the cause and effect relationships within the change programme. The research methodology was based on case study monitoring and action research and a range of questionnaire surveys, detailed interviews with key project personnel, examination of site meeting notes and general feedback reviews were undertaken to identify good and bad practices associated with each project. (Kaluarachchi et al, 2007b)

The innovative timber frame system needed more research and development input prior implementation to reduce defects and the associated costs. The components were over designed to minimise risk which made the product expensive compared to other timber frame housing system in the market. These increased costs and the defects resulted in lack of trust in the contractor and the volume of demand initially forecasted did not materialise. As a result the contractor was the subject of several takeover bids by rivals and experienced a number of problems with both the supply of the timber frame housing system and site personnel, which compromised the quality of construction and resulted in a high turnover of site-based operatives. Key Lessons learnt from the initiative:

• Organisations need to be fully committed to the innovation programme.

• Risk management processes need to be evaluated agreed upon and in place prior to commencing the project.

• Innovative processes require a change in mind-set at all levels within the organisations. Effective mechanisms should be in place to ensure that everyone understands the joint goals and know their part in the overall process. Good communication is needed at all levels in delivering the product.

• Training was identified as an essential ingredient in this process. The lack of familiarity with the innovative approach illustrated the need for formal training for all project managers, prior to commencement of new projects. There was also the need for support systems in terms of knowledge and information to be in place for frontline staff.

• Communication and co-ordination, which lead to continuous improvement of services and products, emerged as some of the key drivers of the process.

• Even though the government encourages initiatives, such as that monitored in the research study, there is little flexibility in support systems to assist in sustaining them.

• Continuous improvement process that would feed information from the site to different stakeholders, who were involved with the project, was never implemented.

4. Uptake of innovative environment technologies in the social housing sector

The EPSRC SUE-IDCOP programme (2005-2008) provided knowledge to underpin the improved sustainability of existing buildings. The overarching aim was to find ways to improve the performance of existing building envelopes, which reduce the consumption of non-renewable resources over the whole building life cycle in a way that is economically viable and socially acceptable. There are many innovative environment technologies that are readily available in the market for this purpose. Case study examples here in UK and extensively throughout Europe show that these technologies can be used effectively and economically in new build housing. In UK, there is very little evidence of their use in routine maintenance and refurbishment. The aim was to identify and review the barriers that stakeholders face in promoting innovative environment technologies in social housing refurbishment. A number of stakeholder consultations were undertaken in relation to three sectors in the procurement of social housing: management, development and the maintenance sectors. It was considered under the following criteria: Energy performance, Water performance, Waste management, Durability and flexibility (Whole life performance), Health and well being of tenants (Quality of life issues).

The results illustrated that:

- The capital costs of most of these technologies are significantly higher than the available budgets and the potential cost savings in utility bills. Also, the tangible benefits of employing renewable technologies are usually long-term and do not result in quick savings. Value for money is a major governing factor in the decision-making process and for the technology to be employed, benefits should outweigh the costs incurred.

- The technology should be proven and fully demonstrated prior implementation. Confidence levels in the new products are low due to high costs in demonstration projects (example- Amphion project) and occupants and organisations are reluctant to take the risks.

- There are quite a lot of products and systems in the market but very little information about their long-term performance, durability and ways in which they can directly reduce cost. More information about whole life performance and cost savings is needed and should be made available to the RSLs.

All the above factors illustrate that there is a demand for more information, effective communication and research and development. Informing and educating tenants and organisations about the long term benefits and whole life cost value seem crucial in implementing innovative technologies. Research and development is essential to bring the cost down and increase market potential.

5. Organisational structure and perceived sustainability

A detailed questionnaire survey was carried out (2009) with a sample of Housing Associations (RSLs) and Local Authorities to survey the innovative environment technologies and processes that are implemented in the sustainable refurbishment of UK social housing. The questionnaire, sent to senior managers and decision makers examined the barriers and drivers to sustainable refurbishment projects and related these to organisational characteristics and management attributes. The questionnaire also sought to measure the level of perceived sustainability by the organisation itself according to four levels of sustainability. The questionnaire comprised 15 questions covering: interpretation of the sustainability agenda; formal policies and business procedures; perceived drivers and barriers to sustainable refurbishment; and the decision making process / business case for action. A total of 500 questions were distributed and 57 responses we received representing the response rate of 11.4 %.

Respondents were asked a series of questions about their understanding of sustainability and the relative importance that they believed each attribute should contribute towards a sustainability assessment. All respondents identified that sustainability was about balancing environmental, social and economic performance of their housing stock but the relative importance that they attached to each attribute varied depending on where they placed themselves on the organisations and national sustainability agenda. The respondents were asked to rate the sustainable refurbishment actions carried out by their organisation according to four levels.

Level 1- (Low) Actions are uncoordinated one offs, low risk and opportunistic.

Level 2- (Low/Medium) Actions are un-coordinated, in multiple projects, high risk.

Level 3- (Medium) Actions are co-ordinated supported by formal decision-making process to reduce risk

Level 4- (High) Actions are strategically planned, supported by formal decision-making process and at medium risk

Of the 57 respondents, 17 placed themselves at level 1, 20 at level 2, 14 at level 3 and 2 at the level 4 (Figure 1).

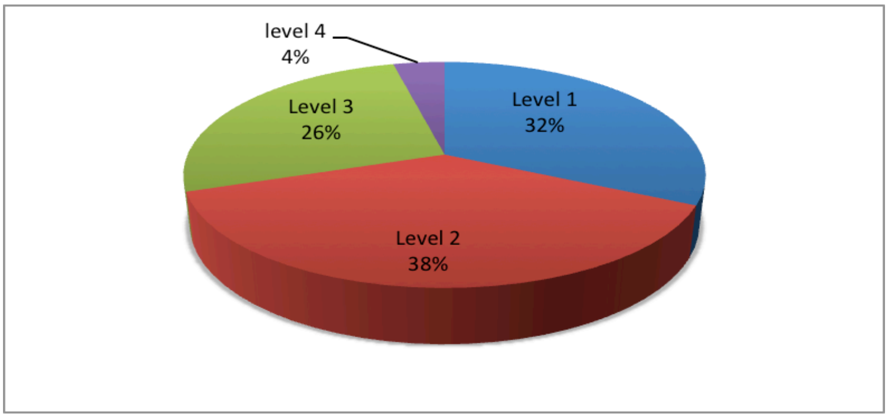

Figure 1 Perceived sustainability by organisations

Respondents were presented with potential drivers relevant to their refurbishment decisions and asked to rank these in priority order. The most important drivers were: tenant satisfaction (20.5%); government policy (20%); available funding/business support (13.9%); legislative support (9.4%) and education/knowledge (9.4%). With regards to the barriers for sustainable refurbishment: lack of funding [17.7%]; high initial capital cost [17.3%]; long payback periods [13.8%]; value for money [12.1%]; fear of risk [8.3%]; and lack of knowledge [8.3%] were perceived as major barriers. Respondents were also asked to identify the governing factors that determined the level of sustainable refurbishment that they believed was required. 80% of respondents identified the state of their housing stock followed by organisational leadership (56%), return on investment (56%), tenant buy-in (52%), and confidence in the solution (52%) as the most important factors when identifying which sustainable refurbishment project to undertake.

An attempt was made to identify differences in the decision-making hierarchy or implementation routes between organisations at different stages of perceived sustainability levels as in Figure 1. Whilst many management and decision-making attributes are common to all respondents, the degree to which they influence sustainable refurbishment decisions vary. The results illustrated that in Level 1, 2 & 4 decision-making is devolved and reporting/ monitoring is flexible. In Level 3 management approaches were more prescriptive and reporting was more formal (Table 1).

Table 1 Decision-making processes for sustainable refurbishment

Stage	*Decision making process*
Level 1	*Organisations have no executive manager responsible for overall delivery of sustainable refurbishment. The actions are one offs.*
Level 2	*Overall responsibility located at the executive level: a short development time between board level decisions to local implementation: decisions are based on the outcomes of a stock condition process: a long-term plan and vision for their housing.*
Level 3	*Organisations had developed specific procurement routes for innovative technologies: begun to involve tenants in decision-making: a semi structured options appraisal process in place to distinguish priorities.*

Level 4	*A senior-level manager is responsible for the overall delivery of the sustainability activities. High levels of tenant involvement throughout the process; individual project monitoring against a long-term asset management plan.*

6. Conclusions

All case studies illustrate that challenging leadership, organisational structure and management, commitment of all parties, a changed mind-set and better communications all levels are crucial to drive the sustainability actions. Knowledge transfer, sharing of best practice, training of personnel were essential to make the initiatives successful. Case Study 1, Amphion (2001) was set up by a visionary who wanted to achieve real change in the social housing sector. But as the lessons from this experience show, the organisational structure and the support needed to facilitate such an initiative was not present. The report 'Offsite Modern Methods of Construction in House Building' (Pan, 2005) stated that the industry has been slow to innovate and adopt offsite technologies, which has inhibited achieving a step improvement in productivity and quality of housing supply. This is almost likely to occur with a combination of government (as potential facilitator, sponsor and major client) and other client and cross-industry support. To date, the level of dialogue and collaboration between designers, contractors and building material producers appears to be limited, and the industry needs to adopt a much more proactive stance on this issue.

From the results of the questionnaire survey it would appear possible to differentiate management characteristics of UK social landlords in their attitudes toward sustainable refurbishment depending upon the level of sustainability they perceived their organisations to be. In general, the more advanced level the organisation is perceived to be in sustainability, the more locally focussed the decision making. Further, given the existence of organisational characteristics it should be possible to develop a profiling tool that allows landlords to recognise their position in the sustainability scale and develop appropriate interventions that could accelerate the journey from their current position to a more advanced level. Given the current low-level of sustainable housing refurbishment this could increase the speed of uptake of innovative technologies and support the UK in achieving lower carbon emissions associated with the social housing sector. The existence of barriers, particularly financial, cannot be underestimated and a solution to provide access to funding is needed alongside management interventions. The Green Deal, if effectively applied to social landlords, has the potential to provide such fiscal stimulus and as such the need to develop tools to assist with the other aspects of the sustainable refurbishment decision making process need to be developed. In developing these tools consideration should be given to where organisations place themselves in achieving sustainability targets, with solutions being developed that match the characteristics for each level to be achieved. In this way UK social landlords will truly benefit from their investment in Low and Zero Carbon technologies.

Innovation requires skill changes and new technical and practical knowledge. A change in industry, employee culture and mind-set is also essential if the anticipated requirement for improved quality, accuracy and precision is to be achieved successfully. This change in mind-set will require training, an explanation and understanding on the part of the workforce as to why the change is required, and clear leadership at all levels and from all industry participants including clients. The results also identified a range of leadership and organisational characteristics that are needed to drive innovation. It concluded that it is possible to profile UK social housing providers and develop management instruments to accelerate their journey along the sustainable innovation path that in turn will accelerate the uptake of sustainable refurbishment programmes.

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Planning for Urban Sustainability: Does Environmental Awareness Lead to Adequate Steering - A Focus Group Study in Finland

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Abstract

Environmental sustainability is increasingly recognised as one of the most critical challenges for the land use planning practices across the world. Sustainable communities are promoted as a desirable policy goal, local authorities are encouraged to contribute to climate change mitigation through land use planning, and international schemes, such as BREEAM for Communities and LEED for Neighborhood Development, are widely used for the environmental assessment of urban areas. However, there is a certain gap between rhetoric and action in the environmental governance at the city level, which stems from issues of institutional capacity and factors of political economy. A widespread political commitment has been recognized at a general discursive level, but agreement around its positive meaning in day-to-day decision-making is sparse.

The purpose of this study is to examine how the professionals of urban planning and environmental sustainability in Finland experience the steering effect of increased environmental awareness on land use. The utilised material was recorded in three focus group sessions, where more than thirty Finnish professionals of land use planning, energy production, residential construction, architecture, urban development consulting, and environmental governance were present. The data is analysed qualitatively. It appears that Finnish cities have rather ambitious greenhouse gas reduction targets and the land use planners who conduct or subcontract the environmental assessment of urban development and new construction have essentially unlimited mandate to devise sustainable solutions. Nevertheless, short-term economical interests are found to constantly dominate decision-making, and the aforementioned actually dispirits urban planners such a way that the results of environmental analyses are seen somewhat vacuous. Rather surprisingly, even if a myriad of sustainability schemes is already available for urban planning, the planners still call for improved tools for assessing environmental sustainability. There is clear demand for a comprehensive numerical environmental analysis of urban areas to be separated from integrated sustainability assessment. Therefore, the results of this study can practically help engineers and consultants to re-design their services of sustainability assessment for the purpose of increasing their impressiveness to decision-making and thus improving their potential to facilitate sustainable land use and construction. However, we argue that in addition to addressing the technical challenges of environmentally aware urban planning, more research is needed on the factors of political economy that may be in conflict with the environmental agendas.

Keywords: urban planning, land use, environmental sustainability, decision-making

1. Introduction

Over the past century, the massive urban population growth has occurred on less than 3% of the global terrestrial surface but the environmental impact has been widespread, with 75% of greenhouse gas emissions attributed to cities and the ecological footprints of the cities being tens to hundreds of times larger than the actual urban area occupied (Grimm et al. 2008). The attention has been drawn to the importance of cities as a means through which to address the global environmental challenges, and transforming urban areas into "sustainable cities" is becoming an increasingly common vision (Shane and Graedel 2000; Bulkeley and Betsill 2005).

The very purpose of urban planning is to prepare for the future, or more ambitiously, to create better futures (Myers and Kitsuse 2000). Sustainable communities are promoted as a desirable policy goal and local authorities are encouraged to contribute to climate change mitigation through land use planning (Bulkeley and Betsill 2005; Gunnarsson and Höjer 2011). Nevertheless, instead of a well-defined guiding policy there are competing discourses about environmental sustainability and less certainty about what it might mean in practice (Bulkeley and Betsill 2005; Gunnarsson and Höjer 2011). An important question is: who has the power to define the planning agenda for environmental sustainability (Gunnarsson and Höjer 2011).

According to Bulkeley (2010), there is a certain gap between rhetoric and action in the climate governance at the city level. The gap stems from issues of institutional capacity and factors of political economy (Bulkeley 2010). Jordan and Lenschow (2010) point to a disconnection between the policy and practice of environmental policy integration. A widespread political commitment has been recognized at a general discursive level, but agreement around its positive meaning in day-to-day decision-making as well as evidence on the actual outcomes of environmental policy integration processes is sparse (Jordan and Lenschow 2010).

Given that most studies have focused on the technical challenges of urban sustainability, the related political struggles have not yet been widely researched (Hall and Pfeiffer 2000; Whitehead 2003). Furthermore, the analyses have often been restricted to local scale ignoring the multilevel political system through which the environmental governance of local economies is conducted (Marvin and Guy 1997; Gibbs and Jonas 2000). To which extent cities and local governments can address the challenges of environmental sustainability should be examined (Bulkeley and Betsill 2005). Urban planners often appear to struggle with the issue of how to reach for area-specific urban environmental quality in practice (Runhaar and Driessen 2009).

International schemes, such as BREEAM for Communities and LEED-ND, are already widely used for the environmental assessment of urban areas. In addition, a myriad of local evaluation tools has been developed to assist urban planners with their environmental tasks. The purpose of this focus group study is to examine how the professionals of urban planning and environmental sustainability in Finland experience the steering effect of increased environmental awareness on land use. Our more specific research topics are: (1) the role of land use planning, (2) the power of urban planners, and (3) how environmental considerations steer decision-making.

2. Study design

Three focus group sessions were organised for the purpose of producing interconnected data. Urban planners and related specialists from fifteen Finnish cities, two architectural firms, four consulting companies, one of the biggest energy companies in Finland and one of the largest construction companies in Finland, as well as representatives of the Ministry of the Environment, the Green Building Council Finland and RAKLI (the Finnish association representing the interests of the property and construction industry) took part to the focus group conversations. The groups are itemised in Table 1. Remarkably, the cities of Helsinki, Espoo and Vantaa (on the first row) form the Capital Region. As can be seen in the table, a few of the participating organisations had multiple representatives, for example the city of Tampere one in each session and the Green Building Council Finland one in two of the sessions.

Table 1: The organisations the participants of the focus group sessions represented

Focus Group 1		*Focus Group 2*		*Focus Group 3*	
1	*The city of Helsinki*	*1*	*The city of Espoo*	*1*	*The city of Vantaa*
2	*The city of Tampere*	*2*	*The city of Tampere*	*2*	*The city of Tampere*
3	*The city of Joensuu*	*3*	*The city of Lohja*	*3*	*The city of Lohja*
4	*The city of Lappeenranta*	*4*	*The city of Kokkola*	*4*	*The city of Kotka*
5	*The city of Pori*	*5*	*The city of Kouvola*	*5*	*The city of Lahti*
6	*Construction company #1*	*6*	*The city of Kuopio*	*6*	*The city of Mikkeli*
7	*Energy company #1*	*7*	*The city of Lappeenranta*	*7*	*Ministry of the*
8	*Green Building Council*	*8*	*Green Building Council*	*8*	*RAKLI*
9	*Consulting company #1*	*9*	*Architectural firm #1*	*9*	*Architectural firm #2*
1	*Consulting company #2*	*10*	*Consulting company #3*	*10*	*Consulting company*
		11	*Consulting company #4*	*11*	*Consulting company*

The focus group discussions were based on a series of questions that the researchers introduced to all the participants together before the actual group sessions begun:
(1) *Why are the environmental improvements of land use planning pursued?*
(2) *What are the most important environmental aims of land use planning? Why?*
(3) *Which environmental considerations are relevant and which are not?*
(4) *How does environmental assessment steer decision-making in land use planning?*
The three group discussions lasted for about 40 minutes each, and two of them consisted of a similar amount of floors, 64 and 68. The third one was more upbeat consisting of as many as 120 floors. One researcher acted as a moderator for each session, and the interaction observed was used as part of the research data. The discussions were recorded and transcribed.

Data reduction was simply based on what was relevant to the purpose of the study. The relevant parts of the conversations were gathered and organised by five themes: (1) environmental aims, (2) the role of land use planners, (3) decision-making, (4) challenges, and (5) opportunities.

The content of the reduced data was analysed qualitatively and re-organised by the research topics. Finally, an initial content analysis and an initial thematic analysis were conducted on the original data as a whole to result in general remarks, which clarify the content of the topic specific results that could be misunderstood if they were separated from the wider context.

3. Findings

It appears that many Finnish cities have rather ambitious greenhouse gas reduction targets and the land use planners who conduct or subcontract the environmental assessment of urban development and new construction have essentially an unlimited mandate to devise sustainable solutions. However, short-term economical interests are found to constantly dominate decision-making, and the aforementioned actually dispirits the environmentally oriented urban planners. Rather surprisingly, the interviewees believe that improved tools for assessing environmental sustainability would bring about mainline change.

The findings are reported in more detail as follows. General remarks, which are based on the focus group data as a whole, are presented as background information for each results section. The topic specific results, which are based on reduced data, form the core of the analysis and follow the general remarks in each results section.

3.1 The role of land use planning in climate change mitigation

Land use planning is seen to have an important role in reducing greenhouse gas emissions. Other environmental issues were rarely mentioned in the discussions about current environmental land use planning strategies. Even if urban planners often used the term "eco-efficiency" they typically considered solely greenhouse gas emissions. Some environmental considerations, such as protecting local natural environment, seem to be seen as a norm and some others, such as global biodiversity issues, as too complicated to be understood and managed. In the context of current Finnish land use planning, improved environmental sustainability or eco-efficiency mainly refers to climate change mitigation.

In many cities urban planning has rather ambitious greenhouse gas reduction targets, for example:
"*Our climate strategy is very ambitious*."
"*The ambition to build carbon-neutral districts has a strong position in the city strategy*."
"*We have joined the network of carbon-neutral municipalities, and even our decision-makers are aware of the greenhouse gas reduction targets*."
"*Our aims of eco-efficiency are included in the city strategy, in the mayor's program and in the climate programs, and the target is to make more eco-efficient land-use plans*."

However, in some cities environmental issues are still not given high priorities:

"*There is not necessarily any greenhouse gas reduction targets or climate strategy. It is easily vague the way that anything can be proved to be sustainable by suited defaults and weights*."
"*In my opinion, everything else than eco-efficiency has been promoted more rapidly in decision-making. In some cities eco-efficiency is a political priority but in some others it depends very much on the officers on duty. We have had strategies and targets but nobody has ever been responsible in implementing them. It depends on who is involved and interested*."

3.2 The power of urban planners to promote environmental issues

All the land use planners from different cities and municipalities shared the ambition to design environmentally sustainable urban environments. It is the land use planners who conduct or subcontract the environmental assessment of urban development. It appears that the power of urban planners to promote environmental issues can be limited not only by formal restrictions or other people but also by their own beliefs.

On one hand land use planners can suggest almost anything. On the other hand, the lack of co-operation and joint environmental aims restrains their mandate in the environmental management of urban areas:
"*We must remember that a land use planner can ordain just anything. Land use planning truly has the means to make a difference.*"
"*Land use planners do not make all the decisions. We arrange the traffic but do not choose the fuel for the combined heat and power production.*"
"*We can decide of urban structure but not of how private companies and municipal decision-making support our solutions. The planned bus routes may not materialise and the schools may be disbanded.*"
"*In my opinion, cities and municipalities are able to develop public transportation.*"
"*Yes, if they want to.*"
"*Land use planning is all about compromises.*"
"*Even decision-making does not always lead to operation. We wait for something to happen but everything happens so very slowly.*"

Remarkably, land use planners do not see a connection between urban structure and lifestyles, for example:
"*We would like to support sustainable lifestyles but it is not easy.*"
"*We cannot affect people's behaviour.*"
"*People's leisure time is an impossible field – something we cannot affect.*"

Urban planners are experts and preparers, not decision-makers. However, they still feel able to affect decision-making:
"*Basically we create the options but do not make the decision between them. The decision-makers very rarely add anything to the plans but they may well not let something through. If our solutions fit the definitions of policy, the chances are better for them to be accepted.*"
"*The politicians have the final word but we can always try.*"

"*One must be like a horn to bring those (environmental) issues forth – to create an atmosphere that this is important.*"
"*A good example of apparent results in one city helps the progress in the others.*"
"*In general, it can be a self-reinforcing process. Increased understanding and apparent results make it easier and it can affect the strategy. The new strategy can then facilitate further improvements.*"

3.3 How environmental considerations steer decision-making

No real tensions were noticed during the discussions. Even if the participants did not always totally agree, the common procedure was to add new viewpoints and perspectives rather than to prove that someone else was wrong. However, the interviewees did not seem to mind their P's and Q's but openly discussed about the problems they experienced in their work, as among colleagues.

Short-term economical interests seem to dominate municipal decision-making:
"*Climate change has been a minor thing in decision-making.*"
"*It is euros that steer. Municipal economy dominates. Unfortunately very few people think about the bigger picture, even in economical sense.*"
"*That is the traditional way to make decisions in municipalities.*"
"*In decision-making, it is obvious that if eco-efficiency and cost-efficiency are against each other, the decision-makers will prioritise costs.*"
"*If municipalities were involved in carbon trading, low-carbon land use plans would most probably proceed at a good pace.*"
"*Decision-makers are interested in monetary benefits.*"
"*Win-win solutions (both environmental and monetary benefits) work well.*"
"*In my opinion, the politicians spend all their time for economical considerations. They do not have time for environmental considerations.*"

Furthermore, environmental issues are found complex in general and very complex to quantify, which deteriorates their position in decision-making:
"*The message should be so simple that the decision-makers could understand it.*"
"*Both urban planners and decision-makers need better knowledge.*"
"*Much has been done without better knowledge.*"
"*Environmental issues are too complicated for an ordinary person who still has to deal with them. Contradictory information makes the challenge unbearable.*"
"*Our outlooks can be wrong.*"
"*True.*"
"*We need better knowledge.*"
"*We need better knowledge also to prove things – to justify our suggestions.*"
"*It would be easier for the decision-makers to make good decisions if we could prove our arguments.*"

"*For decision-making, it must be proved that something is more eco-efficient than something else.*"

"*Eco-efficiency is a relatively new aspect in decision-making, and the environmental considerations do not have a common unit, which would be as easy to understand as euro in economical framework.*"

"*Decision-makers understand numbers. If we could show numbers first, after a while the good practices would be a norm and we would not need to calculate everything anymore. As long as we lean on qualitative reasoning, economical considerations dominate the environmental ones.*"

Even if a myriad of sustainability schemes is already available for urban planning, the planners still call for improved tools for assessing environmental sustainability:

"*Municipalities set some (greenhouse gas emission reduction) targets and then afterwards try to figure out, with the help of consultants, if they materialise, or if not, which actions should be taken. Currently we don't really have tools in place that could advise land use planners to mitigate the climate change.*"

"*We do not have metrics for measuring eco-efficiency.*"

"*It is still unclear when and how the improvements should be done to truly have an effect.*"

4. Discussion

A focus group study was conducted in Finland to examine how the professionals of urban planning and environmental sustainability, at both the municipal and the state level, experience the steering effect of increased environmental awareness on land use. The main finding is that even if many Finnish cities have rather ambitious greenhouse gas reduction targets, short-term economical interests constantly dominate decision-making, which dispirits the environmentally oriented urban planners.

To some extent our findings are supported by earlier research. Our interviewees find environmental issues complex in general and very complex to quantify, which is seen to deteriorate their position in decision-making. According to Jordan and Lenschow (2010), the state of the environment – both at the moment and in the long run – is a highly complex matter, affected by a multitude of factors. Furthermore, a multiple case study on the experiences of sustainability processes in Swedish municipalities by Keskitalo and Liljenfeldt (2012) shows that the complexity of the sustainability issues may make it difficult to cover the scope intended in local sustainability processes and scare people off from working on them.

Even if land use planners can suggest almost anything, the lack of co-operation and joint environmental aims restrains their mandate to promote sustainability. In addition, it appears that the power of urban planners to promote environmental issues can be limited also by their own beliefs. Remarkably, land use planners do not see a connection between urban structure and lifestyles. According to Nielsen and Jensen (2010), local authorities have a unique position to steer society development at local level in connection with society level in general and thus to design sustainable societies. Local authorities can try to reduce regional greenhouse gas emissions through energy supply, transport, urban structure and waste management, more or less independently of central government (Bulkeley and Betsill 2005). Nevertheless, Nielsen and Jensen (2010) argue that numerous decision makers can either promote or hinder the transition to sustainability at both the municipal and the state level.

According to Bulkeley and Betsill (2005), reducing greenhouse gas emissions in the urban arena is important for multiple reasons. One of them is that cities are concentrated sites of high consumption and production of waste, and another one that local authorities are both willing and able to take on board the complex agenda of sustainable development. However, if the land use planners do not see a connection between urban structure and lifestyles, are they able to limit the urban trend of high consumption and production of waste? The third reason by Bulkeley and Betsill for the importance of the urban arena in mitigating climate change makes this question even more crucial: local authorities are the key actors in terms of coordinating action between different partners and facilitating community involvement.

Our findings indicate that short-term economical interests dominate municipal decision-making. A case study by Book et al. (2010) shows that the state remains a crucial actor in sustainability governance. Bäckstrand et al. (2010) argue that despite the tension between the goals of sustainability and competitive image building, the two can potentially function as drivers for one another, if they are co-planned thoughtfully. Nevertheless, according to Theurillat and Crevoisier (2013), there is a clear dissociation in time between the qualitative aspects that are crucial for environmental sustainability and the quantitative aspects of economics that are considered at the very end of the process, by which time everything has been defined from a qualitative point of view. Book et al. (2010) summarise that it is difficult enough to find a solution either to economic competitiveness or to environmental sustainability, and finding a common solution or balance between the two is even more daunting.

Finally, and rather surprisingly, we came to the conclusion that even if a myriad of sustainability schemes is already available for urban planning, the planners still call for improved tools for assessing environmental sustainability. There seems to be a clear demand for a comprehensive numerical environmental analysis of urban areas to be separated from integrated sustainability assessment. Recognising this can practically help engineers and consultants to re-design their services of sustainability assessment for the purpose of increasing their impressiveness to decision-making and thus improving their potential to facilitate sustainable land use and construction. However, we argue that in addition to addressing the technical challenges of environmentally aware urban planning, more research is needed on the factors of political economy that may be in conflict with the environmental agendas.

5. Conclusions

Land use planning is recognised to have an important role in mitigating climate change. Urban planners have the will and the formal authority to challenge the global trend of environmental degradation. Nevertheless, this study shows that both more knowledge and political will are required to facilitate the transition to sustainability. Given that environmental sustainability is a highly complex matter, there is a clear demand for comprehensive numerical environmental analysis of urban areas. Short-term economical interests currently dominate municipal decision-making, which dispirits the environmentally oriented urban planners. The chain of decision-making in land use planning procedures may be long from environmental assessment based findings to adequate amendments in the legally valid land use plan. If the decision-makers at the very end of the chain do not understand the problem or the suggested solution or do not give it high enough priority, all the work the land use planners might have done for more sustainable future gets more or less wasted.

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Comparing Alternate Procurement Operations – The Case of Hospital Soft FM Service in England

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Abstract

The following paper presents a study of the operational cost and performance of core soft FM services in English hospitals, grouped by procurement method applied. A more precise method for discerning the procurement used for cleaning and catering services was developed, allowing 2 important improvements on previous studies. Firstly, controlling for the approximately one third of PFI contracts which do not include core soft FM services within the scope of the contract. Secondly, this allows the inclusion of services that have been procured via separate outsourced contracts. Data for 2008 is analysed and findings suggest that private provision does improve value for money in some services, notably catering. Samples include facilities of varying age, as exploratory data analysis suggested age of facility was not a valid predictor variable, an issue discussed in within the paper. Theory is considered in terms of incentives and opportunities 'to invest in operations', specifically the idea that integrated procurement, such as PFI, can deliver lower overall whole life cost from returns in improved operations. Further, the paper provides insight on the variance in levels of cost incurred and performance achieved for large samples of operational facilities, providing an opportunity for further research into other non-procurement determinants of FM performance. Contextual statistics on the prevalence of healthcare facility procurement via PFI are presented, along with suggestions for improvements regarding how public clients might monitor and assess future performance of services.

Keywords: Hospital FM, value for money, PFI, outsourced, procurement.

1. Introduction

There are now over 700 signed UK PFI contracts with great diversity in duration, size and scope. According to the latest Treasury PFI signed projects list, financial close has been met on projects which have already, or are soon to deliver in the next few years over £50bn in contract capital values (not indexed, HM Treasury, 2013). While this sum seems vast, we should maintain context that this is actually a relatively small proportion of total Government funded investment in gross fixed capital formation (ONS, 2006). The UK Coalition Government recently re-launched PFI following a lengthy review of the role of private financed in publicly funded capital investment (HM Treasury, 2012), yet the role of private finance remains a relatively new experiment in public procurement. Considering the significant sums of tax receipts required to fund these projects, assessments of their operations are imperative to assess PFI's effectiveness in achieving value for money (VfM). The National Audit Office shares this ambition:

> "there is a pressing need for better quality evaluation of private finance and other forms of procurement……Government … need particularly to ensure that they can compare the benefits and costs of different procurement routes." (NAO, 2009a, pg 4)

In light of this, the following paper seeks to provide an insight on cost and quality of core soft FM services within operational healthcare facilities. Specifically, the focus is on cleaning and catering. In addition to observing services provided within PFI facilities, data was sourced to allow comparisons of services provided in–house by the public sector, as well as via outsourced contracts with the private sector. Analysis of soft FM services is imperative to those PFI contracts that include accommodation elements, such as schools and hospitals, as such services will require relatively larger proportions of committed resources over the life of the asset to maintain contracted levels of service.

1.1 Contract scope

PFI is characterised as being a form of *integrated* contracting, meaning it combines the responsibility for both construction and operations of a facility under one contract (Hart, 2003; Hart et al., 1997). The scope of these operations vary greatly between contracts (as do the capital assets commissioned), and as such it is not surprising to point out that approximately one third of the hospital contracts operational in 2009/10 were found not to include cleaning and catering within their scope (NAO, 2010). Previous analysis of these services were unable to control for this issue of inconsistent scope between contracts (Ive et al., 2010; KPMG, 2010). Since these analyses, the required data has been accessed to control for this issue, as well as sufficient data developed to include assessment of separately outsourced services. The following analyses seek to provide insight on the issue of whether procurement method has an impact on operational service cost and quality, and hence indicate the VfM achieved.

2. Theoretical context of PFI soft FM services

The following discussion focuses on the particularities of soft FM services within PFI contracts. An important distinction includes the difference between some forms of integrated contracts, which include only the Hard FM aspects of operations (M&E maintenance, hence DBFM), and those including a range of soft FM services, such as cleaning and catering (DBFO).

There is also range in the scope of soft service provision, some contracts not including IT support or laundry within a hospital for example. This is important, as the potential for savings to be made from investment in operations will depend on contract scope. Improvements in operational services (lower cost or improved quality) may result, for example, from opportunities to locate some services off site (e.g. catering), or potential improvements of facility logistics for movement of resources around the facility. Based on the example below, it is reasonable to expect soft FM services typically ranging between 20-30% of the UCP, so significant sums of public money are at stake (NAO, 2007a, pg. 5).

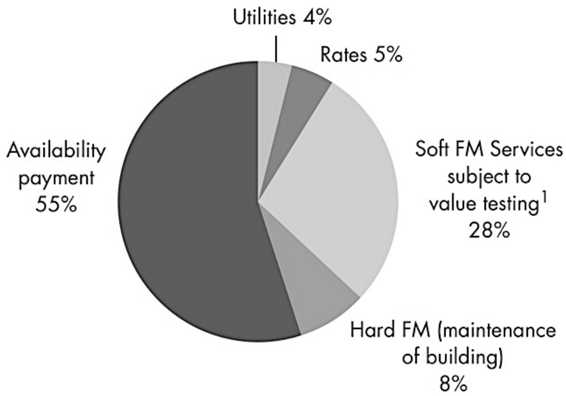

Figure 1: Breakdown of Darent Valley hospital Budgeted Unitary Charge 2004-05 Annual PFI Cost (£19 million p.a.) (NAO, 2007a)

With integrated contracts, the SPV takes the risk for cost of construction and operation of the asset, as well as associated financing costs. Operational costs are downwardly constrained by the quality of service they have agreed to provide in the output specification of the contract (Murray et al., 2012). Non-adherence to these levels of provision incurs prohibitive financial penalties. In this sense, there is an exception for Soft FM services whose price (what SPVs charge, rather than what it costs to provide) is open to a form of negotiation usually every 5 – 7 years. This periodic reassessment of the price of soft services is referred to as the benchmarking and market-testing procedures (BM&MT), which attempt to maintain VfM (NAO, 2007b). Ironically, this pursuit of VfM may limit the extent to which whole life cost risk is actually transferred, undermining the core business case for applying PFI. The relative benefits of alternative procurement methods is fundamental for public clients to consider, as explored in some insightful studies (Bajari and Tadelis, 2001; Ive and Chang, 2007).

Further, the extent to which there is incentive to invest in operations will also depend on the ownership structure within the SPV. Whoever owns the sub-contractor providing the operational service, and has an equity stake within the SPV (typically 10% in total with other shareholders), will have two sources of financial return. These include the profits from their present provision of operational services and future shareholder returns from investments in the longer-term project. The hard FM subcontractors are typically owned by a company that is an equity owner in the SPV, the externalities between design / construction improvements and building operations being arguably greater for hard FM services than for soft FM.

Problems arise when opportunities to reduce WLC for soft FM services become apparent ex-post. If capital sums are required to achieve this (e.g. re-configuration of internal layouts or procurement of additional long-term fixed capital), there is reduced incentive to incur sunk costs given the potential future competition introduced via BM&MT. This is pertinent given the likelihood that WLC reducing innovations may result from accumulated knowledge about operations of often unique facilities (Grant & Ries, 2013). Such innovations can only be assessed during operations, and so are difficult to specify ex-ante contractually. One might imagine an outsourced contractor who is not a shareholder having little incentive within their short-term contract of typically 2 - 5 years to undertake WLC reducing investments in fixed capital, which might reasonably depreciate over a 10 year period. A further point concerns the limits to which well anticipated ex-ante whole life cost innovations are achieved in the context of extensive sub-contracting in non integrated forms of contracting (Rintala, 2004, pg. 45).

The financial consequences for the SPV if underperforming in operations are less than if during construction, as without commissioning UCPs will not begin to flow. Conversely, with sub-par operational services you are likely only to incur part deductions. For that reason, you might expect to see a smaller differential between contracted operational service prices in PFI and those in the open market for outsourced soft FM services, especially when compared to the construction elements of contracts where there is greater risk transfer. This credible risk transfer in PFI construction is well evidenced (NAO, 2009b, 2003), as yet to be so objectively analysed in operational services. Price differentials for operational service contract may be down to superior performance of some PFI services (Mohammadi et al., 2013; KPMG, 2010).

3. Method

3.1 Data sources

The principal source for data in analyses is the NHS maintained Hospital Estate and Facilities Statistics (HEFS) site level report for 2008. This provides cleaning and catering cost data, cleaning performance indicators (NHS National Specification of Cleanliness (NSC) scores), as well as crucial data on site level facility characteristics including size and age asset profiles. Additional data on quality of service indicators, in the form of patient environment ratings (in part resulting from cleaning services as well as physical maintenance of surroundings) and catering service ratings, was sourced from Patient Environment and Action Team (PEAT) reports from 2008 for service indicators, and 2010 for data to help allocate procurement method (as this is only available from 2010 onwards).

3.2 Variables[1]

Cleaning cost: produced by dividing headline HEFS site level 'Cleaning services cost' by 'Occupied floor area' giving an *annual* m^2 *cost of cleaning* variable. The latest year available is 2008 as a result of surprising reductions in the publication of data on hospitals facilities.

Cleanliness: a percentage score assessment against the NSC. This is produced via self-assessment by NHS Trusts, entailing a pass or fail audit of 49 elements, such as cleanliness of fixtures and fittings and equipment available in the hospital.

Cost per patient meal day: a direct read off of the HEFS site level report '*cost of feeding one patient per day (patient meal day) (£)*'. No normalisation was required for this variable as it is already in per patient per day format.

Patient environment and food ratings: patient environment ratings, published by what was the National Patient Safety Agency (NPSA), are results of assessments against non-clinical service aspects of patient surroundings taking into account organisational policies, cleanliness, infection control, environmental aspects and conditions in access/external areas. Food ratings are similarly assessments of aspects of the quality of catering provision.

3.3 Sampling process

The site level HEFS reports formed the basis of the 2008 sample of sites. The process involves removing all sites where patients are not treated and accommodated, as well as those that are *unclassified*, reducing 1,965 sites down to 1,052. This leaves those hospitals classified as Community, General acute, Long stay, Multi-service, Short term non-acute and Specialist. Exploratory data analysis revealed that using facility age (as measured by detailed age asset profile data within HEFS reports) as a predictor variable for both cleaning services cost and quality (NSC) did not produce a significant result (see analysis below). As a result of this finding, analyses proceeded to include older facilities within the analysis to increase sample sizes and the likelihood of findings effects resulting from procurement associated differences. These older facilities are notably present in the large samples of facilities where services are provided in-house.

3.4 Procurement route

Procurement route applied in each facility was determined by reference to multiple sources, including: a list of PFI healthcare facilities made available by the NHS information centre; site level returns to the PEAT report in 2010; as well as a dataset derived from responses to the 2010 NAO survey of operational hospitals PFI contracts. Access to the final source was kindly

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[1] For brevity, readers are encouraged to read (Ive et al., 2010) for further discussion of variables analysed and detailed sampling process applied.

granted by the NAO under a freedom of information request. The years of these reports are different due to data availability. There is a key assumption that allows this empirical analysis, this being that the reported procurement method in 2010 from the NAO survey and PEAT reports is the same as the procurement method applied two years previous in 2008, when the service cost and quality indicators are available. This is a reasonable assumption given the relative infrequency in changes of procurement for operational services once in operations.

4. Analysis and results

For brevity of this paper, analyses are presented graphically and then discussed briefly with reference to observed inferential statistics (ANOVA analysis).

4.1 Age of facility against cost and performance

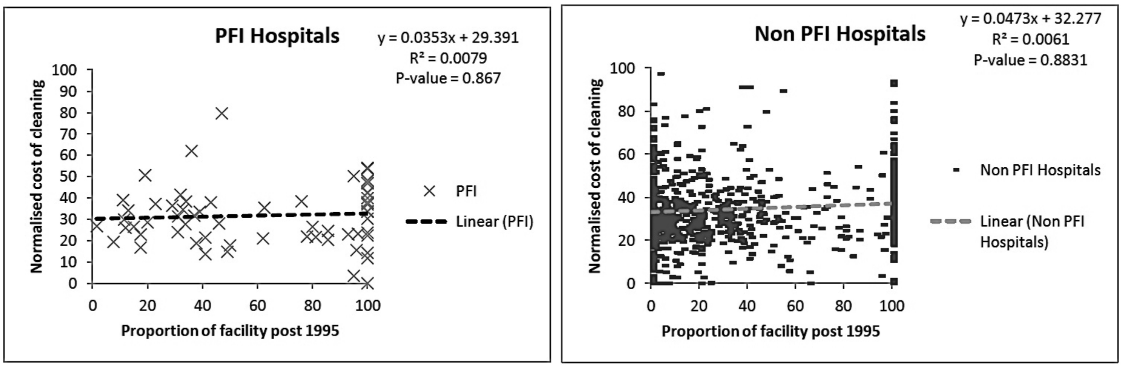


Figure 2 & 3: Normalised cleaning cost to facility age by procurement (2008)

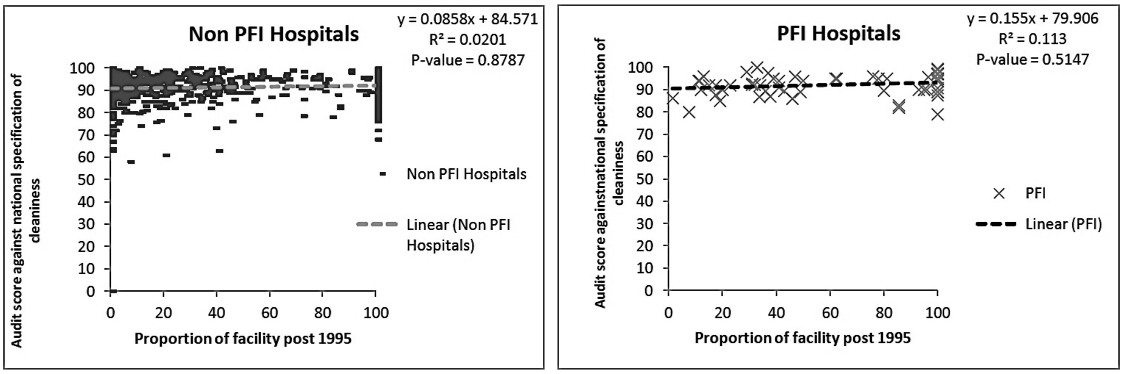
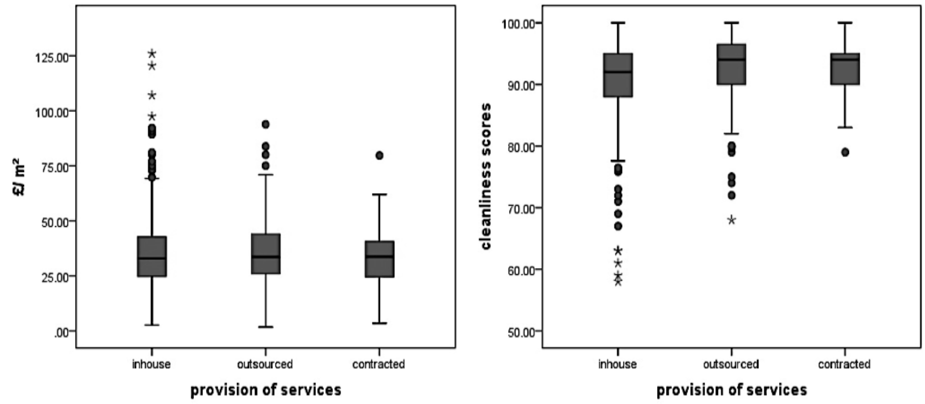


Figure 4 & 5: NSC audit score to facility age by procurement (2008)

As can be seen from the above analysis, the impact of facility age, as measured by what proportion of the facility was built post 1995, on cost of cleaning and resulting NHS NSC score (%) is seemingly negligible. There is no evidence to accept that older facilities, by these measures of resource allocation and service performance, perform any worse. This finding goes against conventional thought, as one of the primary reasons to renew a building is to improve its performance. While surprising, this finding supports the author’s decision to continue to include older facilities within proceeding analyses.

4.2 Cleaning services



Figures 6 & 7: Cleaning costs distribution and NSC by procurement (2008)[2]

The analysis of the distribution in cleaning costs between the three procurement types indicates no obvious difference. In interpreting these results it must be remembered that the in-house sample is much larger (at approximately 335 facilities depending on outlier policy applied) than the outsourced (about half at approximately 160 facilities) and the contracted PFI sample (about one tenth at approximately 35). Hence, it is not surprising we observe more outliers in the in-house sample, many of which may be more easily explained with reference to the particular context of that facility. For example, many mental health facilities are more likely to have services provided in-house, and such are expected to incur higher costs given the stricter requirements of their operations. This visual finding for cleaning cost is supported by ANOVA results that fail to reject the null hypothesis (smallest observed p-value is 0.39 with the strictest outlier policy applied). However, the ANOVA on NSC scores reveals that differences are significant, and that outsourced and PFI contracted cleaning services are associated with better average NSC audit scores than where cleaning services are provided in-house (p-value < 0.003 depending on outlier policy applied).

4.3 Patient environments

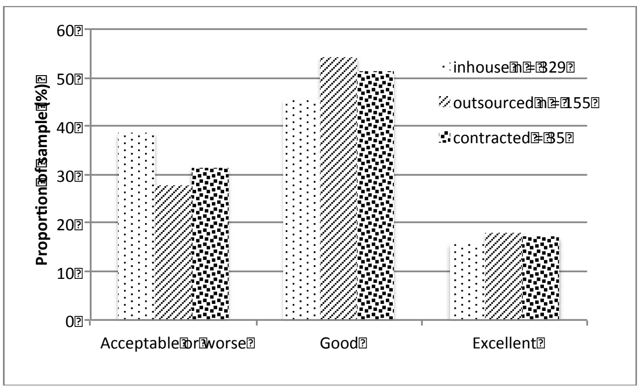


Figure 8: Patient Environment ratings distribution by procurement (2008)

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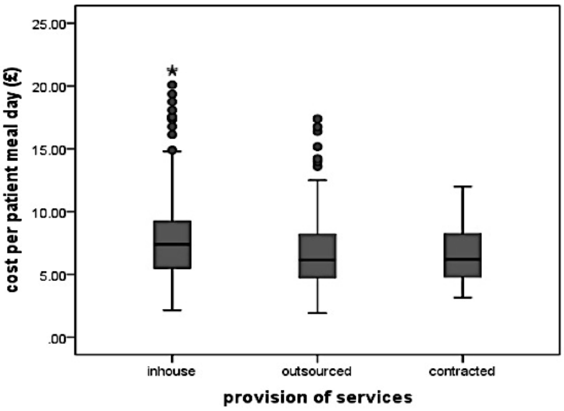
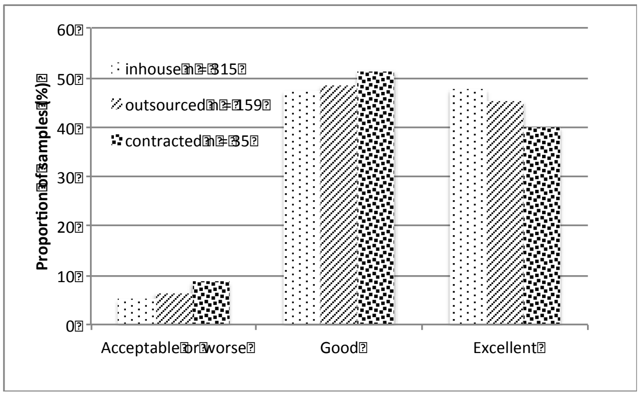
[2] 'Contracted' refers to PFI procured facilities

The figure above suggests that similar proportions of the three samples are within each of the three performance categories, though in-house performs a little worse with higher proportion of its sample in the *‘Acceptable or worse’* rating. Performing a simple chi squared analysis to provide a statistical finding reveals a p-value of 0.22, so again we failed to reject the null hypothesis of no difference in performance between procurement method applied, in terms of which promotes more favourable patient environments.

4.4 Catering services cost and performance





Figures 9 & 10: Catering cost & performance dist. by procurement (2008)

A visual inspection of the above cost analysis suggests in-house provision of catering services varies greatly in cost per patient meal day. As mentioned, this will in part be down to the greater sample size, but that issue aside the lack of outliers in the contracted PFI sample is notable, especially on the upper bounds of the distribution. The statistics support that private provision of catering services is cheaper than in-house (p-value < 0.05).

A chi squared analysis of the food ratings above delivers a p-value of 0.845, suggesting that we can not reject the hypothesis that the above distributions of the three procurement methods over the range of performance levels are sampled from the same population distribution, that is, there is seemingly no difference in service performance. With the strong result for lower cost of catering services when they are provided privately as part of an outsourced contract or integrated into a PFI contract, these findings suggest private catering services provide better VfM than publicly provided catering services.

5. Discussion

The lower level of outliers (higher and lower values) in cost measures for the PFI samples could be interpreted as providing greater cost certainty for services. This is characteristic of PFI in that it passes cost risk for delivery of specified levels of service. This might not necessarily be the case with an outsourced arrangement where the contract is more input based (PFI being focussed around an output specification), where the client may often ask for ad hoc additional resources to be allocated to ensure quality of service. It should also be noted that many of the newer PFI hospitals include the larger General acute facilities, which may reasonably provide significant scope for economies of scale for services such as cleaning and catering. Hence, it may not be the procurement type driving lower catering cost but rather facility type.

Another potential source of the observed lower catering costs might be the presence of returns from investment in operations, which one would expect to continue to be realised in the PFI contracted facilities. Whilst we do see significantly lower cost for PFI catering services compared to in-house provision, the similarity seen between both types of private provision suggest a minimal presence of these returns, given that outsourced contracts are shorter term yet still achieved similarly low service costs.

As for why we have not observed differences in cleaning services but have in catering, one explanation may be greater potential for capital-intensive processes in catering when compared to more labour intensive cleaning provision. Private providers are more likely to seek and consider more capital-intensive methods given their greater freedom and incentive to appropriate returns from investments in operations. This aspect will be limited by the term of the contract and so the opportunity to recoup investment in capital. Conversely, a counterfactual to this restriction includes the factor mobility of machinery and equipment that can reduce cost, given that many large service contractors will have multiple contracts within close proximity to one another.

The data presented is for a particular year (2008) due to limitations in the availability of time series data. In light of the data transparency policy of the recent UK Coalition Government, it is noted that this is one sector where data availability has declined, rather than improved. Given the need for local public clients to monitor service performance and central authorities to maintain a portfolio perspective, it is hoped non-public datasets are of much better quality for appropriate assessment of on-going VfM. This likely varies greatly by Trust and facility.

Finally, given this research observes that PFI soft FM services are of equal or better quality and incur no greater cost generally, thus supporting better VfM, it is questionable why new PF2 contracts will not be allowed to include soft FM services within their scope (HM Treasury, 2012). Given these findings, this suggests a potential lack of evidence-based policy in this area.

6. Conclusions and further research

The first surprising result of these analyses is that facility age seemingly has little impact on as measured cost or performance. The measure of NSC performance is not completely objective and so could be open to potential measurement biases that may partly explain this result. However, cost data should bear out the benefits of newer facilities. That said, recent PFI facilities aside, new facilities are not necessarily designed to benefit the cost (inputs) and performance (outputs) of FM services, but rather the outcomes of users (practitioners and patients), an aspect beyond this papers' scope.

The main finding is that procurement does seem to have an impact on service cost and performance. Private provision is associated with higher NSC audit scores in cleaning services, despite similar levels of cost. In catering, benefits of private provision are not in better quality services, but lower cost, indicating overall improved VfM. The differences between outsourced and PFI contracted services are marginal, suggesting that there is little or no evidence to support the notion of returns from investment in operations. However, we are at present limited in our ability to observe these returns due to the poor availability of data on when new facilities are commissioned, preventing superior comparative lifecycle assessment. It is hoped soon to be published data on FM outputs in schools[3] will allow a study providing a more sophisticated analysis on returns from investment.

Further research which could provide significant insight involves breaking down these samples between different hospital types to ascertain which facilities are associated with higher services costs and performance indicators. These could serve as potentially useful benchmarks for public sector clients to compare the performance of their services to for means of more contextually sensitive contract re-negotiations.

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Assessment of Financial and Environmental Potential of a Real Estate Energy Efficiency Investment

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Abstract

Energy consumption reduction in the real estate sector possesses significant possibilities in environmental point of view but also, interestingly, in economic point of view. Emerging interest in energy efficiency improvements is driven by the growing awareness of energy costs, increasing energy prices and recent technical development in means of improving buildings' energy efficiency. In the environmental point of view, energy efficiency improvements have significant potential in reducing energy consumption related greenhouse gas emissions, which continue to dominate the total life cycle emissions of the current building stock.

The study focuses on financial and environmental performance of an energy audit investment in Finland. The study consists of two phases. First, we assess financial and environmental returns of energy efficiency investments in office buildings. Secondly, we compare rate of returns of energy efficiency investment with initial property investment returns. Possibilities of reducing greenhouse gas emissions of the building by energy efficiency improvements compared to the current energy consumption of the same building are assessed as well.

The results of the study indicate that compared to the average property investment returns, investments in energy improvements tend to result in higher returns and simultaneously in reductions of greenhouse gas emissions of the building. Furthermore, energy efficiency investments have short or moderate payback periods in both financial and environmental perspective. Predicted rises in energy tariffs in the future further increase the relevance of this investment option.

The results of the study reveal genuine financial and environmental advantages of energy efficiency investments. Yet, the benefits of energy efficiency investments are currently not easily reached nor realized by investors. This is at least partly due to mechanisms of distributing the potential returns of an investment between stakeholders and in the case of net leases, the mindset, which considers the heating and electricity costs more as passing through cost elements, eventually paid by the tenant, thus not always directly offering greater interest to the property owner. However, by focusing solely on the energy improvement investments and absolute returns that they generate, there appears to be tempting investment opportunities. Consequently, demand for the development in practices in the industry remains.

Keywords: Energy audit, energy efficiency, property returns, greenhouse gas emissions

1. Introduction

1.1 Background of the study

Buildings consume one third of the energy globally and cause the same share of the total greenhouse gas emissions (Huovila *et al.* 2007). According to McKinsey & Company (2009), building and real estate sector has the most economically feasible potential of climate change mitigation. This has sparked political action, for example the European Union has set climate change mitigation targets for 2020 and 2050 with specific goals for built environment (European Commission Climate Action Website). Increasing energy prices together with the increased environmental awareness and political support have led to a situation where energy efficiency actions of the built environment are gaining more and more momentum, due to their large potential for both financial savings and decreased environmental burden.

Use phase, especially energy consumption accounts for significant share of building life cycle GHG emissions even though new energy efficient building types have had a major increase into the share of construction phase emissions (Junnila *et al.* 2006, Gustavsson & Joelsson. 2010). In Nordic countries, heating accounts for as much as two thirds of buildings' energy consumption and GHG emissions (Junnila *et al.* 2006, Kyrö *et al.* 2011). Reducing energy consumption of building stock is thus an effective way of mitigating climate change. Further, energy efficiency improvements are seen as one of the most cost-effective ways to achieve improved energy security, increase industrial profitability, and guarantee greater competitiveness (Hansen *et al.*, 2009). On the other hand, while the large potential for the energy efficiency improvement appears to be widely recognized and accepted, from property owner's point of view the focus is mostly set on the net rental income, not on the cost minimization especially while net lease agreements are used (i.e. the tenant is responsible for the operating expenses).

The European Union directive 2006/32/EC of the European Parliament and of the Council of 5 April 2006 defines energy audit as: "'energy audit ': a systematic procedure to obtain adequate knowledge of the existing energy consumption profile of a building or group of buildings, of an industrial operation and/or installation or of a private or public service, identify and quantify cost effective energy savings opportunities, and report the findings;" According to Khan (2006) the Energy Audit Programme (EAP) in Finland was launched in 1992. Companies and organizations, which carry out energy audits for their buildings, are subsidized by 40 to 50 percent by the Finnish Ministry of Employment and the Economy (MEE) when energy audit process is carried out according to MEE's general guidelines and the model audit guidelines. Saving potentials for energy and water and saving measures are identified in the energy audit and companies and organizations can then decide whether to carry out the activities or not. Motiva is an affiliated Finnish Government agency promoting efficient and sustainable use of energy and materials. According to Motiva energy audits are suitable for properties with standard building technologies including also big or complex buildings e.g. hospitals or large business centers.

The aim of this study is to analyze and understand the potential for positive economic and environmental impacts that energy efficiency improvements of existing buildings can withhold. Moreover, the research compares the estimated returns of the energy efficiency improvement actions to the impacts on overall values of the properties and sets out the potential for decreasing properties' energy consumption along with GHG emissions. Energy efficiency improvement potential is based on actions identified in the energy audit processes. The profitability of the investments is estimated using two factors, through internal rate of return (IRR) and payback period. The environmental performance of energy audit processes is measured in GHG emissions reduction per net area of a property.

1.2 Description of data

The energy audit data set consisted of concluded energy audits of altogether 76 properties in different cities in Finland. For the purposes of this study, all other property types apart from offices were excluded from the data, thus resulting in 29 office properties. The average gross area of the properties was approximately 9,100 m2 and the median 7,800 m2. Average volume was 39,000 m3 and median 37,900 m3. The audits have been done between 2005 and 2012. The amount of suggested actions varied between 4 and 15 and they were related to HVAC/HPAC systems, water systems, lighting and building automation. On average, the identified energy improvement investment measures are approximately 33,800 euros and the average annual savings 15,100 euros. The average lifetime of the savings is 6.4 years, based on the notional savings of each energy improvement measure, following the principles for energy audit savings calculations as set out in the general Finnish guidelines (The Finnish Ministry of Employment and the Economy *et al.* 2012).

For the purposes of the property value calculations property market data was required. The data for operating expenses was received from KTI Property Information Ltd. (KTI). As the energy audit data did not include the addresses nor other identifiable data of the 29 subject properties, each of the property are valuated using rental levels, operating expenses, vacancy rates and yield levels as close to the given market as possible. The operating expense data includes benchmark data of occurred expenses of office properties in 2012 in the different subject cities in Finland. The operating expenses include administration, upkeep and maintenance, upkeep of outdoor areas, cleaning, heating, water and waste water, electricity and gas, waste management, property insurance, (land) rents, property taxes, other operating expenses, repairs and activations of capital expenses. In addition, existing gross rental levels and vacancy rates for the subject properties' cities were received from KTI (KTI Rental benchmarking 2013) and estimated yield levels (RAKLI-KTI Property Barometer 2013, Catella 2013).

2. Method

2.1 Profitability analysis of energy audit actions

The economic impacts were assessed using three methods. First, the profitability of the actions was modelled by calculating the internal rate of return (IRR) and payback periods for the suggested energy efficiency improvement actions and corresponding annual operating expense savings. Secondly, the impact on the property values was modelled using a Discounted Cash Flow model.

IRR indicates the rate of return when the investments net present value is zero; thus all projects with equal or higher IRR than the investor's required rate of return are profitable. IRRs for the 29 subject properties were calculated based on the identified annual savings, required initial investment and notional lifetimes of the savings.

The economic impact of the energy audit actions on the property value change (i.e. on the returns) was conducted using Discounted Cash Flow valuation method. In the Real Estate and Construction sector, DCF is recognized as the most popular commercial property investment valuation method, both in the literature and in practice (e.g. KTI and IPD 2012; Shapiro *et al.*, 2013). The property value in DCF is the present value of future net rental income and the exit value of the property. These input parameters (i.e. rental income, maintenance costs, repair and replacement costs, vacancy rate, and discount rate) are mainly drawn from market information while using the specifications of the property as a basis for the market information search.

2.2 Greenhouse gas emissions of energy audit actions

The environmental comparisons of energy efficiency improved buildings and average office buildings were conducted with life cycle assessment (LCA). LCA method used in the study is ENVIMAT, an input-output (IO) LCA application, which is presented in more detail later in the chapter. LCA takes all life cycle phases of a product or a service into account in assessments of their environmental effects. According to Hendrickson *et al.* (2006) an example of life cycle phases of a typical product consists of raw material acquisition, material processing, fabrication, use, disposal and landfill. In the case of reuse or recycle, the life cycle of materials extend into a life cycle of another product. In addition, besides assessing the direct emissions of product manufacturing process LCA also compiles the emissions of indirect emissions of supply chains. Thus LCA provides a holistic perspective of all life cycle phases of a product or service with extensive insight into supply chains of each process in a product life cycle. The details concerning the boundaries of the life cycle assessment are described in the LCA boundary definition according to the characteristics of chosen LCA application.

IO LCA is one of the two primary LCA applications along with the process LCA (Sharrard *et al.* 2008). IO LCAs utilize national IO tables to combine sector-by-sector economic interaction data with sector level environmental effects on resource use data (Bilec *et al.* 2006). According to Hendrickson *et al.* (2006) one of the main advantages of IO LCA applications is that there is no need for boundary definition as the input output tables cover entire economy. Additionally, IO LCA data is often publicly available and IO analyses are faster to conduct compared to more data intensive process LCAs.

ENVIMAT IO LCA application used in the study is based on input output tables of Finnish economy. IO table consists of 151 industries, which is based on 918 domestic and 722 imported products or services (Seppälä *et al.* 2011). ENVIMAT IO application converts monetary costs spent on a sector of an economy into GHG emissions according to the sector intensities. ENVIMAT consists of 159 sectors, which are compiled using Statistics Finland data of years 2002 and 2005. The ENVIMAT tables model the Finnish economy of the year 2005. The ENVIMAT IO tables are publicly available in Internet.

3. Research process

3.1 Profitability analysis of energy audit actions

The profitability analysis was done using a dataset of energy audit information. As the data contained office, retail and warehouse properties, the original dataset was edited to include only office properties (which are in the scope of this study), thus decreasing the number of properties into 29.

The internal rate of returns (IRR) for the energy improvement investments for all of the 29 properties were calculated using the following formula:

$$NPV = CF_0 + \sum_{t=1}^{n} \frac{CF_t}{(1+d)^t} = 0$$

Where CFs denote cash flows in different years NPV is the Net Present Value of the investment and d is equal to IRR, when NPV is zero (Knüpfer & Puttonen, 2004, pp. 85). The payback periods were calculated by dividing the total energy investments by the total annual savings identified in the energy audits.

The simulation of the effects on the property value for the properties was done using spreadsheet software based ten-year-discounted cash flow (DCF) modelling. DCF is based on the formula for Net Present Value where the cash flows are net rental income:

$$NPV = CF_0 + \frac{CF_1}{(1+d)^1} + \cdots + \frac{CF_n}{(1+d)^n} = CF_0 + \sum_{t=1}^{n} \frac{CF_t}{(1+d)^t}$$

, where CF_t denotes the Cash Flow of year t and d is the discount rate (Knüpfer & Puttonen, 2004, pp. 83). In addition, the model included the exit value of the property.

The property market data (i.e. rental data, vacancy rates, yields, operating expenses) for each given property were used in the modelling, using each city's data for the corresponding property value calculations. The lease period was assumed to be 10 years and the properties single tenanted. The used inflation rate was 2.0 percent, which is based on long term average in Finland (OSF 2013).

Two sets of calculations were done for each of the 29 properties, one without the energy improvement investments and one with the investments and corresponding annual savings in operating expenses. The lifetime of savings in the energy audit actions was calculated as weighted average, which was then inserted into the cash flow model's residual value component. In cases where the lifetime of the savings was less than 10 years, the corresponding investments were repeated in the cost component after each period of time. Since the area details in the original energy audit data were reported as gross areas, the data was converted into net rentable area for the DCF purposes. In Finland, the rentable area is the basis for the market rents and thus the transformation was deemed necessary in order to maintain the comparability of the rental income and operating expenses. The gross-net area conversion factor 0.7 is based on the study of Lylykangas *et al.* (2013) and is calculated using the Official statistics Finland data.

3.2 Greenhouse gas emissions of energy audit actions

The research of greenhouse gas emissions was conducted using the same initial dataset of energy audit information of the properties as in the economical part of the study. The dataset was used to calculate the emissions based on the costs and the future savings of actions recommended as a result of energy audit processes. Another dataset of property operation costs for various office-building types were provided by the KTI Property Information Ltd. (KTI cost benchmarking 2013) and used to enable GHG emission comparisons with the energy audited and the reference properties.

Operation of a reference property that was used as a basis in the analyses was created using the KTI dataset. The dataset consist of average operation costs of office premises for cities of Helsinki, Tampere, Turku, Helsinki metropolitan area and other major cities. GHG emissions of premise operation were assessed using appropriate ENVIMAT sector for each operation activity. The details of the sectors are following:

The GHG emissions of operating the reference premise in each city were assessed in order to create the GHG footprint of the reference building operation in each location. GHG emissions of reference building were then modified with the energy efficiency improvement tasks according to the energy audit recommendations individually for each case. Investments into energy efficiency improvements caused some GHG emissions and operation GHG emissions reduced at the same time. Some improvements had to be renewed according to lifetime of a saving in order to maintain the reduced level of energy or water consumption during the whole analysis period. GHG emissions for these activities were included into the model of the study.

First phase of LCA was to model a GHG emissions caused by the energy efficiency improving actions recommended in the energy audits. Three different sectors of ENVIMAT model were used in the process. First, other construction services sector was used for the actions that included some construction activities. Second, other residential services sector was used for the activities that included tasks done on the property location. Third, business related services sector was used for the minor activities that could be executed remotely. Details of the three ENVIMAT sectors used for modeling the investment GHG emissions are presented in Table 1.

The GHG savings gained as a result of improved energy or water efficiency were modeled by categorizing saved resources for electricity, district heat or water supply according to the system that was enhanced by the energy audit recommendation. Categorized savings were then modeled into avoided GHG emissions using three ENVIMAT sectors. Electricity production and supply sector was used for decreased electricity consumption. Distribution services of hot steam and water sector was used for reduced consumption of district heat. Collected and cleaned water and water distribution services sector was used for reduced water consumption. The details of the ENVIMAT sectors are presented in Table 1.

Table 1: ENVIMAT sectors used in the GHG assessments

Operation activities	***ENVIMAT sector***	***(kg CO2e/€)***
Administration	*Business related services*	*0.23*
Upkeep and maintenance	*Other construction services*	*0.28*
Upkeep of outdoor areas	*Other real estate services*	*0.32*
Cleaning	*Other real estate services*	*0.32*
Heating	*Distribution of hot steam and water*	*5.23*
Water and wastewater	*Collected and cleaned water and water distribution*	*0.4*
Electricity and gas	*Electricity production and supply*	*4.56*
Waste management	*Collected and cleaned water and water distribution*	*3.94*
Property insurance	*Electricity production and supply*	*0.32*
Property tax	*Financing and insurance services*	*0.26*
Other operation expenses	*Business related services*	*0.23*
Repairs	*Residential construction*	*0.43*

Energy audit investments	***ENVIMAT sector***	***(kg CO2e/€)***
Construction related activities	*Other construction services*	*0.28*
Tasks on property location	*Other real estate services*	*0.32*
Minor remote activities	*Business related services*	*0.23*

Energy audit savings	***ENVIMAT sector***	***(kg CO2e/€)***
Electricity	*Electricity production and supply*	*4.56*
Heating and hot water	*Distribution of hot steam and water*	*5.23*
Water consumption	*Collected and cleaned water and water distribution*	*0.4*

These steps enabled assessment of GHG emissions for 10-year analysis period for each energy audited property and the reference properties in each location. GHG emissions analyses of the reference properties consist of constant GHG emissions caused by building operation for each year. GHG emissions of the energy audited properties consist of reduced GHG emissions for building operation according to energy and water savings of the energy audit process. Additionally, GHG emissions caused by the investment and maintenance of the energy audit activities were taken into consideration in the analyses of the energy audited properties.

4. Results

4.1 Profitability analysis of energy audit actions

The energy audit improvement investments resulted as internal rate of return of ***40.6 percent*** on average, while the IRR in individual properties ranged from the minimum of -4.6 percent to the maximum of 881.2 per cent (Figure 1). The median IRR was 66.0 percent. In addition to the IRR, the payback periods for the investments were calculated. The average payback period for the projects was ***2.0 years***, the minimum being only 0.1 years and the maximum 8.2 years. The median payback period was 1.4 years.

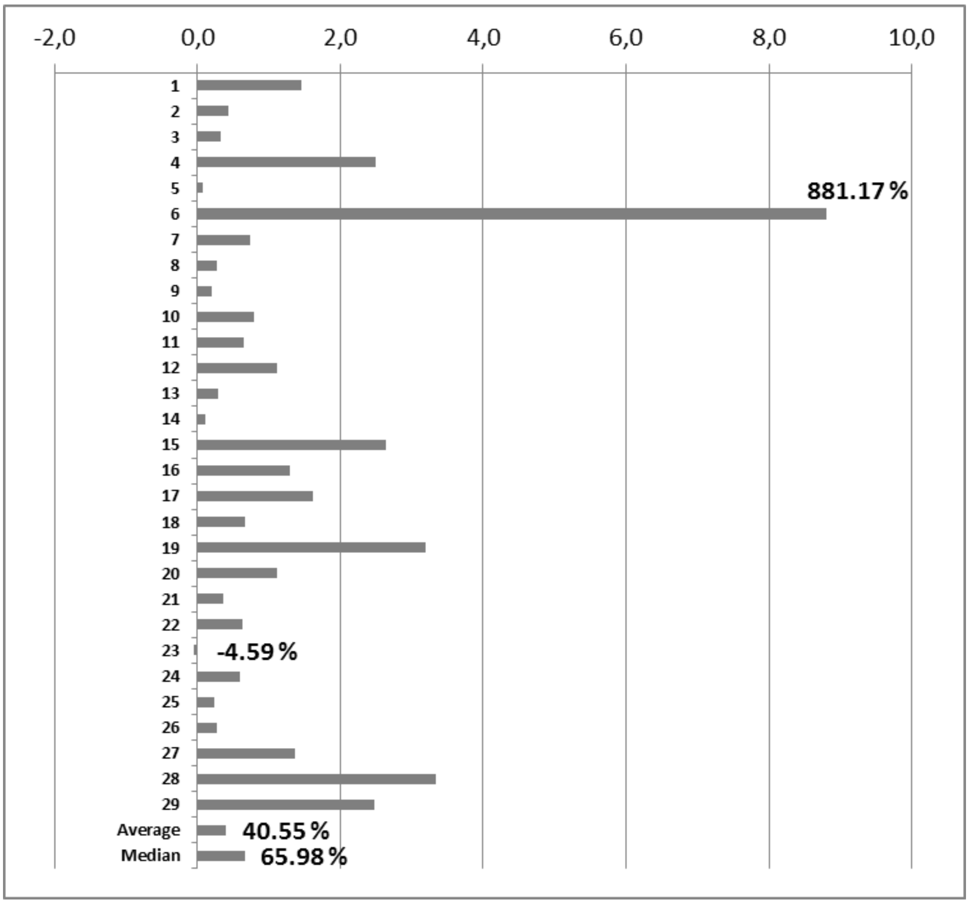

Figure 1: Internal rates of returns of energy improvement actions

Regarding the impacts on the property value, the energy efficiency improvements had some effect. The DCF modelling resulted in an overall average value increase of ***1.72 percent***, the median being ***1.40 percent.*** The value changes of individual properties ranged between the minimum of -0.06 per cent to the maximum of 5.60 per cent (Figure 2). The corresponding euro amounts of value change were approximately -11 400 and 623 900 euros, the average being 147 000 euros.

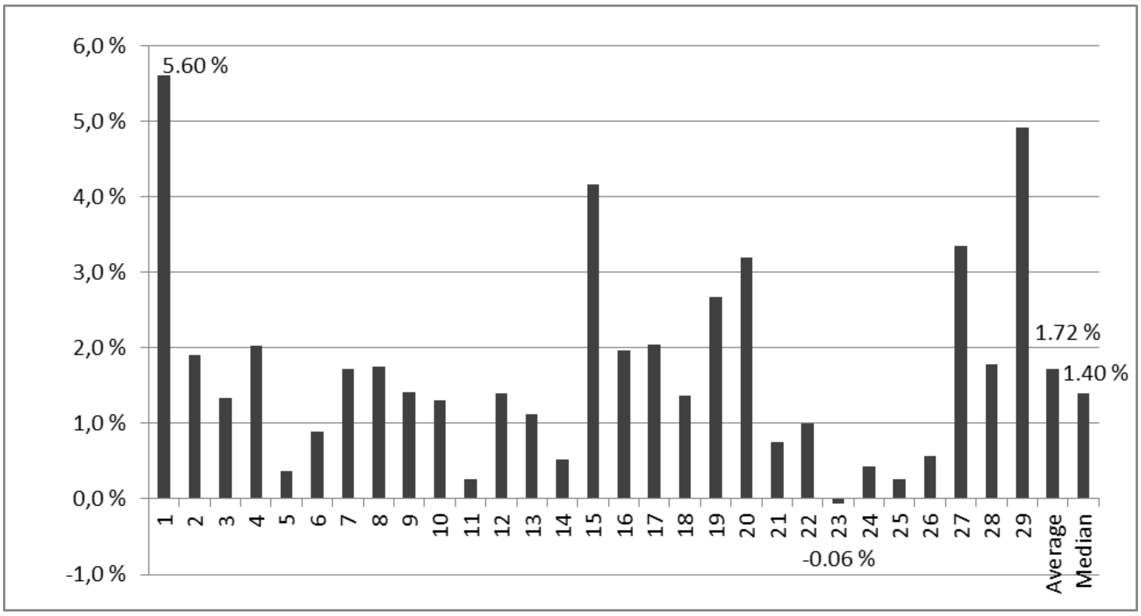

Figure 2: Property value change due to the energy efficiency investments

4.2 Greenhouse gas emissions of energy audit actions

Energy and water consumption activities recommended in the energy audit process had a significant effect on carbon footprint of the property. GHG emission reductions in energy and water consumptions were calculated for 10-year time period, as it is a time frame used in the economical analysis of the energy audit performance. GHG emissions caused by the investments into energy and water consumption reductions and emissions of the maintenance activities that maintain the reduced level of energy and water consumption were then added into the GHG reduction figures.

Based on the average of all 29 cases on the 10-year analysis period, operation of reference property caused approximately 0.89 tons of GHG emissions per net sqm. Operation of energy audited properties caused on average 0.80 tons of GHG emissions. Thus, decrease of emissions is approximately 11 percent. In the case of only including energy and water consumption related GHG emissions of property operation into an account, reference property caused an average GHG emissions of 0.76 tons per net sqm. On average energy audited properties caused GHG emissions of 0.66 tons per net sqm. Energy audit activities reduced water and energy consumption related GHG emission by 13 percent on average of the all assessed case properties compared to the reference property. Cumulative GHG emissions of an average local reference building and an average energy audited building are presented in Figure 3.

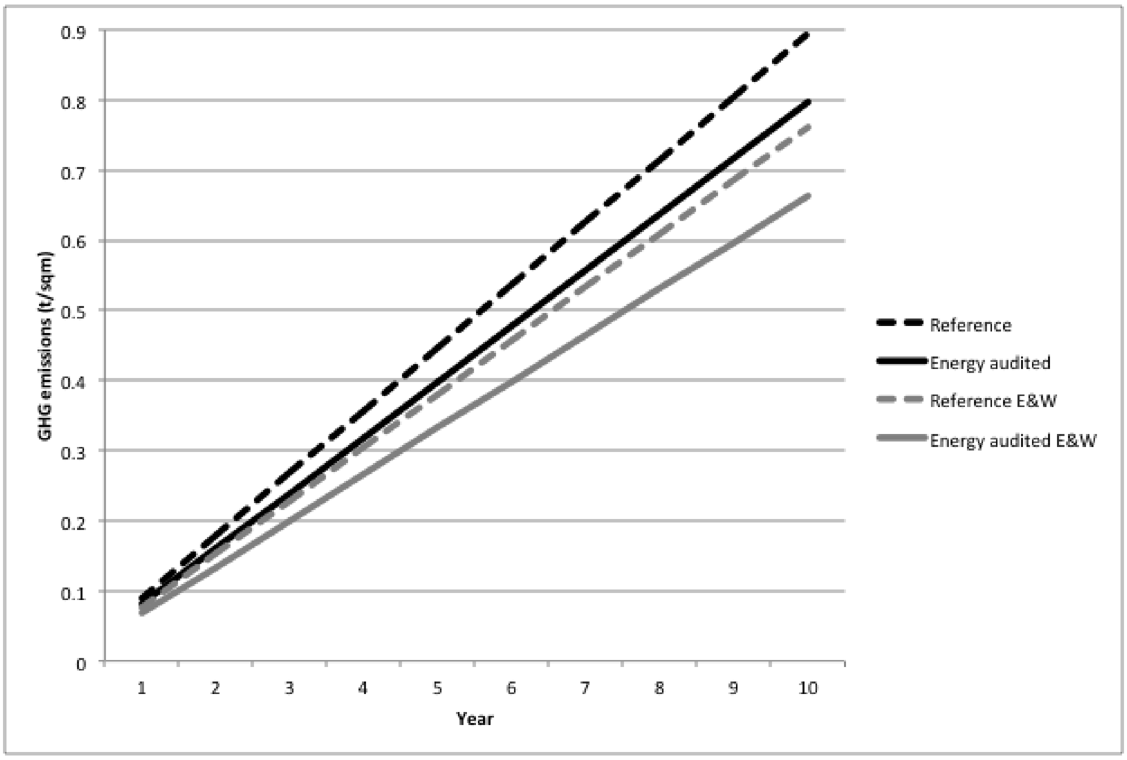

Figure 3 Cumulative GHG emissions of an average reference property and an average energy audited property

Property operation GHG emissions caused by decreased need for electricity, heat and water were also analyzed separately in order to enable comparisons of GHG reductions between different energy types and water. On average energy audit activities reduced GHG emissions caused by electricity consumption by 21 percent. The corresponding figure for district heat was 7 percent. Water consumption focused energy audit activities decreased water consumption related GHG emissions on average by 8 percent.

The activities recommended in energy audit processes had very short GHG payback periods of 1.7 months by average while median GHG payback period of activities was 1.2 months. Accordingly, GHG emissions of activities maintaining the reduced level of energy and water consumption were negligible and hardly visible in cumulative GHG emissions of energy audited properties. The GHG emissions of initial investment and maintenance activities of energy and water consumption reductions were not taken into consideration in GHG emissions payback periods as they occur unevenly during the assessment period.

5. Conclusions and discussion

When the investments were analysed from return perspective, the internal rates of returns were as high as 40.6 percent on average, which could be translated to be a highly profitable investment. On the other hand, the impacts in the overall property returns were 1.7 percent on average, which does not appear to be as tempting at first glance. However, when regarded as absolute value change, the 147,000 euro increase with investment of 34,000 euro is clearly of interest and has significance. Further, it is noteworthy that the positive effects on value change are in line with previous knowledge: e.g. German residential building stock has been reported to yield up to 3.2 percent higher return due to energy efficiency improvements (Cajias and Piazolo 2013).

Indeed, energy efficiency improvement investments could produce tempting returns when analysed *per se*. However, the positive effect on the overall value of the property appears to get diluted, perhaps due to setting too much emphasis on the percentage increase and not on absolute value. Also, depending on the lease structure (net or gross), the operating costs might not even be in the focus of the property owner; in the case of net lease they are considered to be the responsibility of the tenant(s) and in case a net lease is already signed, there is no direct economic benefit. Moreover, since the total project values for the energy efficiency improvement investments are much smaller by scale compared to average property investment values, it could provide another possible reason for regarding the actions so far not always worth conducting.

In the environmental point of view the energy audit activities lead to significant decreases in property GHG emissions. The energy audit activities produce negligible GHG emissions in the investment phase compared to the GHG emissions reductions caused by reduced electricity, heat and water consumption. The GHG emissions caused in the energy efficiency renewal phase, which extends the lifetime of an energy efficiency improvement, are minor as well. Reasons for this are the low GHG intensities of activities recommended in property energy audits compared to electricity and heat generation. This is due to the fact that majority of the costs of energy audit activities are low GHG intensity staff expenses whereas costs of energy generation include use of high GHG intensity fossil fuels. For example one euro causes 17 to 20 times less GHG emissions when it is invested in energy efficiency improvement activities instead of purchasing electricity or heat with the same amount when modelled with the current IO LCA model. This is also the main reason for the better environmental (GHG wise) performance of energy audits compared to the economic performance where one euro of investment leading to saving of one euro is meaningless.

Majority of the energy audit actions were aimed towards electricity consumption reduction and thus GHG emissions caused by the production of consumed electricity in properties reduced the most. Noteworthy point is also the GHG intensities of the energy or water production sector. Saved euro in electricity or heat consumption reduces GHG emissions by factor ten compared to water consumption. The reasons for this are approximately ten times larger GHG emissions per euro of electricity or heat generation compared to delivery of cold water.

There are some limitations and uncertainties related to the results of the study. First, final dataset of the study consists of a rather small amount of properties. Moreover, as it was not possible to obtain the full details of the subject properties due to confidentiality issues, the exact rent or operating expenses for each property were not obtained for the property value modeling. However, as the study analyses the relative change of the values, using market rent and operating expense levels is justifiable. Further, regarding the property value analysis, the possible impacts of improved energy efficiency actions on the yield or achievable rent levels due to for example possible better rentability and marketability of the premises are not included into the study. Thus, the positive impacts on property values (indicating better returns) are analyzed only from the improved net rental income component.

The GHG emission reductions caused by the activities recommended in the energy audit processes were derived by using the savings measured in euros as the initial data for the IO LCA modeling. The properties are located in various Finnish cities and different cities have dissimilar prices for energy and water. Thus, the monetary savings in energy and water are based on different amounts of energy across the cities as the prices differ, which this study does not take into an account. We suggest this as the next step for the future research of the subject in Finland.

While the economic payback periods of the energy efficiency improvement investments were on average 2.0 years which could be considered rather short, in terms of the GHG the payback periods were even shorter, only 1.7 months on average. One possible interpretation of this is that the environmental burden is more quickly eased albeit the economic payback is still within reasonable limits. Thus, the investments appear attractive from both the economic and environmental perspectives.

By highlighting the rather tempting returns on energy improvement actions the authors of this paper accentuate the large energy efficiency improvement potential that properties can withhold. Especially large property owners' portfolio-wide energy efficiency improvement actions could generate significant outcomes both in terms of value increase and decreased GHG emissions, thus taking advantage of economies of scale. Further, there is a relevant business opportunity for an actor that manages energy efficiency improvements of a large building stock as primary business information technology for managing the technical adjustments of building technology. Using the approximate figures the investment for energy audit activities for the 29 properties analyzed in the study would cost 1.0 million euros. The annual savings achieved by energy consumption reductions would be 0.44 million euros. Thus, the IRR using weighted average of lifetimes of savings for improving energy efficiency of the property stock would be approximately 43 percent considering energy and water savings as revenue.

Further, in order to take full advantage of the energy efficiency improvement potential, it will require the distribution of the benefits between landlord and tenant(s) to be clarified in lease agreements in full detail in order to avoid any disputes. Since the energy prices are likely to increase in the future, the unlocked potential that properties withheld is probable to increase in economic point of view.

Future research possibilities could include e.g. implementation of larger dataset of properties and usage of different property valuation modelling approaches. In addition, analyzing the impacts of improved energy efficiency on the marketing and rentability of the premises could provide another interesting topic: this study only considered the value influence through the decreased operating expenses. The reliability of the findings is considered moderate while the amount of properties was low. Larger dataset could provide further reliability and generalizability through the application of quantitative methods.

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Suitability of Project Alliancing for a Customary Apartment Renovation – A Case Study

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Abstract

Frustration felt toward the opportunism inherent in traditional contracting has made the construction sector to develop new collaborative project delivery models globally. This is especially true in Australia, where Project Alliance has been introduced as a solution to the experienced problems. This model has been applied mostly in road, rail and water infrastructure projects. The building and real estate sector has hardly used the mode and exceptions include predominantly only few uniquely demanding landmark buildings involving a lot of uncertainty.

More recently, owners in Finland have started to utilise Project Alliance. In addition to a few infrastructure projects one relatively standard/common apartment renovation project has been implemented in accordance with alliancing practices. The study will focus on this building project and experiences gained from it. More precisely, the objective of the study was to find out whether it makes sense to use Project Alliance in more common projects and on what conditions it benefits building construction involving more parties (i.e. technical experts and subcontractors) than a typical infrastructure project. Interviews with project's participants had a role in the study and results from a survey to parties to the project were analysed broadly.

In the presented case, key features of the Project Alliance contributed for high levels of collaboration between participants and enabled achieving very positive results. Thus, this research work allows concluding that the alliance was definitely worth applying at this relatively small renovation project, although several suggestions for modifications could be identified and should be incorporated in future projects.

Keywords: project alliance, procurement systems, renovation, collaboration, survey

1. Introduction

Construction industry is typically slow in adapting to changes, especially when it comes to construction management, organizational and cultural changes (Naoum, 2003). However, due to the increasing demand for more efficient and integrated approaches, alternatives to the traditional practice are finally being developed. Barnes (2000) supports this by saying that civil engineering management in the next century will be dramatically different from the last, thanks to a growing and long-overdue realization that the traditional forms of contract have had their day. One of the novel collaborative delivery models is Project Alliance (PA), which has its background in Australia where it has been a successful approach for many years in infrastructure projects (Lahdenperä, 2009).

This research work will focus on these innovative delivery models, particularly in a PA in the public sector context in Finland. The purpose of this research is to contribute for a better understanding on the application of a PA to a relatively small building construction project, which is not the most common target of application for PA which has been mostly applied in large infrastructure projects. The main research question is the identification of key PA features and their confrontation with the collaboration and performance levels registered at a specific construction project. In this sense a case study will be considered and several interviews and project surveys conducted will be reported in order to support the exploratory work.

2. Literature review

2.1 Traditional delivery models

Traditional practice can be characterized by models in which the owner and the contractor have a relationship without any degree of objectives alignment or any sort of improvement in work processes (Thompson and Sanders, 1998). Basically, this is the way many construction projects are still executed. This kind of environment can also be described as highly fragmented and individualistic, as involved parties focus on achieving individual objectives and maximizing their profit margins, without a sense of others or the consequences that might result from this adversarial behaviour. As Naoum (2003) describes, most of the traditional procurement systems are adversarial as they still rely much on contractually explicit procedures rather than on mutually agreed methods to achieve financially sound objectives for all the team. Also, this kind of arrangements and projects develop in a transactional and competitive environment that includes the characteristics that can be seen in Table 1.

Table 1: Typical adversarial environment characteristics (Thompson and Sanders, 1998).

▪ *No common objectives; they may actually conflict*	▪ *Little or no continuous improvement*
▪ *Success coming at the expense of others; win/lose mentality*	▪ *Single point of contact between organizations*
▪ *Short-term focus*	▪ *Little trust, with no shared risk*
▪ *No common project measures between organizations*	▪ *Competitive relationship maintained by coercive environment*

Often, this type of mind-set leads to conflicts, litigation and eventually, disastrous projects (Thompson and Sanders, 1998). Another fact about traditional delivery models is related to the inflexibility of their contracts and clauses. That happens because these contracts try to reduce uncertainty, minimize opportunism, and predict and specify every possible contingency by assigning responsibilities and liabilities for each specific project participant in case of change. Knowing that it is impossible to predict and plan every possible event, this sort of traditional practices increases transactional costs and leads to adversarial relationships when anomalies occur emphasizing best-for-individual culture instead of best-for-project culture, and its best example is individuals focusing on protecting their profit and having no interest in collaboration to optimize project performance, with customers and contractors becoming greedy and often assuming a bullying position (Naoum, 2003; Sakal, 2005).

The traditional practice and its compensation models also focus on individual party's performance instead of the overall success of a project. Once again, this leads to individualistic and opportunistic sorts of behaviour. These traditional models might be suitable for slow, simple and fixed scope projects, but the same is not likely to happen for complex projects involving uncertainty and in need of innovation and flexibility.

2.2 Collaborative and relational delivery models

Collaborative and relational delivery models are a powerful tool to fight against inefficiencies of traditional delivery models (Wu et al., 2010; Löfgren and Erikson, 2009). By using both formal and informal measures, these approaches intend, most of all, to achieve a more collaborative joint-development environment among all the key participants of a construction project, ideally involving sub-contractors and suppliers, which are still, unfortunately, often ignored (Bygballe et al., 2010). The formal ones include all the clauses and structure of contracts and teams and all the procedures related to decision-making. The informal ones include more subjective aspects, such as how efficiently entities communicate, how committed they are to achieve overall project success and how they trust and understand each other's individual expectations and values.

Literature refers several types of delivery models, methods, approaches and contracts but there is no consensus among authors. Several mixed interpretations can be found among recent research works. Yet, in the last 20 years there has been an evolution towards a more convergent terminology. For example, Cheung (2010) described that partnering, strategic partnering (see Lu and Yan, 2007), project alliance, strategic alliance (see def. in Cheng et al., 2004), public-private partnership (see Tang et al., 2010) and joint venture (see Walker and Johannes, 2003) are the six major types of relational and collaborative contracting methods. In this research work the PA type has been considered.

2.3 Project Alliance

An alliance is an agreement between actors and has the purpose of integrating goals and operations. As defined by Lahdenperä (2011), PA is a project delivery method based on a joint contract between key parties to a project whereby the parties assume joint responsibility for the design and construction of the project to be implemented through a joint organization, and where the parties share both positive and negative project's risks and observe the principles of openness in cost monitoring and information accessibility in pursuing close cooperation. It should be mentioned, that an alliance has been commonly used in the European context as a general concept to describe collaborative arrangements in general, and not PA and its characteristics in particular (Lahdenperä and Petäjäniemi, 2012).

PA can be defined as an approach comparable with design-bid-build, design-build and construction management into some extent, which has a contractual structure forming a virtual organization with a joint risk approach, differing from traditional risk-allocating frameworks (Lahdenperä, 2012). Characteristics that distinguish PA from other kinds of arrangements include a multi-party contract with joint liability (and risk-sharing) and eventually a co-location arrangement which expects to have the team working at the same place (DTF, 2010). It has been designed to foster collaboration and innovation and enhance levels of efficiency. Based on literature, general alliance principles and characteristics can be structured in five key features which can be seen below in Table 2.

Table 2: Alliance's key features

Features	***Key references***
▪ *Joint agreement and joint organization*	*DTF (2006), Jefferies et al. (2006), Lahdenperä (2011)*
▪ *Joint decision-making and problem-solving*	*DTF (2006), DIT (2011)*
▪ *Open-book and communication*	*DTF (2006), Jefferies et al. (2006), DIT (2011)*
▪ *Team-building: meetings and workshops*	*Jefferies et al. (2006), Yeung et al. (2007), Bresnen et al. (2010)*
▪ *Monitoring performance and job satisfaction*	*DTF (2006), Jefferies et al. (2006)*

First PA construction projects took place in Australia in the late 1990s but the actual breakthrough of PA took place only a few years later and since then hundreds of projects have been implemented using this method. Alliance approach has been evolving and developing significantly from project to project. Projects using this approach include mainly road, rail and water infrastructure projects, with only few exceptions including construction of buildings (Lahdenperä, 2012).

PA was introduced in Finland a few years ago and since then a number of projects applying alliancing practices have been launched. Yet, only three pure PA projects have progressed to the implementation /construction phase so far, and the case project of this study is, in fact, the only one where the construction has been completed and the overall experiences can be examined. In the following sections, further attention will be given to the application of PA in this renovation project.

3. Research method

The paper presents a glance at a research (Amaral Fernandes, 2013) that took place in Finland and included a case study with interviews and project survey analyses. The interviews were formulated based on literature review, the documentation of the case study project and the feedback of the participants in the project. A total of six semi-structured interviews were conducted and they included owner's, contractor's and designer's representatives in equal numbers.

The project survey was initially developed by the parties to the construction project to measure and assess levels of project's performance and satisfaction. The intention was to determine such key result areas (KRAs) on which the incentive system of the commercial model was dependent. By using those survey results descriptive and statistical analyses were made to test/validate research findings.

4. Case project

4.1 Building project

The targeted property (at Vuolukiventie 1b) (Fig.1) was built in 1968 in the Pihlajamäki neighbourhood in north-eastern Helsinki and it is owned by the University of Helsinki. The building was initially designed as a retirement home and had no major renovations since its completion. The case project consists of renovation of the existing, protected buildings (incl. the construction of additional apartments on previously unused space on the basement floor; i.e. stages 1–6) and construction of a new building (stage 7; Fig. 2) on the same plot (adjacent to the street in Fig. 1). The objective was to provide quantity of small, modern apartments (arriving at 306 in old blocks and 27 in the new construction) for international students and researchers at the University of Helsinki.

Fig. 1: Property overview prior to the start of the construction project.

Fig. 2: New building preview (from the yard side; by SARC Architects).

The project by itself is not different from others in general, but precisely because of that, it was considered a good opportunity to test a new procurement approach that intended to maximize the performance and efficiency through collaboration and innovative procedures. The owner's main objective towards this project was to achieve a result that best serves the final use of the facilities and to improve the economic efficiency of the property's use by also involving project's parties in the warranty period of the project. In that regard, the alliance will be responsible for the design and construction of the project, while their liabilities also extend over a 5 year warranty phase. All the contractual parties to the alliance share project-related risks and benefits.

4.2 Establishment of alliance

The selected procurement procedure was the ‘competitive dialogue’ (see Act, 2007; Directive, 2004). The competitions to award design and construction works were combined and both the designer and the contractor were selected as a team. The selection phase had two stages. In the first stage the client (owner) called for candidates and shortlisted the three most suitable tenderers. In the second stage those three candidates were invited to make their proposals. So, candidate teams submitted global designs for the project which were then taken into account in the comparison, in addition to team capability and independent estimator’s estimate on those bases, for instance. The owner’s budget was also efficiently tied to the selection method to guide the proposal compilation. The most advantageous tenderer was then selected in the alliance. Fig. 3 depicts the selection phase and its steps in more detail.

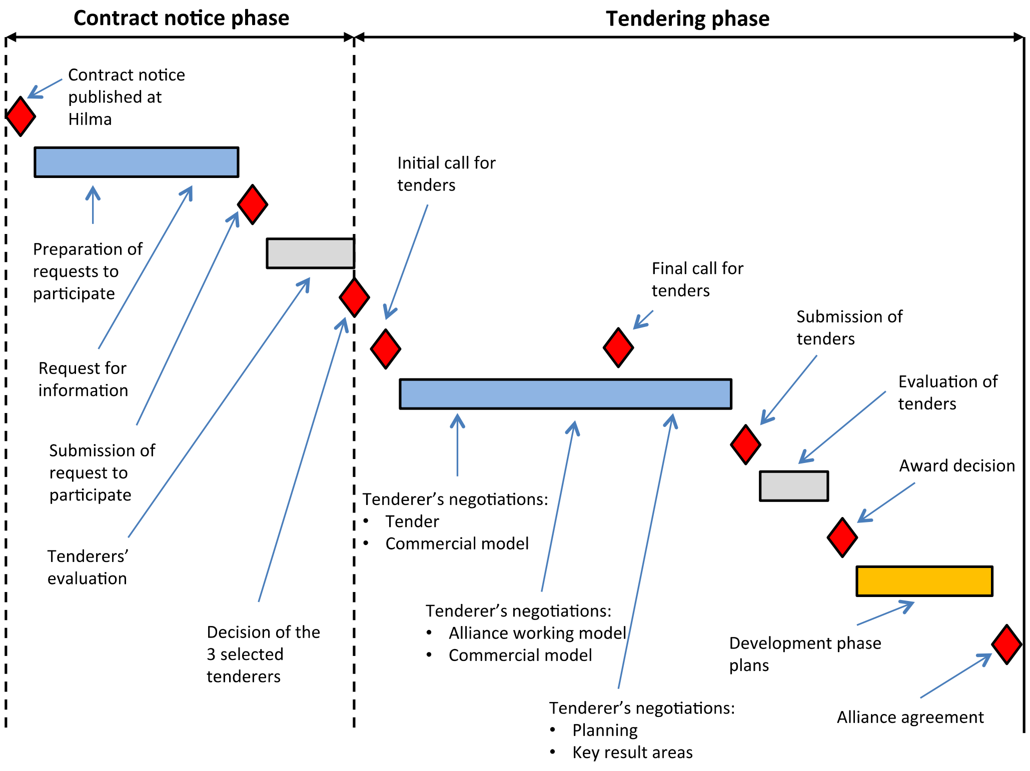

Fig. 3: Selection phase overview.

Alliance was formed by the project owner, main designer and main contractor. Unlike in most forms of traditional contracts, in the alliance model the client and service providers are to reach common understanding on the project costs and KRAs and the corresponding targets are jointly defined and agreed during the project’s development phase. During the implementation phase, positive and negative risks are common to alliance parties.

The project had one alliance agreement covering the development, construction and warranty phases of the project. The generation of the alliance agreement started initially with a draft made by the client which worked as the basis for negotiations during the selection process. After being set up, the agreement included also organisational details, the commercial model of the project (the target cost, KRAs and their price impact, etc.), and the warranty period plan.

5. Results

5.1 Interview results

The results from the interviews completed as a part of the study are summed in Table 3 per party, and classified according to the alliance features deducted in section 2.3 above (see Table 2).

Table 3: Parties' views on the renovation project alliance.

Key features	***Owner's view***	***Contractor's view***	***Designer's view***
Joint agreement and joint organization	- *Closer interaction between participants allowed establishment of common goals and fostered commitment and collaboration* - *Heavy and slow selection phase* - *Early involvement seen as essential for good working routines*	- *High levels of commitment between stakeholders* - *Best-for-project solutions* - *Selection phase was a heavy and time consuming process for contractor* - *Early involvement fostered collaboration*	- *Time-consuming* - *Unclear objectives* - *Better collaboration with the contractor thanks to early involvement* - *Owner's objectives were sometimes unclear to designers* - *Minor decisions should be taken individually*
Joint decision-making and problem-solving	- *Owner shares decision responsibility with other parties* - *Too small decisions had to be unanimously taken* - *Owner does not have the final word* - *Prompt and effective problem solving*	- *Difficulties achieving mutual agreement with owner and designers* - *More solutions studied than traditionally* - *Time spent studying solutions not always led to optimal solutions*	- *Required more time than traditionally since the decision group was wider than traditionally* - *Flexible process since designers were more involved in cost issues* - *More solutions were studied*
Open-book and communication	- *No hidden financial interests* - *Clear and honest communication between participants* - *No blaming culture*	- *Generally positive* - *Contractor had some communication problems on site*	- *Consciousness on others' concerns* - *Talkative environment* - *Everyone within the alliance had opportunity to share their ideas and perspectives*
Team-building: meetings and workshops	- *Fewer meetings during selection phase suggested* - *Workshops should be placed in outset of phases* - *Promoted discussion and problem-solving*	- *More effort should be put on team-building during implementation phase*	- *Allowed people see and openly discuss the project from a wider angle than usual* - *The existence of an alliance counsellor helped by sharing his insights*

Monitoring performance and job satisfaction	- *KRA's, incentives and feedback meetings contributed to job satisfaction and performance improvements* - *KRA's could focus more in project's risks*	- *KRA's and incentives contributed to contractor's job satisfaction and continuous improvements*	- *KRAs made designers' more willing to make compromises and be flexible as the financial bonuses affected participants' attitude towards the project*

5.2 Project survey analysis

In the study the project survey results worked as an assisting tool to help validate interview results. The survey intended to measure levels of performance throughout implementation stages. From the owner's perspective the purpose of the survey was to stimulate improvements between rounds as the areas under assessment were directly connected to the KRAs influencing on alliance members' payments. The survey had six main fields with a total of 26 positive statements in a Likert scale from 1 to 5, where 1 means "Totally disagree" and 5 means "Totally agree". The survey results consisted of seven rounds that took place at the completion of each stage between November 2012 and January 2014 (whereas the actual construction dated from June 2012 to December 2013). Average results per category can be seen in Table 4. A distribution of participants can, again, be observed in Table 5.

Table 4: Performance according to survey.

Key Result Area	***Round***						
	1	***2***	***3***	***4***	***5***	***6***	***7***
1. Schedule	*3,2*	*3,8*	*3,8*	*3,6*	*4,0*	*4,1*	*3,8*
2. Site organization	*4,0*	*4,1*	*4,1*	*4,0*	*4,1*	*4,0*	*4,2*
3. Collaboration and interaction	*4,0*	*4,2*	*4,2*	*4,1*	*4,2*	*4,3*	*4,3*
4. Design	*3,9*	*4,1*	*3,9*	*4,0*	*4,2*	*4,2*	*4,3*
5. Procurement and contracting	*3,4*	*3,8*	*4,0*	*3,9*	*4,1*	*3,8*	*4,1*
6. Quality	*4,0*	*4,2*	*4,3*	*4,2*	*4,2*	*4,4*	*4,4*
Weighted Average	***3,7***	***4,1***	***4,1***	***3,9***	***4,1***	***4,1***	***4,1***

Table 5: Number of respondents by round.

Respondents	***Round***						
	1	***2***	***3***	***4***	***5***	***6***	***7***
Alliance	*15*	*14*	*17*	*10*	*13*	*11*	*9*
Technical Designers/Experts	*5*	*5*	*4*	*5*	*4*	*3*	*3*
Subcontractors	*11*	*11*	*8*	*5*	*4*	*5*	*6*
Total	*31*	*30*	*29*	*20*	*21*	*19*	*18*

The assessments have improved slightly since the beginning as it can be observed from Table 4. As it is possible to verify, the results are positive in overall although some reservation is due to lack of comparable data from other projects. Moreover, one of the most notorious findings comes from the different perspectives on project's course given by survey's respondents. By observing Fig. 4 it becomes clear that technical designers and experts were generally satisfied. Alliance participants' assessment initially increased over project's course until it became approximately constant, which is believed to be related to the alliance features and continuous improvements. However, subcontractors were more critical of overall success of the project which is believed to illustrate their higher vulnerabilities and marginalization over project's planning and decisions, leading to lower levels of satisfaction when compared to other project's participants. Yet, the grade improved in the second half of the project to values closer to other respondents.

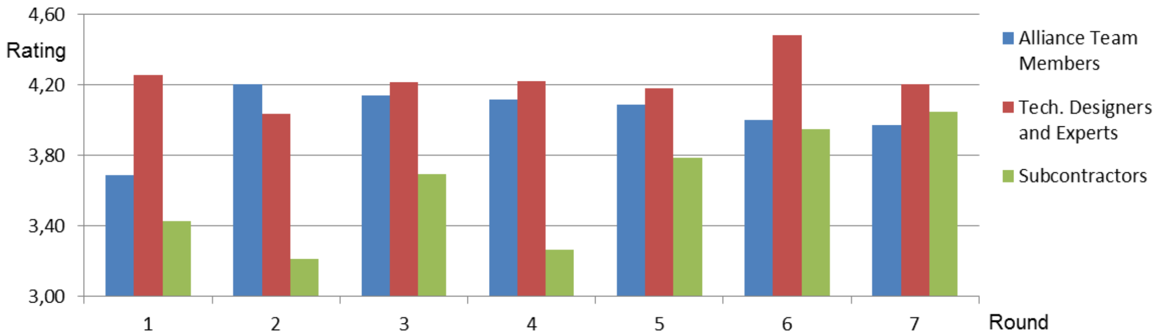

Fig. 4: Project's overall performance by respondent group

6. Discussion and conclusions

The benefits of alliancing in demanding infrastructure projects are well known and reported, but the application in customary building projects is a different question. A lot of case studies have focused on the use of alliancing in infrastructure projects but, to our best knowledge, none has done this in case of a customary building project, what makes the presented work a pertinent contribution.

In the presented case, the PA key features contributed for high levels of collaboration between participants and enabled achieving very positive results. Thus, this research work allows concluding that the alliance was definitely worth applying at this relatively small renovation project, although several suggestions could be identified and should be incorporated in future projects.

The research gave important feedback and insights over PA and its main features and experiences. In terms of project's participants' perspectives, the key features were unanimously seen as an asset and they are believed to have left a decisive impression and preparedness towards future involvement and willingness to be part of alliance projects. As expected, some weaknesses have also been identified. All the major impacts of the PA in the renovation project are presented in Table 6.

Table 6: Impacts of the PA features on the renovation project performance

Key features	***Strengths***	***Weaknesses***
Alliance agreement and organization	- *Higher levels of commitment and collaboration* - *Clear, honest and open communication*	- *Complex selection process* - *The formal agreement itself does not guarantee real collaboration* - *Participants' roles become sometimes unclear*

		<u>*Suggestions:*</u> - *Leaner selection phase with less workshops and meetings* - *Subcontractors should be included in the alliance*
Joint decision-making and problem solving	- *Well-structured and participative process; best for project decisions* - *Project's decisions are jointly agreed by alliance members* - *Problem-solving capabilities are improved by a collaborative and non-blaming atmosphere*	- *Decision process requires more time and resources than in traditional projects* <u>*Suggestions:*</u> - *Decision-making process should be simplified for minor issues*
Open book and communication	- *Improved communication and face-to-face interaction* - *Clear and promptly available financial and technical information drives commitment and collaboration and accelerates decision-making processes* - *Open environment mitigates hidden financial interests*	- *Some participants were not prepared to work under alliance principles, particularly those working only at the implementation phase* <u>*Suggestions*</u>*:* - *More effort should be put to enhance communication among participants during implementation phase especially on site and office*
Team-building: meetings and workshops	- *Smaller and more efficient project meetings* - *Strong commitment and proactive discussion, which improved problem-solving abilities* - *The existence of an alliance counsellor was inspiring and helped foster new practices*	- *Selection phase meetings were heavy and time-consuming* - *Development and implementation phase workshops and meetings were sometimes excessive and misplaced* <u>*Suggestions*</u>*:* - *Selection phase meetings should be simplified and standardized to smaller Alliance projects* - *Development and implementation phase workshops should be introduced since the very beginning to concentrate on the major decisions in the preliminary phases of the project and its use should be limited in minor decisions*
Monitoring performance and job satisfaction	- *KRAs were considered adequately set and it is believed that the incentive system positively affected participants' attitude, encouraging better project performance, collaboration and continuous improvements* - *Project survey, which is directly related with KRAs, was an important tool to assess performance and job satisfaction in the project* - *Feedback meetings after survey rounds also helped to reinforce commitment and continuous improvements over project's course* - *Innovation was encouraged even though this kind of project did not have a lot of space for innovations*	- *An excessive number of questions might have made the survey too heavy and time consuming* <u>*Suggestions*</u>*:* - *The number of survey's questions and KRAs should be adapted to the complexity of the project* - *Monitoring efforts should focus specially on project's risks*

Another important finding was the perception that subcontractors should play a more important role in an alliance project, firstly, in terms of better contracts with adequate clauses. More importantly, subcontractors' views should also be taken into account in the decision-making process, since they can help to improve project's efficiency in terms of costs, schedule and quality by sharing their insights and know-how. It is, however, recognised that this will be a challenge since even now joint decisions took much time and effort although joint decision-making was mostly considered a positive feature. On the other hand, the idea of subcontractors stronger involvement is not totally new in alliancing while in some other parallel, relational contracting philosophies subs are often included even in multi-party contracts (cf. Lahdenperä, 2012), which therefore also supports the understanding that such an improvement could be done.

All in all, the experience in the case project indicates that involved parties recognized the benefits and limitations of PA, but most of all they unanimously agreed that it has a huge potential for future projects, under certain circumstances, as defined before. Thus, the application of PA in more customary building projects is pertinent and recommended although some further developments should be encouraged. This is not yet to say that it is for all projects, however.

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The Futures of Construction Management Research

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Abstract

Construction management has established itself as an internationally recognised area of research with an established and growing community of academics. It has grown from largely 'research consultancy' activities to attracting large amounts of academic research funding, and has partially moved away from its applied, engineering dominated origins to increasingly engage with, and contribute to, mainstream academic debates in business and management, economics and the social sciences. It has as such become an academic field in its own right. However, recent dynamics within both university institutions and national economies are now changing the landscape of construction management research. A global economic crisis, reprioritisation of research funding and increasing emphasis on national and international rankings lead to increased pressure on individuals academics. In this paper we ask what, in the face of a turbulent environment, might the futures of construction management research be? We outline four potential futures for construction management research, which are depicted as four potential scenarios; convergence, retrenchment, disappearance and hybridisation. Our intention is neither to predict the future, nor prioritise one scenario over another, but merely to begin an open debate on the institutional pressures we are facing, their possible outcomes and the future of our community.

Keywords: construction management, futures, institutional trends, academic fields

1. Introduction

Since the 1970's construction management (CM) has established itself as an internationally recognised area of research with an established and growing community of academics. Over this period, construction management research has grown from largely 'research consultancy' activities to attracting comparatively large amounts of research funding, and has partially moved away from its applied, engineering dominated, origins to increasingly engage with, and contribute to, mainstream academic debates in business and management, economics, and the social sciences. Recent dynamics within both university institutions and national economies are now changing the landscape of construction management research. Noticeably a global economic crisis has not only stilted growth of construction sectors internationally, but also has resulted in a reprioritisation of research funding. Universities in general are also in transition, with increasing emphasis on national and international rankings leading to increased pressure on individuals to publish, increased competition for student recruitment and pressure for commercialisation and 'spinning out' of research activities. In the face of this turbulent environment it is worth posing the question of what the futures of construction management research might be. In this paper we build on Harty and Leiringer (2007; 2008) in briefly discussing some emerging trends in institutional pressures and how these can affect the CM community at large (note: we see CM as related to, but distinctively separate from, construction technology). Our, perhaps rather grand, aim is to lay the foundation for a discussion on the future of construction management research (CMR). In so doing we make no pretence to be objective, neither do we set out to portray a reality that it is shared by one and all. This is simply not possible!

To start we provide a broad sketch of the origins and development of CMR. We make the case that even if it is not always possible to provide clear boundaries the necessary characteristics for it to be considered an academic field exists. The argument is then turned to the many co-existing pressures that CM academics face and an attempt is made to position these against increasingly noticeable institutional trends. Building on this contextualisation we then outline four potential futures for construction management research. We suggest four potential scenarios; *convergence*, *retrenchment*, *disappearance* and *hybridisation*. *Convergence* represents the development of a consensus on the core topics and problems that CMR is concerned with, the methodological approaches to address these, and a set of distinct construction management journals in which they are disseminated. *Retrenchment* describes a move away from 'academic' funding and research programmes, towards a core of delivery of industry-approved teaching, and shorter-term consultancy activities for the construction sector. *Disappearance* is a narrative of construction management dissipating as a distinct entity, with academics and research moving from construction management schools and departments into business schools, social science departments and engineering faculties. Mainstream journal outlets, general funding and broad academic quality become the benchmarks for success. *Hybridisation* describes a scenario where CM retains its distinctiveness, continues to respond and be close to industry issues, but also is able to attract academic funding and contribute to mainstream knowledge generation. We refrain from drawing strict conclusions as our intention is neither to predict the future, nor prioritise one scenario over another, but merely to begin an open debate on the institutional pressures we are facing, their possible outcomes and the future of our community, and what is, compared to others, a young academic field. In reality, none of these will come true, but there are elements of possibility within each of them.

2. The construction management field: at a glance

Although there are several examples of early chairs in building economics, CMR has its home within the engineering sphere, has frequently been associated with the more technical disciplines, and has been dominated by the 'engineering paradigm' of knowledge creation. However, over time, the breadth and scope of what is commonly included in the term construction management has expanded, and long gone are the days when it was an extension of operations management in the construction context. CM is today populated by individuals with vastly varying backgrounds who do not necessarily share the same ontological and epistemological perspectives regarding the methods they mobilise and the products that their work generates. These academics nonetheless coalesce to form recognisable organisations – e.g. research groups, divisions, departments, schools and faculties. Hence, while we might not be able to agree on a clear cut definition of the term, it is not too farfetched to conceptualise construction management research as an academic field in its own right, with a relatively easily defined membership. CM academics are also governed by a network of social relations as they regularly interact through multiple activities and events such as: the refereeing process of books, journal articles and research proposals; edited books; co-authorship of books and articles; visiting professorships; the external examination system; membership of various committees and professional bodies; national and international conferences and; numerous seminars, panels and events. Accordingly, it is possible to conceptualise CMR as an arena with particular co-evolved logics representative of the configuration, coherence, interests and formation of its members over time (cf. Oliver and Montgomery, 2008). In short, CM is an academic field. As a field, it has a set of objectives and historical relations anchored in certain forms and relations of power (capital) (cf. Bourdieu and Wacquant, 1992). CM organisational units are subject to reputational and regulatory pressures, such as research assessment exercises, publishing conventions and promotion boards. But the pressures are not only academic. Research requires participants; individuals, firms and sectors which see value in the work we do, but also have their own ideas about the function and contribution of an academic CM community. This spans the spectrum from an interest in long term, theoretically informed research, to short term, problem solving, and directly impactful outcomes. The relevance versus rigour debate has been well rehearsed over the last few decades (cf. Pettigrew, 2001) and is likewise playing out in CM, which is arguably experiencing a growing tension between having an impact on industry and demonstrating academic excellence. In other words, what CM researchers, around the world have in common is that they consistently find themselves facing numerous institutional challenges and inconsistent demands. Obviously conditions vary between contexts, but in short industry is often characterised as wanting easy, directly applicable solutions. Research funders want industry-engaged, problem-solving research which demonstrates impact on the one hand and publications in quality journals on the other; and their priorities and funding systems are forever changing in attempts to resonate with industry and government. Universities as employers, place pressure on researchers in the form of: winning funding; the quality dissemination of corpus knowledge through teaching; and publication of cutting edge research that both addresses industry problems and maintains and enhances the academic reputation of the institution. The outcome is the diversity and heterogeneity of CM and the wide range of research activities undertaken; pure and applied, practical and abstract.

3. Gaining academic recognition and having an impact

To better understand these pressures, and how individuals have responded, it is useful to look at how recognition is gained. Breslau (1997) proposes that recognition is gained in contrasting social arenas. He refers to Bourdieu's concept of 'capital' and to the suggestion that individuals work to amass various forms of capital (economic, cultural, etc.), which have significance within different fields. Breslau develops the idea that 'credibility' constitutes one such form of social capital within business and academic domains. Logically, for research to be relevant and academically sound, it needs to be credible in both locations. The problem is that the mechanisms through which credibility is endowed are not the same in each. Within the academic field, established reputational sources of credibility are underpinned by a disciplinary structuring of knowledge and peer review. As such, academia revolves around a number of more or less internally consistent and relatively homogenous structures. At present, credibility is increasingly dependent on citation indicators, and the 'value' and 'quality' of an academic journal publication is measured against the number of citations it gets. For universities, in general, citations and journal rankings have long been used as an index of institutional quality and as a means to establish prestige. Thus, publications in high ranking outlets and citations accrued by academic departments are significantly related to rankings of their academic quality (Judge et al, 2007). The ISI index, with all its flaws (cf. Macdonald and Kam, 2010), has become a dominant measure and is recognised in most countries.

Several key institutional trends are shaped by (and reinforce) this view of academic credibility. For example, evaluations of 'research excellence', in various guises, are becoming ever more common across the world. In general, these are predominantly based on evaluation of publications, and the results have a significant impact on the allocation of state funds. Similarly related to university funding is the increased competition for international students. Doing well in the various university rankings, such as the Times Higher Education ranking, in which citations and publications are significant factors, is crucial in in this competition and accordingly has gained in priority. Another example is the emphasis and weight given to publications and citation indexes by major funding bodies. In summary, all this leads to mounting pressures on individuals to publish, preferably in the right places, and has led to the development of official and sometimes highly unofficial reward systems that incentivise (or coerce depending on the view taken) authors to publish in certain types of outlets. The end result is a university system where publications, citations and impact factors are intrinsically linked with the procedures of appointment, promotion, pay and external funding decisions. For established academic disciplines and mature fields this provides a rather consistent playing field, but in CM the ideas of disciplinary structuring through reputation are not at all straightforward. To start the majority of the journals in the field, including most of the more ‘prestigious’ ones, are not ISI listed. Most research directors have grown accustomed to putting forward convincing arguments to this effect to the higher echelons of the university hierarchy, but these ‘rules of the game’ unavoidably puts the CM academic unit at a disadvantage against other departments and faculties. To publish in journals outside the field necessitates a shift in cognitive gears, and can to various extents force a change in methods applied. It is also worth noting that the calls for interdisciplinary approaches to real world problems made by research funders such as national research councils do not juxtapose easily with the disciplinary based structures of academic assessment through journal publication. These disciplinary based mechanisms are themselves reproduced by the present methods of the Research Assessment Exercise conducted by those very same institutions calling for interdisciplinarity – quite a paradox.

4. Gaining credibility outside of academia

If we instead look at the status of research within the private sector, we will find that it is much more heterogeneous. Credibility and recognition is conferred by multiple external groups, including advisory panels, research funders, industry spokespersons and practitioners. In business (broadly defined), credibility comes from the practical (and non-academic) implications of research, and from its utility as a resource for controlling, influencing or understanding business contexts. Thus, looking at academic outputs from an industry perspective it is clear that the effectiveness of the resultant outputs in actually impacting on industry and society is not deducible from citation indexes or journal rankings. It is indubitable that few in industry would ever worry about citations or which journals academics choose to publish in. Much more important are the direct benefits that might accrue from the outputs of the research endeavour in question and the perceived competitive advantages that these might bring with them. In terms of framing research; potential impact is good, but easily identified benefits are better! There is little doubt that industry prefers short term solutions ahead of potential for long-term impact. So too, it seems, do policy makers. Why else would there be so many and so frequent reviews and initiatives urging the industry to do better (cf. Fernie *et al.*, 2006)? Thus, research closely focused on solving current industry problems, and hence with supposedly high relevance, is favoured. Recent trends towards increased emphasis on match funding by national research councils can be argued to be further increasing industry influence on academic research. Furthermore, as well as thinking about the different networks that individual researchers inhabit, and the activities they perform in getting funding and doing research, the wider institutional contexts in which they operate should also be considered. Increasingly there are moves to physically bring academia and industry closer together. This takes many forms, but is noticeable in: the provision of space for start-up companies; the establishment of science parks on or near university grounds; and the co-location of commercial organisations and academic units. Universities are also increasingly moving into areas such as spin-off commercialisation of research outputs and consultancy. Indeed, ‘enterprise’, commercial as well as social, has become a key strategic theme. This means that in practice, construction management researchers have to sell their ideas (and themselves) to a range of potential customers in competition with other players in turbulent and increasingly overlapping marketplaces. It is not quite so simple as offering distinctive qualities or 'unique selling points' of academic research – which traditionally has tended to be its scholarly rigour; its particular (non-business based) approach to understanding; and its commitment to long-term knowledge development. It follows that trying to find middle ground and negotiate between academic and practical impact is no trivial task. Indeed, some have gone as far as stating it to be unrealistic as the two sets of requirements are incompatible (e.g. Hammersley, 2000). The issue is not made easier by that *a-priori* selection of themes – variations of which could be argued to be the standard environment in the non-neutral research agenda - to large extent determine outcomes of research. It should also be remembered that academic research is just one possible route to new knowledge production, with others typically including consultancy, training, and using the skills of in-house staff.

5. Universities provide education

It is easy to get carried away with arguments around research agendas, relevance and rigour, and how to view and assess research impact. Hence, further to the arguments provided above, it is important to stress that research is not the only, or even the main, activity of universities, either practically or economically. Teaching is central to a university's success, and competition for attracting students is fierce. This too brings with it inconsistent demands regarding the focus of research and dissemination of outputs. Academic teachers and researchers are expected to respond to new and emerging problems and to engage with current non-academic priorities. At the same time, academic institutions are expected to provide a relatively stable platform of knowledge (i.e. text-book learning) in digestible chunks, which informs and sometimes even constitutes the activities, problems and contexts of 'construction' and 'construction management'. There are, indeed, tensions between training students to become effective practitioners, and to provide an academic education. This is not least apparent in the professional accreditation processes. There are now even trends towards universities in countries that historically have not had the professional system (e.g. Sweden) to start looking for professional accreditation for their courses as a means to remain competitive on the international scene. Somewhat paradoxically, according to many managers, university teaching in general often does not provide industry with individuals possessing the relevant skills to increase firms' competitive edge (Pfeffer and Fong, 2004). But it remains the case that the success of university institutions is largely governed by the attraction of students, which is at least partly derived from the employability of graduates with qualifications from specific schools or universities. Also, worth noting here is the increased provision of continuous professional development (CPD) and company bespoke courses (at times at the scale of academies) offered and accredited by universities.

6. Four future scenarios for the CM community

If the discussion above tells us anything, it is that construction management as a field of enquiry is dynamic, and currently facing a number of pressures. In the past we have described how individual academics respond to these pressures as 'playing the game' (cf. Harty and Leiringer, 2008); and by this we do not mean dubious practices such as writing clubs, citation clubs and salami slicing etc.. We have noted that within academia, established reputational sources of credibility are underpinned by a disciplinary structuring of knowledge and peer review. As such, judgements of academic outputs revolve around more or less internally consistent and relatively homogenous structures, even if some of these might disadvantage CM over other more established disciplines. The status of research within the private sector, on the other hand, is much more heterogeneous. Our argument has been that CM researchers, in general, are very good at working with industry and getting research funding. Indeed, many researchers and research institutions pride themselves on developing and maintaining long-term relations with both research funders and industry partners. We have further argued (*ibid.*) that CM academics are more or less sensitive to the larger contexts in which sectors, businesses and other institutions, such as universities and research councils, operate, and that most would try to take measures to position their research accordingly. Thus, CM academics have adapted to these different criteria by playing multiple games across different stakeholder arenas. It is through concerted efforts to play these multiple games that ideas and outputs are constituted and transformed as they go through processes of funding, researching and publishing. So far, our argument has revolved around the plight of the academic within the CM community, or academic field. But we recognise some potential institutional risks here. Swinging too far towards impact and relevance can come at the price of drifting away from the epistemic terrains of academic research (cf. Elzinga, 1985). Too far the other way potentially removes us from both our empirical context and our market for our graduates. CM is a relatively new area, but neither of these options feel sustainable in the long term. So instead we now begin to tentatively extrapolate some of these dynamics – the institutional pressures around publishing and funding, the increasing emphasis on 'impact' or relevance, the shifting landscapes of construction sectors – from a CM community or field perspective, rather than at the individual level. In doing so we can imagine a number of potential future scenarios of CMR and these are outlined below. We would reiterate here that these scenarios are not predictions, and we are not trying to propose any scenario over another. Nor are we trying to privilege any set of activities over another. Furthermore, we are not claiming that the sorts of activities variously described below are novel or our own invention; they are, in one form or another to varying degrees, happening already. But as tools for thinking about the continual development of CMR these scenarios demonstrate, if nothing else, the range of potential futures ahead. So we suggest four potential narratives of the future below; *convergence*, *retrenchment*, *disappearance* and *hybridisation*.

Convergence: This scenario considers the harmonisation of the body of knowledge and set of research problems around which construction management might be oriented. The development of disciplines can be roughly characterised as moving towards increasing specialisation and fragmentation, for instance into various sub disciplines or lines of tension or as converging on a set of specific problems, epistemological positions or empirical spaces. Indeed, Kuhn's model of 'normal science' describes the slow accumulation of new knowledge around established and consensual theoretical positions – paradigmatic revolutions are both few and far between. The consistent calls for the CM community to become more cumulative in its knowledge production, and to stop reinventing long-standing problems and repeating existing research studies, could be one driver to bring about this scenario. Another driver might be the institutional pressures to position research intensive CM schools, departments and divisions as having a distinct and clear identity within the university, in order to compete for internal resources and support. The need to improve citation rates is a further potential driver – a shift towards a narrower and more incremental agenda could lead to more consistent and regular citation of previous related work. In terms of relevance, the continual search for improvement would presumably find favour across large swathes of any construction sector. However, this needs to be approached with caution; existing, similar work may seem alluring and straightforward in terms of application, but the actual uptake of academically derived redesign of construction firms or processes has been arguably limited. In research terms, this scenario implies shared approaches and languages to enable gradual accumulation and incremental additions to an accepted knowledge base. Institutionally, CM becomes more cohesive, homogeneous and clearly differentiated from related disciplines (such as social science management and organisation studies). In terms of funding, the research agenda certainly would reflect an emphasis on impact, and a coherent voice might have more persuasive power in terms of expressing the need for research funding. Our journals would become similarly more coherent and cohesive, with the potential to compete reputationally with what we would call 'mainstream' journals on the basis of increased citation rates, potential ISI ratings and so on. A strongly focussed community would lead to journals which reflect and represent this focus. Where exactly the main focus would be put is by no means evident. But there has always been an extensive amount of research around improvement and efficiency issues within construction management, such as learning across projects, critical success factors for projects or firms, productivity (at organisational and sectoral levels) and so on, which, implicitly or otherwise, generally adopts a positivistic and instrumental / rational perspective. This application of broadly operations management oriented approaches could come to define a coherent research agenda for the CMR community. However, this would narrow the opportunities for diversity, and in a community sense, risks the ostracising of those few voices which speak outside of the accepted majority. Indeed, one of the key characteristics of CMR is its diversity, and the way it (sometimes well, sometimes less well) draws on a whole range of supporting disciplines.

Retrenchment: If we consider the development of construction management as a field of study, its (rather short, compared to most) history can be characterised as moving from an initial focus on supporting industry, through consultancy, provision of specialist expertise and response to emerging sectoral or policy shifts, to one where the community looks outside of itself and engages with theories, methodological approaches and debates outside of construction management – whether within the social sciences, organisational studies or elsewhere. But publishing in high quality journals outside of CM is a challenge for the community. Indeed, the reputation-building activities which are part and parcel of the academic profession (as well as of career advancement) is time consuming within the community as it is, let alone taking on other disciplines. It is a fact that construction management research is not highly cited outside of CM journals, and not seen externally as contributing to debates in more established disciplines. As we have argued, this lack of publications in high impact journals, and citations thereof, is increasingly likely to impact on funding possibilities. The competition for funding is increasing, and lack of reputation, profile and disciplinary background can act as a barrier to accessing funding sources more usually associated with social science (or hard-engineering / science). Developments in national and international university rankings, with citations becoming a key indicator, also serve to undermine CMR's standing within the university. In spite of this, the community would always be required to teach and train the emerging generations of construction management professions and provide specific post-graduate training. This requires an understanding of the industry graduates will enter, and the continual development of sector specific knowledge and capabilities as the sector itself evolves. Retrenchment describes a scenario where the community withdraws from the pursuit of 'pure' funding, academically oriented publication and research drawing on established disciplines. In fact, it is something like a return to the roots of the area. Strong and successful undergraduate and post-graduate recruitment and education delivery would keep construction management's identity and positioning within universities as both an income generator and provider of specialist education. Closeness to industry remains, and the gap between university and practice is closing rather than widening. Consultancy and the provision of specialist expertise to the industry for more short-term oriented problems are the main non-teaching activities for CM academics. Journals become much more practitioner oriented, reporting case studies, or developments within the sector, with less emphasis on drawing on or standing alongside, academic perspectives from other disciplines. In many ways this looks like a healthy scenario for construction management as a community with a combination of a strong institutional position and closeness (and hence relevance) to industry. However, this potentially spells the end of the nascent development of CM as an academic discipline with its own body of knowledge, set of approaches and character. It could also lead to a potentially tenuous position for departments in institutions which consider themselves more 'research active' and given the fact that national league tables tend to privilege these in the rankings, it might eventually damage the academic reputation of our education programmes within the sector. Individuals might also find themselves forced to change job titles as to 'fly under the radar' in research assessment and ranking exercises. A further risk with being overly close to industry, and responsive to industry demands, is that of continuing to follow whatever fads, fashions or policy improvement agendas that are currently rolling out. Chasing relevance could remove a small but important function of our community; that of being a critical voice of both policy and the activities of the sector, and an advocate of those who run counter to the instrumental rhetoric of 'business'.

Disappearance: It is not far reached to describe construction management research to be occupying a rather uncertain space in academia. Juggling industry relevance while competing in a crowded academic space of two to four year publication processes, large data sets, disciplinary conventions and, not least, a diverse set of similar (but perhaps more established) research communities. Competing in the various established disciplinary spaces is a significant challenge, but what if, as a community (rather than individually), we were to be successful? Success in this sense would be: publishing, and being cited, in mainstream social science and organisation, rather than construction management specialist journals; securing the majority of our research income from social science finding bodies; and establishing construction management as an empirical field, and CMR as a community of academics, which makes substantive contributions to debates about individuals, organisation, and society. Would this mean the end of CM as a community with a distinct identity? This scenario suggests a widening disconnect between research and teaching, with the latter's focus on providing transferable skills and sector specific practical knowledge, and between research and industry, with the latter's practical and short-term focus and emphasis on productivity and efficiency. This raises some fundamental issues. Firstly, what would happen to our education programmes? We already hear of large consultant and contracting organisations who no longer want to recruit construction management graduates; rather they want to recruit civil engineers, architects or scientists, and then train them in management internally. At the same time professional accreditation is increasingly prioritized. Construction management degrees are dependent on demand for graduates, so if this demand declines, so does student recruitment. Secondly, industry impact becomes a secondary concern to more introspective (and rigorous) academic research. The connectivity we have with the sector will inevitably be weakened through this, and although this removes the problem of becoming a handmaiden to industry, the relatively unproblematic access we currently tend to enjoy will become more of a challenge, and long term relationships difficult to establish and maintain. These two issues are intimately linked. A large part of the demand for graduates stems from the sector recognising that we know something about construction management, that we have a profile as a community contributing to the sector, and that we provide knowledge that the sector lacks. If we take away this level of relevance and engagement, our reputation in industry could diminish, and the demand further decrease. Research is, then, longer term, and much more oriented to a different academic community; indeed the full implication is that we merge with, or are subsumed within, more established academic disciplines. In research output terms, specialist construction management journals also disappear, as academics relocate to non-CM departments, and submit to non-CM publications. In this scenario, construction management as an area with a distinct identity and existence inside universities disappears. The community becomes a diaspora across a range of different disciplines and institutional departments. Construction becomes just an empirical domain, the subject of academic scrutiny from organisation scholars and social scientists. It is no longer unique, although it does make a contribution to knowledge within these disciplines.

Hybridization: There have been a number of discussions in recent years within construction management about the notion of co-production (cf. Harty and Leiringer, 2008; Green et al., 2009; Stokes and Dainty, 2010). This is defined as the development of both research agendas and questions, and new knowledge which comes from it. Hybridization might be one way to describe this synthesis of the problems of relevance and rigour. Rather than take one over the other, or indeed try to do both simultaneously, research becomes an integrated process which clears the double hurdles. It retains academic rigour, demonstrated through both the strength of specialist construction management journals and the community's presence in mainstream social science and management fields, and the field demonstrates the academic and impact reputation necessary to maintain healthy streams of funding. Cross citation between construction management and other areas leads to the rise of higher impact-factor CM publications, and the positioning of construction management within the agendas of business schools and similar. What is significant here is that it is not about combining all the 'good bits' of what the CM community does. Instead, if we push the scenario further, it implies new ways of developing and conducting research, of producing new knowledge, of achieving impact and quality. Future research agendas will not be developed independently or *a priori*, but emerge from the interaction between the industry and the CM community. We will not be responding to specific problems, or policy and organisational agendas around efficiency, productivity, use of technology or whatever. Instead, we are developing new questions, new foci and new approaches to enable responsiveness, continual feedback between participants, and the ability to flex with emerging challenging and interests. This requires not only a shift in the practices of the community, but also a shift in the expectations and practices of the industry. This is all well and good, but a significant change in practice also implies a significant change in the institutional accoutrements around them. Does this model of hybridization fit with the contours of existing construction management departments? Or with existing social science or business schools? Probably not. The nearest we possibly get to this are university hospitals with a strong connection between research, teaching and practice, but they do have the advantage of the well-established methodical approaches, and cohesive, incremental knowledge production described in the convergence scenario. Admittedly, there are, as previously mentioned, tendencies for universities and industry to co-locate and physically come closer together. But can we imagine the corollary university contracting organisation? A hybrid academic department with academics and practitioners moving in and out, with activities of research, teaching and consultancy (or even 'work') being indistinguishable from one another? This would mean a very different institutional business model for CM schools and departments. Are new models of funding needed, where a mix of government, sectoral and individual firm resources are combined? If so, this implies quite a radical change; not only in allocation, but also in the ways funding achievements are recognised and rewarded in terms of career progression, resourcing and so on. A new model of research output is also implied outside of demonstrating a particular version of academic rigour. We are effectively producing a new type of knowledge that is neither academic nor practical. Hence, what at first appears a persuasive and sensible third way around the impact versus quality (relevance vs. rigour) debate in fact becomes the most ambitious scenario, and the least consistent with emerging trends.

7. Discussion and concluding remarks

A formidable hurdle is that of achieving a closer integration with the wider base disciplines of the social sciences whilst at the same time retaining the field characteristic skills of high contextual knowledge and the ability to interact with industry. One solution might be to think of CMR as having a certain amount of 'interpretive flexibility' to allow it to be shaped or mutated in different ways according to its intended audiences. Following from this, beneath this flexibility must lay core research activities which represent the real and autonomous interests of researchers. Questions then arise of precisely how much flexibility the 'core' research inherently has and to what extent the shaping of research ideas can be separated from the research process itself. And how would we avoid the problem that in attempting to satisfy multiple audiences, the research itself becomes somewhat diluted or stretched, and thereby loses or changes its focus – Elzinga's (1985) 'epistemic drift'? As the priorities of academic institutions shift in responding to new external pressures, for instance demands from government to engage more with industry or to demonstrate the non-academic relevance of research, so too do their research agendas and research processes. This paper is about raising questions and has been written from a self-consciously confrontational perspective. The objective has been to illuminate the structures that govern the CM academic field and explore the potential impacts thereof. Given the nature of the exercise we are certain that there are trends that we have missed and that we might well have up or down played the importance of some of those that we have reported on. We have refrained from getting into a discussion about what is right and what is wrong; or what is good and what is bad. But if we do claim to make a strong argument here, it is that the CMR community as a field, in the light of current institutional trends, is not capable of continuing playing multiple games, and that whatever the alternatives may be, the field is in a crucial period of transition. Our hope is that this stimulates debate and hence contributes to the development of the field.

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Designing Healthy Homes

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Abstract

Recent research into the relationship between health and housing is dominated by two recurring themes: first, the influence of deprivation and poor housing conditions on measures of health (e.g. POST 2011; Thompson et al. 2009; Easterbrook 2002), and secondly the political and technological agendas that are shaping notions of healthcare at home (Steventon et al. 2012; Harris 2010). Both themes draw attention to the home as a place of sickness and care but ignore much of the socio Cultural literature on the notion of the home as a place of meaningful spaces and practices (e.g. Cieraad 2010; Daniels 2010; Manzo 2003; Easthope 2004). Investigating the links between the home and practices of wellbeing requires a more holistic understanding of how the home contributes to healthy living, beyond issues of sickness and care, to see how space is used, what practices are created and maintained and how they can be set into socio cultural contexts. In the words of the World Health Organization, being healthy is "a state of complete physical, mental and Social wellbeing, not merely the absence of disease or infirmity" (WHO 1946:2). In line with that definition, this paper advocates the need to look more closely at issues of health and wellbeing inside the home, and considers ways that we might usefully investigate the domestic environment with a view to promoting health in the widest sense as a fundamental driver for the design of the homes of the future.

Keywords: health, wellbeing, design, homes

1 Introduction

This paper sketches the context for a new research project – 'Designing Healthy Homes' – by outlining the key themes to be addressed and describing how methodological challenges are being confronted.

The relationship between health and housing is dominated by two recurring themes: first, the influence of deprivation and poor housing conditions on measures of health (POST 2011; Thompson et al. 2009; Easterbrook 2002), and secondly the political and technological agendas that are shaping notions of healthcare at home (3MillionLives 2012; Harris 2010; Steventon et al. 2012). Both themes draw attention to the home as a place of sickness and care but ignore much of the socio-cultural literature on the notion of the home as a location of meaningful spaces and practices (Cieraad 2010; Daniels 2010; Easthope 2004; Friedman 2010; Manzo 2003 etc.). Investigating the links between the home and practices of wellbeing requires a more holistic understanding of how the home contributes to healthy living, beyond issues of sickness and care, to see how space is used, what practices are created and maintained, and how they can be set into socio-cultural contexts. According to the World Health Organization, being healthy is "a state of complete physical, mental and social well-being, not merely the absence of disease or infirmity" (WHO 1946:2). In line with that definition, this paper considers how being 'healthy' as a holistic sense of well-being, is contextualised in the domestic arena, to better understand the ways that individuals and households make sense of their construction of a healthy space. Methodologically, an anthropological approach to data gathering is suggested, along with the need to use an intermediary device to facilitate effective discussions between industry professionals and lay-designers, in particular by using a Virtual Reality Environment (VRE) as part of a design package produced by the householders.

2 The home as a place of healthcare

The current political and socio-economic climate in the UK is driving the need to change health service infrastructure, including a key concept to view the home as an effective location for care delivery (Dyck et al. 2005; Ham et al. 2012; Lansley et al. 2005). A number of factors have coincided to highlight apparent need and consequently increase public expectations (see Ham et al. 2012 for more details), including:

Demographic change: The population of England has risen by 30% since 1951, and that rise is predicted to be 50% by 2032. Alongside this increase in basic numbers is the shift to a more elderly population, with huge increases in the proportion of the over-85s predicted over the next 20 years (from 416,000 in 1971 to 2.6 million in 2032).

Medical advances: More diseases can be treated more effectively through recent technical and pharmaceutical innovations. As treatments, procedures and diagnosis techniques are developed they are more widely demanded at an earlier stage. Inequalities of availability spark furious headlines of the 'healthcare lottery', which either deliberately or not raises the commercial pressure to continue to put healthcare innovation near the top of the political agenda.

The IT explosion: Coincident with demographic changes of the last 50 years has been the rapid development of communication technologies. IT is now ubiquitous, and is increasingly seen as a valid solution to many social problems. This is of course not without its controversies and unexpected consequences, but has created a new relationship between the home and issues of health. The concept of 'smart homes' (Chan et al. 2008) with a proliferation of sensors and connections, raises the possibility of linking the health of the occupant to the care services in a way that shifts the burden of responsibility towards the individual, and away from healthcare professionals.

Financial constraints: The demand for health and social care has increased and is predicted to continue, as has the expectation among the public for uninhibited access to ever-more complex medical interventions. At the same time, the current 'age of austerity' is restricting the financial resources available to cater for these demands and expectations. For several years there has been a focus on reducing waste and inefficiencies, but the nature of social and health care is such that demand is infinite whilst availability is always limited.

How then can we increase the provision of better health and social care, while at the same time reducing how much it costs to do so? One answer is to shift the place of delivery away from traditional institutions such as the hospital and surgery, and into people's homes. This has a number of potential benefits – reducing hospital admissions and alleviating bed congestion; increasing efficiency through remote care; and delivering better outcomes for the patient by reducing the stress involved in moving to an unfamiliar environment (Ham et al. 2012). This has been enthusiastically adopted by the government (Dept. of Health 2012) in a series of initiatives (3 million lives, DALLAS, Whole System Demonstrator etc.), seeing the potential benefits to the health service but also to the economy through technological leadership and the development of new products. In particular, the care of the elderly has been prominent in future strategies, as a result of some of the factors described above: there are more elderly patients with higher expectations, who are thus occupying more hospital space, using more resources and require support at home that may be difficult to organise (Heywood and Turner 2007). Answering this need, technology companies have developed a range of 'telecare' systems and devices to remotely support and care for patients, with the encouragement of the UK government, despite some uncertainty about their effectiveness in recent trials (Steventon et al. 2012). Telecare has thus dominated ideas of health-at-home for several years, with a focus on essentially technological issues and the notion of ageing-in-place (Fange and Iwarsson 2005; Iwarsson et al. 2006; Costa-Font 2012).

3 The home as a dangerous place

The second dominant paradigm relating the home to health lies in the ways that the home can act as an agent for ill-health; the link between quality of housing and quality of life as seen through the lens of health and safety. Considering the home as a technical envelope with the power to provide for some of our most basic needs – shelter, security and sustenance – emphasises the precarious potential of the home to somehow deny those needs. A typical example is the Housing Health and Safety Rating System (HHSRS) used to define a 'Decent Home Standard' (reviewed in POST 2011), the basic metric defining how the standard of housing is perceived and consequently how we react to our housing, politically and technologically. This follows on from a substantial body of research that has considered the links between housing and health and essentially recommended improvements to two areas: thermal comfort and physical hazards (e.g. Thomson et al. 2009; Easterbrook 2002; Somerville 2000). As the POST review notes: “45% of accidents occur in the home and accidents are in the top 10 causes of death for all ages” and “cold homes are linked to increased risk of cardio-vascular, respiratory and rheumatoid diseases, as well as hypothermia and poorer metal health” (2011:1).

The potential for the home to cause or exacerbate illness and injury is the basic starting point for this paradigm. The question becomes, how can we reduce the likelihood of significant harm? So issues that take priority relate to either heating and ventilation, for example the difficulties of insulating the ubiquitous Victorian terrace, or reducing physical injury by removing trip hazards, installing safety systems and so on. Recognising the dangers that lurk within the home is only the first step to ensuring our health and wellbeing however. We are then presented with the difficulties of actually doing something about it. For example, Government initiatives to insulate homes have been well received, but criticised for not adequately allowing for the large proportion of existing homes do not have cavity walls. By 2012, 60% of homes with cavity walls had been insulated (11m of 19m), but only 1.6% (122,000 of nearly 8m) of those with solid walls (DECC 2012). And reducing the physical hazards inside the home has proved equally problematic. Lansley et al. (2005) have shown that the range of existing housing combined with the variety of personal circumstances makes prescribing effective adaptations extremely complex. Certain home types, such as converted flats, especially on upper floors, are difficult to alter in a way that makes any meaningful mitigation to physical inconveniences. This means that the only realistic approach is an individually tailored solution, specified by experienced professionals, usually occupational therapists, based on guidelines designed to provide equal access to all (e.g. COST 2006; Dept of Health 2010). While well-meaning, and politically necessary, this is not necessarily the best solution, sometimes providing adaptations that are unnecessary, or even actually harmful (Heywood 2004). So from this viewpoint the home is potentially and actually a dangerous place, where the health and wellbeing of the occupants can only be secured by reducing, through good design, the risks of the many potential sources of illness and injury.

4 Home as a place of healthiness

Taken together, these two agendas (on the one hand the home becoming part of the infrastructure of the health and social care system, and on the other as a place needing to be tamed and neutralised) conjure up a lasting image of the links between the home and health: Home as a Place of Illness. While not seeking to minimise the importance of the need to provide adequate care at home, or to improve the housing stock generally, I feel there is a more holistic, inclusive and common-sense point of view that deserves to be more widely expressed. This is nicely summed up by the famous definition given in the founding document of the World Health Organisation, stating that health is “a state of complete physical, mental and social well-being, not merely the absence of disease or infirmity” (WHO 1946:2). In other words, to see how a home is connected to the health of its occupants, we need to look at more than the potential for disease or infirmity; we need to look instead at a complete state of well-being.

If we think again about the twin agendas that form the ‘Home as a Place of Illness’ approach, it becomes clear that there are other aspects that also need to be taken into account. In particular, and this is where the social sciences can play an important role, how can we investigate of the socio-cultural influences that shape the role of the home in living a healthy life? For example, a successful technological solution to the problems of caring at home depends on more than devices and systems; it requires social adoption through mechanisms such as user acceptance (McCreadie and Tinker 2005) and integration into the wider system of care (Imrie 2004a; Victor et al. 2012). It also requires a careful consideration of the effects this has on the use of space inside the home when seeking to integrate medical care and work into an otherwise domestic environment. The design of a conventional home is not based in any significant way on the need for medical technologies or adaptations, these must be squeezed into an existing envelope (Lansley et al. 2005). This inevitably entails a physical and emotional reconfiguration of space and disruption to daily routines. A healthcare-friendly house design, or re-design through adaptation, is usually based on the technical knowledge of architects, occupational therapists and technologists, rather than experienced occupants. This is supported by the limited amount of research that has gone into the social adoption of assistive technologies (e.g. Hoffman and McKenna 2004; Mann et al. 2002), which demonstrates that there are still significant gaps in our understanding of the home as a location for practices of health and caring. Furthermore, this suggests that we should look beyond simplistic notions of health dominated by chronic illness or lack of mobility, and consider ways we might design healthy homes that suit a multitude of different personal situations.

Social science research has generated a large body of literature on the home (e.g. Miller 2001; Daniels 2010; McDowell 2007), but this sits uneasily with the concept of the house as a technical structure, often dichotomising the house/home relationship so that one can only be seen in the context of the other (Easthope 2004; Rowles and Chaudhury 2005). By this view, the house is an enclosing structure designed through technical conventions and professional training, whereas the home is a house given special meaning through the practices and possessions of the occupants. This division is reflected in different concepts of a healthy dwelling – the technical approach sees the relationship between the house and health as a deterministic one, where housing conditions are causally linked to health issues (Thompson et al. 2009), or the choice of materials and construction process directly affect the health of the occupants (e.g. Baker-Laporte et al. 2008). Conversely, social scientists, wary of the heritage of overly analytical structuralist approaches to the home (Bourdieu 1977), have moved radically to re-position the home as an abstract construction, defined purely by the cultural behaviours of those within (Daniels 2010; Miller 2001). This is an unhelpful dichotomy that separates the user as the home-owner and creator of meaningful space, from the house-builders in their various guises of planning, design, and construction: the abstract home distinct from the meaningless house. One of the aims of the Designing Healthy Homes project is to question this separation and through user-engagement with industry professionals in the design and (VRE) construction of a house, bring together house-builders with home-makers.

5 New design approaches

Designing a house on the basis of practical experience is conceptually different from the process of designing a house on the basis of expert knowledge, such as the technical conventions and training of architects and construction industry professionals. Effective community-based or participatory design depends on local systems of knowledge augmenting technical knowledge (Al-Kodmany 2001) – a difficult outcome to achieve since the culture of architectural design is one of specialism (Cross 2011), dependent on technical training. Conversely, experience is not in itself sufficient for successful design. It requires a means of communicating the ideas contained within the design in a meaningful and unambiguous way. After exploring the gap in communication between lay-people and architects, Al-Kodmany (2001) suggested that to bridge the divide depends on non-technical tools and techniques for visualization and forums for informal discussion. This is supported by Whyte and Cardellino (2010) who also emphasise the role that visual representation plays in circulating ideas and enrolling stakeholders. Methodologically this leads to the contention that there needs to be a forum for discussion which is democratic, rather than technical and exclusive, and visual as well as verbal or textual, discouraging as far as possible slippage into what Bucciarelli's called 'object worlds' (1994). Bucciarelli described how translating between common experience and technical jargon requires the understanding of a complete culture, all of the 'objects', and not simply a dictionary of terms, which leads me to suggest the use of a bridging device – the design package of VRE house constructions, plus the other information put forward by the householders (such as scrapbooks or posters). This is intended to act as a visual intermediary to mediate and facilitate discussions between participants and technical professionals from design, construction and healthcare. It suggests a means of interacting with industry in a meaningful and informative way, empowering participants in academic research projects to engage with experts without being disadvantaged by a lack of technical knowledge.

Data for the designs and discussions comes from more detailed and nuanced understandings of concepts of everyday healthiness, which implies an anthropological approach to data gathering. That of course has its own limitations and benefits, not the least of which is the fact that the participants are small in number, restricting the potential for large scale generalizations. But the advantage of these methods is that they provide a detailed picture of those participants, much more than the ubiquitous questionnaires and surveys so beloved of the construction industry. In particular, the emerging discipline of Design Anthropology (Gunn et al. 2013) provides theoretical underpinnings by applying design methods to ethnographic research and by adopting an anthropological approach to the act of designing. Adopting a design-based philosophy of intervention and collaboration allows the ethnographer to engage actively and directly with the participants, rather than remaining remote and denying active participation in the process, as is usual in traditional anthropological fieldwork (e.g. Bryman 2012). Thus for the process of designing a VRE healthy home, the researcher acts to intervene by providing participants with the tools to be able to design, through non-technical discussions and exchange of ideas, user-friendly software and opportunities to refine and adjust the design. This process is seen to take place in a specific context, drawing on anthropology's traditional strength of cultural sensitivity, so that the design itself is recognised as the product of a particular set of personal and circumstantial influences. The finished designs will then form the basis of a body of largely visual evidence to be presented to non-academic partner organizations, including architects and designers, construction industry professionals, and occupational therapists.

Detailed social research such as this is notoriously difficult, since the inside of the home is a compact and private space, where the intervention and intrusion of a researcher is likely to alter the usual patterns of behaviour of the occupants. The traditional anthropological fieldwork technique of immersion into the (home) culture, especially through participant observation is therefore difficult to access and even more difficult to sustain, at best encouraging participants to be overly reflexive on their own practices by exposing them to unusual levels of scrutiny. For that reason, most social research into the home has been based on interviews and questionnaires, which although useful, are limited. The structured nature of questionnaires is inherently limiting, and unstructured interviews have been shown to create anecdotal life histories (Hurdley 2006), and often disregard the importance of the home environment itself (Daniels 2010). Situating this research in the personal spaces of the current and imagined home therefore requires the use of innovative methods – a combination of visual and design anthropology (Banks 2010; Gunn et al. 2013), and an adaptation of Gaver's Cultural Probe (Gaver et al. 1999).

A Cultural Probe is a package of objects left in the home, inviting a series of responses from the participant. Gaver's premise was that by facilitating 'playfulness' the respondents would be more engaged in the research, and provide more and better quality data. Individual information and attitudes will emerge in the detail of each set of responses, and patterns of similarity and difference will be exposed through comparison between respondents. For this project, the probes will be structured around spaces and activities. The use of space can be identified by conversations and observations, which in turn lead to the tasks that householders will be asked to complete. Typically and fairly obviously for example, this might lead to the kitchen being identified as a key space for the activity of food preparation, so the householders will be asked to prepare a particular meal and record their actions through photographs or a video diary. Other probe tasks will be aimed at activities such as mealtimes, morning or evening routines, family visits etc. leading to a qualitative database of participants' thoughts about their use of spaces and how these relate to activities, in the context of holistic healthiness.

Furthermore, visual and material anthropological approaches, which assume that the physical and observed world will be reflected in interactions with the images and objects around them, will form the basis of a series of targeted visits, interviews and conversations. The first hand observations of the researcher will be supplemented by the use of visual and material prompts. This provides the potential for a two-way engagement – first through the possessions and images that the participants possess and offer in conversation, and second as tools for elicitation (Banks 2010). While intensive participation in the households is unlikely, and possibly undesirable, regular shorter visits will present opportunities to document both forms of engagement. For the first, as well as noting observations of targeted daily routines, the householders will be encouraged to discuss their domestic environment through the pictures and objects in their home, for example a biography of home changes (Brand 1994). Secondly, materials resulting from the Probe exercise will then be used as elicitation tools for further explanation and discussion, to supplement and direct subsequent conversations, offering corroboration of the researcher's interpretation and an avenue to greater detail.

In total, the data collection activities will encourage participants to reflect in some detail about issues of health and the ways they act in their home, and spark their imagination into thinking about potentially different schemes of spatial organization in preparation for the design exercise.

6 Participant designers

While embodied experience conditions the everyday use and organisation of space in the home, different personal circumstances dictate the scope of an imagined healthy home, so that for example an elderly person considers different needs to a young family. Even within these broad categories there are a myriad nuances that make it difficult to generalise about the similarities between them and thus comment on changes in perception of what makes a healthy home. Sociological studies of life transitions provide a context for viewing the influences and consequences of different stages in life (George 1993; Almeda and Wong 2009), and suggest how this research might be conducted by highlighting two relevant and important points. First, during the process of change its potential effects are foregrounded in the individual’s thoughts (Almeida and Wong 2009; Lockwood et al. 2012) and second, significant transitions exert an enduring effect on later life (Salmela-Aro 2009). Therefore by identifying and focussing on transitional events, we can see the beginnings of future beliefs and practices at a time when there is heightened awareness of the significance and consequences of change. This provides the basis for a sampling strategy in engaging users to design their concepts of a healthy home, by selecting a small number of participant households, each of whom are encountering life transitions that are directly relevant to their health at home.

To fit with that aim, three types of household have been identified, with 3 or 4 participants being recruited for each, limiting the total number to around ten. Sample sizes have been chosen not only for practical reasons, but also for sound methodological ones: while such small numbers cannot be generalized to a larger population, there is enough overlap to highlight similar concerns, and enough variety to encourage a range of ideas. This is explicitly an attempt to delve deeply into the lives of these householders, to supplement to quantitative data that already exists (e.g. DCLG 2006). My contention is that this lack of depth is a basic flaw in the process of defining the political and technological agendas described at the beginning of this paper. Instead there is a generalising effect, where ‘the elderly’ become one group with particular needs, often causing social strains (Iwarsson et al. 2006; Ham et al. 2012), or the needs of ‘the disabled’ are reduced to wheelchair access (Imrie 2004b), and the majority of households and the range of differences between ostensibly similar households are far less visible. Therefore the three groups targeted in this research will reflect a wider proportion of the population: young families, recently retired, and recently disabled. The emphasis is on a transitional phase that has raised their awareness of the links between the home and health, without presuming stereotypical health issues. So for example, the recently retired group are not assumed to see reduced mobility as a central concern in their lives overwhelming the potential opportunities that their new situation offers. Despite the small numbers of the study, heterogeneity will also be presumed from the start, so that the disabled participants will be no more considered to be ‘the same’ than any other small set of research participants, and their response to specific situations likely to be equally varied. All three groups will be in a transitional state that, as discussed above, foregrounds their thoughts on the changing relationship between home and health, and raises issues that they will deal with according to individual circumstances and personal convictions. Families with young children may be more interested in issues such as safety, noise, storage, feeding and sleeping. Retired households will be coping with changes such as reduced income, new daily routines, possibly bereavements, downsizing and grandchildren. Recently disabled people may need to adapt (to) their surroundings, physically and mentally, learning new skills, and possibly reconfiguring the spaces of their home. There is no presumption of design skills or experience, since the object of the exercise is to foreground their daily lives and encourage their thoughts on how their home allows or restricts them to live in a healthy way.

7 Analysis and outcomes

A key principle of this project is in its aim to be collaborative and inclusive, and this will be continued through an innovative ‘Participatory Analysis’ approach to the mutual creation and study of data. Much of the methodological focus is on generating data as a joint enterprise, such as the responses to the Cultural Probes and the participatory design exercise, rather than affording undue privilege to traditional ethnographic techniques of notes and observations. This is deliberately intended to avoid the ‘ethnographer’s gaze’, which only documents particular events and qualities as significant, with a subsequent self-conscious, controlled attempt to derive meaning. Instead, through Participatory Analysis, outcomes will rely on the multiple voices of project stakeholders (including industry and non-academic partners) - analysis of the data will be descriptive and themed, according to the perceptions of the researcher and the ideas put forward by participants. For example, responses to the cultural probes will be organised into categories in conjunction with participants, scrapbooks will be presented in facilitated discussion groups and circulated to other stakeholder groups. The participant VRE house designs will generate insights through academic interpretation, such as similarities and differences with current homes, but it will be through the involvement of other experienced observers that those insights will gain greater meaning. Therefore, by involving architects, planners, members of the construction industry and health professionals, their various perspectives and cross-disciplinary interactions will act as the basis for more rounded analyses.

Thus it is through the knowledge of people who have direct experience, and not via the abstract academic or specialist industrial worlds, that we will gain greater understanding of the issues of health and wellbeing in the home. The results will highlight the synergies and tensions between house design and use, but will also provide the basis for a re-thinking of the role of the home in the wider healthcare system.

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Reducing Building Information Fragmentation: A BIM-Specifications Approach

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Abstract

The world of Construction is changing, so too are the expectations of stakeholders regarding strategies for adapting existing resources (people, equipment and finances), processes and tools to the evolving needs of the industry. Building Information Modelling (BIM) is a data-rich, digital approach for representing building information required for design and construction. BIM tools are instrumental to current approaches by industry stakeholders aimed at harnessing the power of a single information repository for improved project delivery and maintenance. Yet building specifications, which comprise information on material quality, and workmanship requirements, remain distinctly separate from model information typically represented in BIM models. BIM adoption for building design, construction and maintenance is an industry-wide strategy aimed at addressing such concerns about information fragmentation. However, to effectively reduce inefficiencies due to fragmentation, BIM models require crucial information contained in building specifications. This paper profiles some specification tools which have been used in industry as a means of bridging the BIM-Specifications divide. We analyse the distinction between current attempts at integrating BIM and specifications and our approach which utilises rich specification information embedded within objects in a product library as a method for improving the quality of information contained in BIM objects at various levels of model development.

Keywords: BIM, Specifications, bimspecs, information fragmentation, integrated specifications

1. INTRODUCTION

Over the years, the recurrence and pervading impact of fragmented information on various aspects of the construction industry has been substantially researched and served as the central theme of acclaimed reports. (Anumba, Baugh, & Khalfan, 2002; Egan, 1998; Gledson, Henry, & Bleanch, 2012; Latham, 1994). As a result, various remedial measures geared towards the realisation of construction efficiencies at different stages of the construction process by stakeholders across the industry have been prescribed (Issa, 2003; Kagioglou, Cooper, Aouad, & Sexton, 2000).

While a substantial number of tools and processes have been employed across industry and academia, Building Information Modelling (BIM) has been recognised as an approach which has significantly tackled some of the challenges with information fragmentation (Succar, 2009). Such success is closely linked to the concept of BIM *interoperability*, which describes the extent of interaction between systems and organisations (Kandil, Hastak, & Dunston, 2014). Yet even with their capacity to improve cross-platform interoperability, there is no evidence that the generic libraries, contained in most BIM-authoring software, have capacities that are sufficiently robust to handle many of the requirements for cataloguing key product data (Owolabi, Anumba, & El-Hamalawi, 2003) especially those contained in building specifications.

Although Industry Foundation Classes (IFC) are popular as platforms for BIM-interoperability (Ilal, 2007), inefficiencies between different BIM platforms still exist (Rumor, Coors, Fendel, & Zlatanova, 2007). By investigating a few, commercially available tools, we aim to review current approaches to reducing information fragmentation in contrast to one which combines Building Information Modelling and Specifications (BIM-Specs) as a means of exploring the potential benefits inherent in adopting a BIM-Specs approach which emphasises integration over fragmentation through the embedding of building specifications (which are important sets of building information) in BIM models.

2. LITERATURE REVIEW

2.1 Problem Overview

Fragmented Information is described by Bergman, Beyth-Marom, & Nachmias (2006) as being characterised by the disjointed distribution of different configurations of a specific dataset across multiple user-platforms for interpretation and processing by disparate applications (see figure 1). Although their paper focuses on Personal Information Management, Bergman, et al. (2006) highlight the challenges with working with different formats of project information. Some of the outcomes to be expected from the compartmentalised nature of fragmented information are challenges with information coordination, transformation and interpretation. As such, an emerging solution to the problem of fragmentation is the concept of interoperability which has been defined by the IEE (1991) as: "the ability of two or more systems or components to exchange information and to use the information that has been exchanged".

Interoperability lies at the heart of Building Information Modelling (BIM) (Grilo, Zutshi, & Jardim-Goncalves, 2011). Only a decade ago, the cost of problems with interoperability was 10.5 billion dollars in the United States alone (Aguilar & Ashcraft, 2013). Subsequently, stakeholders have taken active measures to promote interoperability by: demanding for compatible data formats (Palos, 2012), encouraging the use of open standards, such as the Construction, Operations, Building Information Exchange (COBie) (Aguilar & Ashcraft, 2013).

BIM enhances construction communication on the basis that information from different project stakeholders can be seamlessly assessed and utilised in the course of the project (see figure 2) (Arayici & Coates, 2012) consequent upon its reliance on interoperability. Nevertheless, while there is confidence that BIM will overcome existing problems with interoperability (Wang, Wang, Wang, Yung, & Jun, 2013), the potential legal issues, especially with respect to ownership are yet unresolved in the construction industry (Aguilar & Ashcraft, 2013). Information storage in the product library discussed subsequently was achieved using a COBie approach.

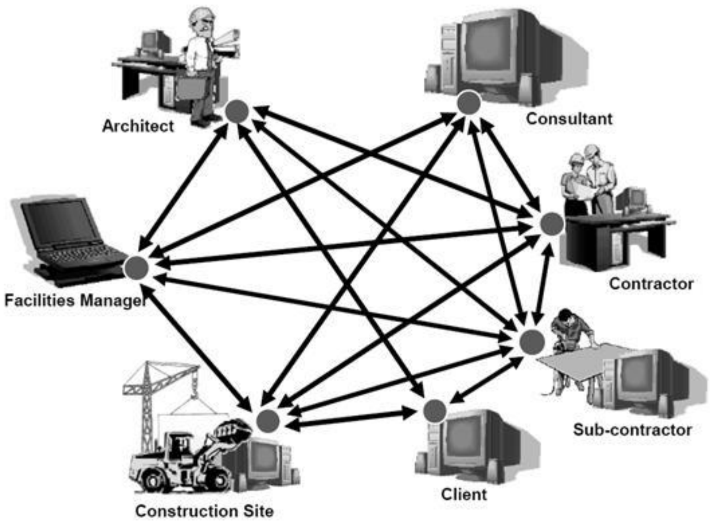

Figure 1: Information Fragmentation in the AEC (Bergman, et al., 2006)

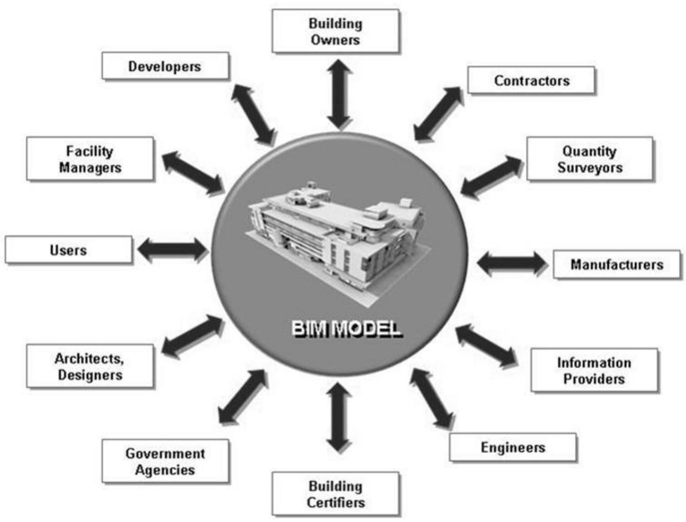

Figure 2: Interoperability of BIM Models (Graphisoft, 2013)

Due to the interoperable functionality of BIM-authoring software, and in response to the limited number of model objects in their generic libraries, alternative means of capturing proprietary products unique to certain projects have been sought after. The importance of product libraries to the overarching goal of reducing fragmentation in the construction industry is highlighted by the fact that the major components of BIM models are captured by the interactions between model objects. Yet, it is difficult to find any one generic product library that captures project-related specification information in a way that they are readily available to users of BIM information prior to, during and after project implementation.

Apart from the objects in BIM-authoring software, a number of these product libraries - for example, Google's 3D Warehouse (Google, 2013) and Autodesk's SEEK (Autodesk, 2013) - are freely available to users online, others are accessible through subscriptions. Three of the more popular commercial product libraries are: *AutoSpec*, *Reed Construction Data*, and McGraw Hill's *Sweet Catlaog*.

2.2 An exploration of Product-Library Initiatives

In this section, we examine instances of evolving national product libraries, exemplars of commercialised product libraries and other model transfer initiatives in research that are exploiting advances in information modelling targeted at the needs of the AEC.

2.2.1 AutoSpec

Autospec is a commercial library of products assessable both on line as well as from within the local libraries of subscribing organisations. At the time of writing, 53 manufactures were listed as clients who subscribe to Autodesk. The library is Specifier and manufacturer-centric and tailored to users' requirements. The library is especially useful to specifiers as it has been designed in a way that takes cognisance of the typical requirement of manufacturers and has tools, with menus and task bars to aid the specification process (AutoSpec, 2013). The search functionality of the library can be used in one of three ways, that is, searching: by manufacturer, keyword or project range. In order to assess full library functionalities, including the CAD / BIM files, however, users must have a subscription.

2.2.2 Reed Construction

Reed Construction is a robust database of manufacturers' products complete with the usual features of product libraries (Reed, 2013). The costing feature of the products in the product library are supported by a subsidiary product *RSMeans* while the search function ties in with the Masterformat classification system to enable users knowledgeable about the classification system carry out searches easily. These Masterformat-based classifications have 25 broad product categories which are further broken into 230 other categories. However, users are only able to access and assess the full product library capability such as specifications, CAD and BIM files from the product library.

2.2.3 Sweet's Catalog

The McGraw Hill owned Sweets Catalog, like the Reeds Construction Data, uses a Masterformat classification to enable users execute a product search (McGrawhill, 2013). Its database of product is however more robust as there are 45 main categories in the library serving over 10,000 manufacturers of building products.

Although the increasing availability of product libraries means that users are better able to choose from a range of providers according to project requirements, there is the potential danger of BIM object proliferation which fosters rather than reduces information-fragmentation in the long run. Furthermore, and more importantly, with the key focus of such product libraries being the provisioning of model objects, it is evident that information exchange across organisational boundaries will be near impossible. The fulfilment of certain conditions must be fulfilled if such product libraries to be considered truly interoperable, including: data-format compatibility, (Palos, 2012) and use of similar standards in library creation (Aguilar & Ashcraft, 2013).

Research interests in product libraries and information modelling has steadily risen over the years. A few examples include the ARROW project, CONNET-MPS and GEN Projects (Amor, Jain, & Augenbroe, 2008) as well as research at the University of Auckland (Amor & Kloep, 2003) and University of Edinburgh (Ofluoglu, 2003) where accessibility to product information from manufacturers and beneficial ways of interacting with product information formed the research foci respectively.

Other examples include research by Murphy, McGovern & Pavia (2013) and Fleming, Long & Swindler (2012) who explore new ways of utilising model information for Historic Building Information Modelling (HBIM) and the creation of energy models from online repositories, as well as energy modelling based on the United States Building Component Library.

3. METHOD

In this section, we select the *Productspec* of New Zealand and the *National BIM Library* of the United Kingdom as product library exemplars and conduct a comparative analysis of both tools against our tool - the Australian National Object Library - in terms of overall focus on integrating BIM and specifications in a manner that fosters integration over fragmentation in BIM. Using Autodesk's *Revit* as the tool for comparative analysis, we illustrate the chief differences between window products from each of the three libraries and present an argument on the value of adopting a platform-independent product library, in which specifications can be seamlessly embedded within BIM models as a means of attaining the goal of reduction in fragmented construction / building information.

3.1 Results

3.1.1 ProductSpec

Productspec serves as a national library of products in New Zealand with 22 main categories, 101 sub-categories containing over 12,500 CAD and BIM files for architecture, design and landscape products. With a client-base of over 50,000 professionals, the database consists of over 50,000 objects (Productspec, 2013) and allows free access to more than 9,000 BIM/CAD files through its downloadable CAD add-on. Figure 3 shows a 3D view of a *residential awning window* (Window A) downloaded from the database. The database offers a significant number of products to users ranging from generic CAD/BIM objects to specific manufacturers' products. However, users do not have the option of making any changes to the properties of the products from within the library of objects.

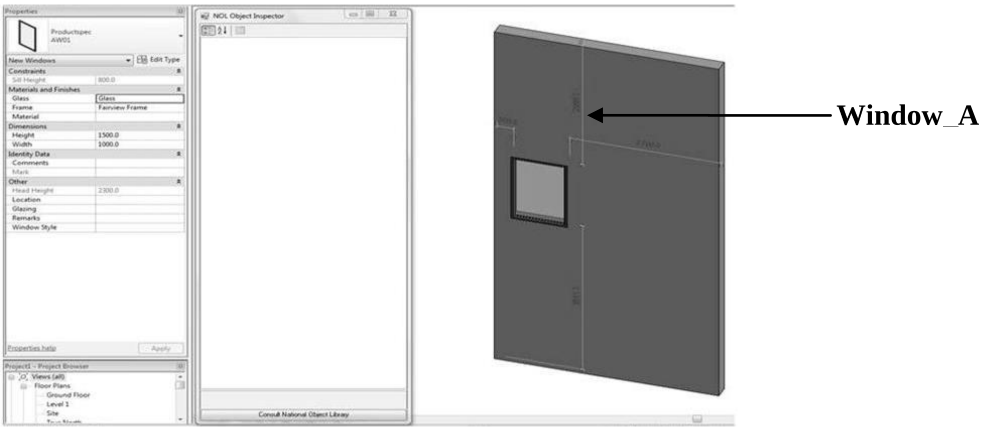

Figure 3: A Productspec Window imported with its associated properties.

3.1.2 The National BIM Library

The National BIM Library is a product of the National Building Specification (NBS) owned by the Royal Institute of British Architects (RIBA) in the UK. The library of products offers users free access to IFC-compliant content and the choice to download products in any one of four software formats according to system requirements - Autodesk Revit, ArchiCAD, Vectorworks, Tekla and Bentley (NBS, 2013). Beyond the usual product library service, the components of the National BIM Library are offered together with property set definitions integrated with the Uniclass tables of classification.

Furthermore, users are given the option to browse the library according to two broad categories; by objects or by manufacturers. Consequently, access is provided to 28 product categories which cater to 709 objects as well as 155 proprietary objects derived from 9 manufacturers. Products from the library download in a zipped folder containing a user guide in PDF format, a text file for product-specific parameters as well as a text file of shared parameters in addition to a CAD/BIM file as modelled in the software environment selected by the user. Figure 4 is an illustration of a *single panel window* (Window B) imported into a Revit wall beside Window A.

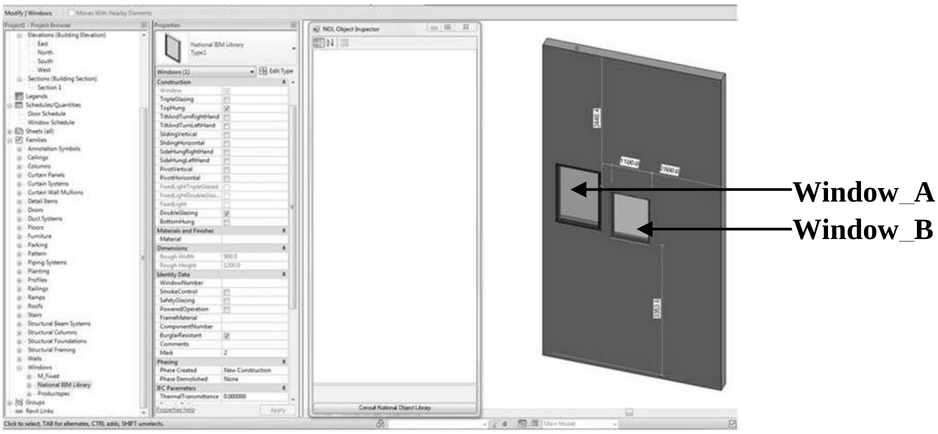

Figure 4: A National BIM Library window imported with its associated properties.

3.1.3 The Australian National Object Library.

This library is proprietary and undergoing development. The idea behind its development is the creation of a platform-independent database of model objects complete with manufacturers information and at varying levels of development.

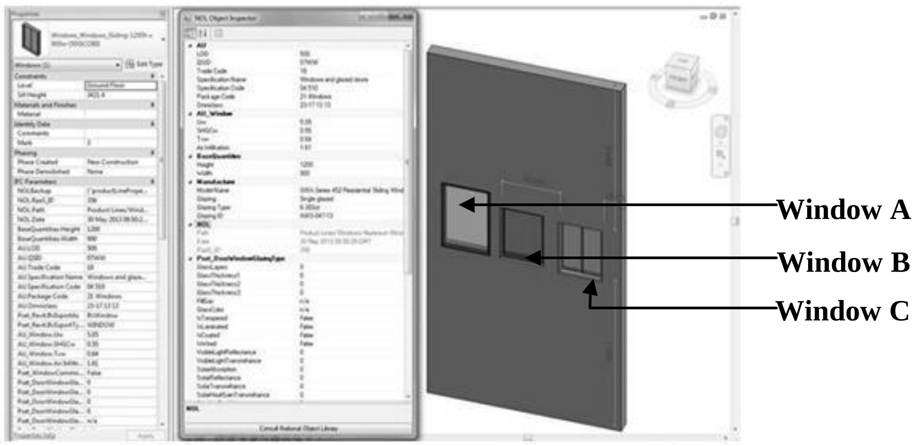

Figure 5: A comparison between products from the three libraries

Figure 5 exemplifies the functionality of a 1200x900 Aluminium sliding window (Window C) - imported from the product library into Revit and compared against Windows A and B. The screen capture indicates that Window C is platform independent and so can as easily be imported into ArchiCAD as Revit. Furthermore, not only will users be able to manually edit the parameters of Window C from within the modelling tool, they can also:

- import specific properties from the library which will be automatically added to the already existing window parameters;

- add properties from library products to native model objects

A key distinguishing feature of window import C from the other windows illustrated is that it is platform independent and, using the *object inspector* window, users can make changes within the generic BIM library as well as update the information contained in their localised version of the product library.

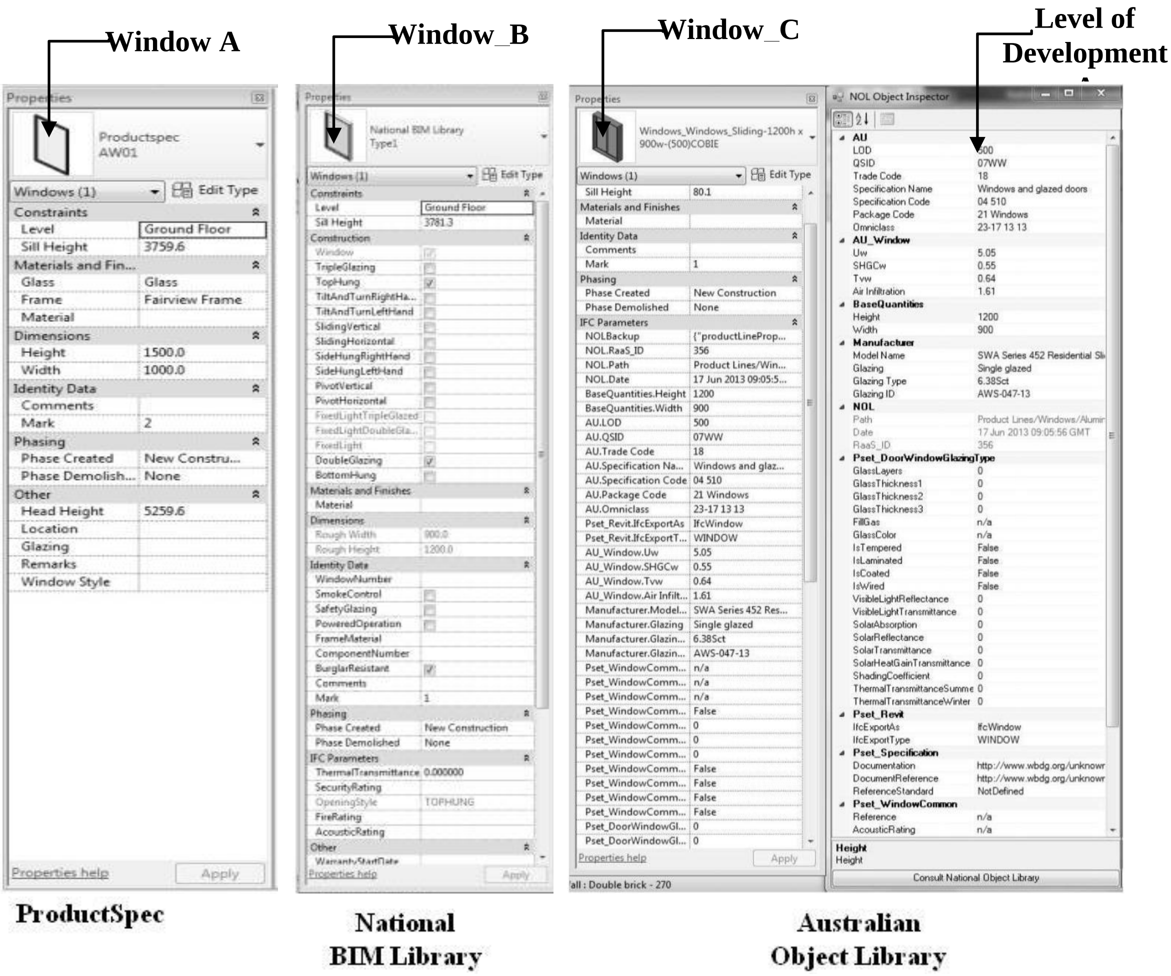

Figure 6: Further comparisons between products from the three libraries

Furthermore, another distinguishing feature of Window C from A and B as illustrated in figure 6 is that it is specified at a particular Level of Development (LOD). Ciribini (2013) describes a Level of Development as the level of granularity to which the geometric and non-geometric features / properties of model objects are defined. In this sense, a user is able to select the level of development of Window C and distinguish it from other windows within the model that have been developed at other LODs.

3.2 Discussion

The method of using product libraries, as illustrated in figure 6 by window C has implications on the way building products are specified as building specifications can potentially be linked to LODs and embedded within BIM models (see figure 7).

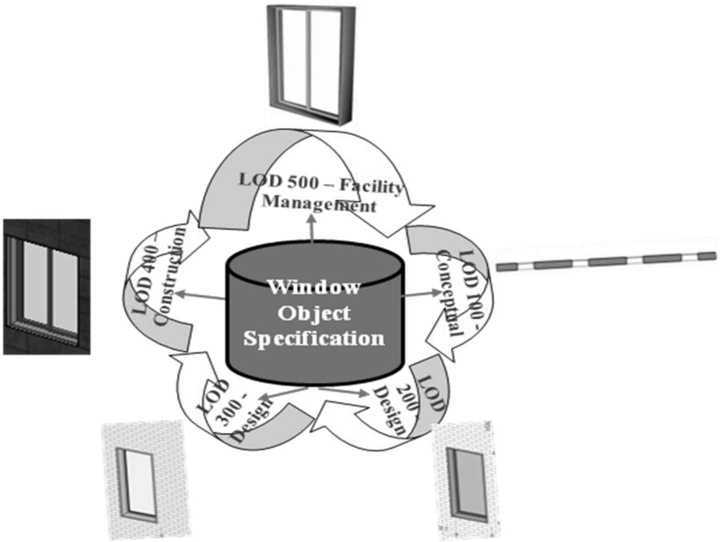

Figure 7. A window example of a BSL (BIM-Specifications-LOD) Framework (Utiome, Drogemuller, & Docherty, 2013).

The BSL approach has been amply described by Utiome, et al., (2013) and proffers a different way of specifying the objects contained within BIM models. The challenge with using the BIM-Specification approach, however, is determining what attributes of traditional specification should be embedded or omitted from BIM models.

Embedding data such as product information, manufacturers' details, supplier information, etc within BIM models enriches users' access to data and can potentially influence their work culture, especially in Facilities Management. For example, where formally a downstream data user would have had to require access to specific manufactures information in order to make a decision regarding a product, with the right authorisation, such information can be readily sourced from within the model. Thus, business process inefficiencies can potentially be avoided by adopting an approach that combines the intelligence of BIM models with the robustness of specification-rich product library information.

Ensuring the integrity and quality of such information, however, would require the creation of the role of a *librarian* who will have sufficient technical knowledge of BIM and specifications to ensure that only information which conform to standards of interoperability make up the contents of the library. By implication, therefore, the librarian-role will entail monitoring, conformance-checking, and overall integrity management for products at all levels of development for BIM models.

4. CONCLUSION

This paper analyses some specification tools in use in industry as a means of dealing with traditional construction challenges in terms of information fragmentation. As a result, distinctions between current approaches at addressing fragmentation through the use of product libraries and a BIM-Specifications strategy are highlighted. We show, using a BIM-Specification-LOD (BSL) framework, that in attempting to improve library-model integration and interaction, it is beneficial to specify products at different levels of development prior to embedding library objects in BIM models.

The results indicate that the goal of fragmentation reduction through the adoption of a BIM strategy is not only feasible, but significantly depends on specification information at varying levels of granularity. We also describe the validity of the role of a librarian to ensure data integrity and model accuracy.

ACKNOWLEDGMENT

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Project Management (PM) standards implementation and competitive advantages: The case study of a real state development firm in Colombia

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Abstract

The standardization of Project Management (PM) processes in organizations is often linked to diverse types of benefits. It was found in the literature review that “standardization may lead to the creation and enhancement of new competitive advantages for Architecture, Engineering, and Construction (AEC) organizations” (Polesie, 2013). The objective of this paper is to evaluate this statement based on the case study of a Project Management Office (PMO) in a real estate development firm in Colombia. This company is implementing a new management model called AXIS that consists of new management processes for portfolios, programs, and projects according to the OPM3® standard. An analysis of how the organization case study adapted and adopted the OPM3® standard, an identification of organizational benefits obtained by this standardization process, and competitiveness factors acording to the"Porter's Diamond" model in the AEC sector (Liu, et al., 2010) are presented. The research methodology includes interviews with members of the organization and other six companies about gaining competitiveness through the standardization of Project Management (PM) processes. Results show that achievements obtained from the adoption of a PM standard in the organization case study can be directly related to competitive advantages gained by the company. These results contribute to the PM body of knowledge by providing empirical evidence on the critical role that standardized project management attributes and practices in a PMO can have for the strategic development of an organization.

Keywords: Project, program, and portfolio management; PMO; PM standards; competitive advantages; AEC sector.

1 Introduction

The standardization of Project Management (PM) processes within Project Management Offices (PMOs) helps managers, teams, and various management levels to consistently implement new portfolios, programs, and projects through defined principles, practices, methodologies, tools, and techniques (Xiaoyi & Wells, 2004). Standardization is often linked to diverse types of benefits of project portfolio management including, among others, those related to economic success, strategic fit, portfolio balance, and preparation for the future (Heising, 2012). The benefits can be attributed to the implementation of new PM practices; they also are associated with competitive advantages that allow an organization to perform better than competitors. Therefore, such benefits can be considered internal competitive factors. Other sources of competitive advantages are those related to the local context and market, commonly named external competitive factors. This article provides a list of sources of competitiveness and identifies those resulting from the definition of portfolio, programs, and projects inside organizations, according to the Organizational Project Management Maturity Model (OPM3®) standard.

It was found in the literature review that “standardization may lead to the creation and enhancement of new competitive advantages for Architecture, Engineering, and Construction (AEC) organizations” (Polesie, 2013). The objective of this paper is to evaluate this argument through the case study of a real estate development firm based in Colombia. This company adapted and adopted a PM standard, with the introduction of a new managerial model called *AXIS.* The standard was implemented after the creation of a Project Management Office (PMO). The new practices are well documented in this article in order to identify differentiating factors from other companies, considered competitors of the company case study. Interviews with members of the organization and six companies about gaining competitiveness the standardization of Project Management (PM) processes, and an assessment using the "Porter's Diamond" model (Liu, et al., 2010) allowed the identification of benefits perceived by the company and the market due to the implementation of *AXIS.*

This study is based on a deductive approach, where preliminary remarks are supported by a literature review and conclusions are validated through a comparative analysis of semi-structured interviews composed by 20 open-ended questions and conducted with 7 real estate development companies. This research intends to answer the following questions:

- What are the internal or external factors that may generate competitive advantages for real estate development firms in Colombia?

- Can those factors be related to the implementation of PM standards in organizations?

- Is the organization case study an example of achieving competitive advantages trough the implementation of a PM standard?

2 Literature review

2.1 Benefits of PM standards implementation in the AEC industry

In the international literature, some authors have found that PM standards implementation generates different benefits for project, program, and portfolio management in the AEC industry. Polesie´s (2013) research in Switzerland concludes that PM standards implementation increases consistence, coherence, efficiency, and productivity of projects. Ahlemann (2009), through an extensive survey conducted with PM standards users, recognized that they can reduce workload and increase free time. Moreover, companies managing multiple projects, by using programs and portfolios, obtain some benefits, such as (Heising, 2012): economic success (market and commercial success), strategic fit (match strategy with project and portfolio), portfolio balance (constant utilization of resources), and preparation for the future (competencies and sufficient new technologies developed within the portfolio). The following PM attributes and practices have been identified in the literature review as tools to achieve the benefits mentioned above:

- Controlled processes (Polesie, 2013).
- Defined inputs and outputs for certain processes (Ahlemann, et al., 2009; Polesie, 2013).
- Reduced unnecessary use of resources (Ahlemann, et al., 2009; Polesie, 2013).
- Integrated processes (Polesie, 2013).
- Consistent communication and better information quality (Ahlemann, et al., 2009; Unger, et al., 2012).
- Better process quality (Ahlemann, et al., 2009).
- Harmonized terminology (Ahlemann, et al., 2009).
- Defined actors´ responsibilities and their selection processes (Ahlemann, et al., 2009; Unger, et al., 2012).
- Knowledge transfer (Xiaoyi & Wells, 2004).
- Training and education (Ram, et al., 2013)
- Project management information systems (Ram, et al., 2013; Winch, 2013).
- Project, program, and portfolio management (Heising, 2012).

2.2 Competitive Advantages in the AEC Industry

Michael Porter developed the “Diamond Model” in 1990, a useful technique to identify the conditions to be considered in order to gain and sustain competitive advantages. It comprises six conditions that shape the environment in which local firms compete: four internal and two external (See Table 1). The external conditions can influence the four internal positively or negatively.

Porter’s diamond model has been applied to analyse competitive advantages of organizations in the construction and real estate industry. Zhao (2012) adapted the diamond model based on the unique characteristics of the AEC industry and proposed some specific competitiveness factors in the Chinese context. The author stated that specific factors differ between countries.

Research is limited regarding on the conditions that influence competitiveness in real estate market in Colombia. Therefore, this paper is focused on international literature review in order to identify potential factors of competitiveness in Colombia. The diamond model is used as a conceptual framework to classify them (See Table 1).

Table 1. Potential competitiveness factors (elaborated by the author based on Zhao, 2012)

Diamond model categories	*Competitiveness factors*	*PM attributes and processes influencing competitiveness factors.*
Factor conditions (internal)	*1. Labour cost (Deng, et al., 2013; Wu, et al., 2009).* *2. Personnel education (Deng, et al., 2013; Öz, 2010).* *3. Land supply (Wu, et al., 2009).* *4. Capital resources (Deng, et al., 2013; Öz, 2010; Wu, et al., 2009; Zhang, et al., 2009)* *5. Information Technologies (Öz, 2010; Zhang, et al., 2009).*	• *Knowledge transfer (Xiaoyi & Wells, 2004).* • *Training and education (Ram, et al., 2013)* • *Project management information systems (Ram, et al., 2013; Winch, 2013).*
Related and supporting industries (internal)	*6. Partnering (Deng, et al., 2013; Zhao, et al., 2012).* *7. Materials costs (Deng, et al., 2013; Öz, 2010).* *8. Designs costs (Deng, et al., 2013; Öz, 2010).* *9. Geographical decentralization.*	• *Defined actors´ responsibilities and their selection processes (Ahlemann, et al., 2009; Unger, et al., 2012).*
Demand conditions (internal)	*10. Consumers’ needs.* *11. Consumers’ complaints.*	• *Consistent communication and better information quality (Ahlemann, et al., 2009; Unger, et al., 2012).* • *Better process quality (Ahlemann, et al., 2009).* • *Controlled processes (Polesie, 2013).*

Diamond model categories	*Competitiveness factors*	*PM attributes and processes influencing competitiveness factors.*
Firm strategy, structure and rivalry (internal)	*12. Efficiency (Deng, et al., 2013).* *13. Cost management (Deng, et al., 2013; Lim, et al., 2010; Zhang, et al., 2009).* *14. Organization structure (Zhang, et al., 2009; (Zhao, et al., 2012).* *15. Internal firm's processes (Deng, et al., 2013; Lim, et al., 2010; Öz, 2010; Wu, et al., 2009; Zhang, et al., 2009).* *16. Risk management (Öz, 2010).*	• *Reduced unnecessary use of resources (Ahlemann, et al., 2009; Polesie, 2013).* • *Integrated processes -(Polesie, 2013).* • *Harmonized terminology (Ahlemann, et al., 2009).* • *Defined actors´ responsibilities and their selection processes (Ahlemann, et al., 2009; Unger, et al., 2012).* • *Project, program, and portfolio management (Heising, 2012).*
Government (external)	*17. Construction licenses and regulations (Wu, et al., 2009; Öz, 2010).*	• *Defined inputs and outputs for certain processes (Ahlemann, et al., 2009; Polesie, 2013).*
Chance (external)	*18. Changes in production costs (Wu, et al., 2009)* *19. Changes in the exchange rate (Öz, 2010; Wu, et al., 2009).*	

3 Company Case Study

Terranum Group is an integrated corporate and institutional real estate platform focused in investment, development, and provision of services in Colombia. It was created in 2010 and its business model is based on six business units specialized in real estate value chain as follows: real estate asset management and specialized investment, development and management of class A offices and logistics projects, development and acquisition of hotels affiliated with international brands, design and construction services for commercial and corporate properties, and facilities management of corporate properties. Terranum Corporate Properties (TCP), the business unit in charge of the development and management of class A offices and logistics projects, gathers a group of experts focused in structuring leasable business parks and build-to-suits for large corporate clients with unique characteristics such as sustainability and flexibility.

3.1 PMO origins and development

TCP organizational structure has evolved as new projects and challenges emerged. Originally, during 2010, the company had a rigid projectized structure. This initial structure had limitations such as: unclear definition of roles and responsibilities, undefined communication channels, and inefficient use of resources.

Later, in 2011, TCP´s PMO was created led by a project management officer who defined a strong matrix structure. Some functional areas (architecture, costs, and sustainability) were centralized, while maintaining an independent operative base for each project (project management teams). Projects were grouped into two programs: the corporate program (offices and commercial projects) and the logistic program (logistic parks and industrial plants), each one led by a program manager. The definition of programs accelerated the learning curve of the organization and its employees, and improved project monitoring and control. TCP´s PMO structure had better defined roles and responsibilities, and brought a more consistent overall project management.

3.2 OPM3® implementation and improvement route map

In 2011, when the PMO was set up, there was a need to stabilize, integrate, and document the operation of projects. Even though project management teams had an important background managing projects, the lack of a standardized methodology hampered the application of the strategic vision of senior management for project execution. Indeed, there was a risk to deviate efforts to non-value-added activities for the company and it was difficult to communicate project performance, since no standard metrics were in place.

On the other hand, obtaining a predictable cost, time, and scope performance was a capital priority as financial viability of projects depends on a no-variable initial investment and a non-delayed delivery date. After undertaking a market benchmark and an academic research, TCP senior managers decided to develop an in-house managerial model fit to company's needs and priorities. The model was called *AXIS* and was based on good practices promoted by the Project Management Institute (PMI).

The PMI Organizational Project Management Maturity Model (OPM3®) was selected to progressively plan PMO´s operation improvement. Organizational project management is the application of knowledge, skills, tools, and techniques to achieve objectives by managing organizational projects, programs, and portfolios. In the OPM3® maturity model the performance of the organization is assessed by using a list of 488 best practices identified through an extensive process of benchmarking by the PMI. OPM3® cycle suggests 5 Steps: Preparing for the evaluation, assessment development, planning improvements, implementing the improvements, and repeating the process (Proyectiza, 2012).

OPM3® started in July 2011. Some initial activities were carried out: first, focus groups were conducted to involve top managers. Later, some project managers, identified as key multipliers within the organization, were trained in PMI principles and basic PM software skills. Once the organization became familiar with the standard, the OPM3® consultant defined an organizational performance baseline, establishing the starting point for organizational transformation by assessing the presence and absence of relevant best practices within the company. As a result of the assessment, a route map was designed, including eight improvement cycles carried out between July 2011 and July 2015.

Cycle 1 began in July 2011; during this period the team structured the *AXIS* management model, initiated the development of cost, time, scope, integration, communications procedures, and performance measurement, and outlined the structuring phase of projects. Cycle 2 began in May

2012 and concluded in October 2012. In this period, the team developed risk, procurement, and quality procedures, improved the assets produced in cycle 1 and undertook the implementation of PM information systems like an Enterprise Resource Planning (ERP) that integrates procurement, cost, and time management, and performance reporting processes. Cycle 3 has begun in July 2013. During this cycle, the PMO has been working in three areas: updating of processes already established, dissemination of work implemented, and creation of non-existing processes. The main objective of this cycle has been the full implementation, monitoring, and control of the new way of working, by using an online work-flow tool which provides short-term visibility and governance of the processes. This seems to have encouraged collaborative work among TCP team members.

One of the main achievements of *AXIS* was the reduction of the time for the implementation of projects. Each bar in Figure 1 represents the timeline of projects implemented by TCP. Figure 1 illustrates that the duration is shorter for projects implemented after *AXIS* introduction in October 2012. The time per square meter was calculated for each project phase (feasibility, design, construction –or design and construction-, and closing). After the implementation of *AXIS (October 2012)*, the time per square meter needed for structuring decreased 76%, the time for design and construction 81%, and the time for closing reduced 64%.

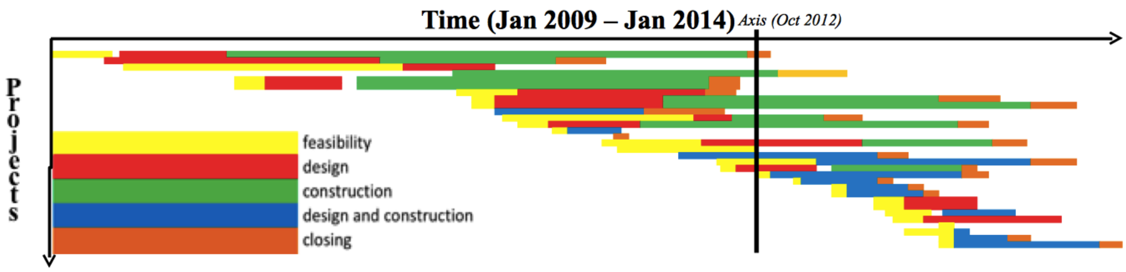

Figure 1: Gantt chart of TCP's projects.

4 Results

Aiming to determine if the benefits obtained by implementing *AXIS* represented competitive advantages within the local market, a comparative analysis of PM attributes and practices implemented by TCP and its competitors was performed. This analysis was based on primary data collected from interviews conducted with members of those companies.

Six firms operating in the same industry, same geographical context, and with similar structure and activities as TCP were selected to be interviewed. Then, a semi-structured interview composed by 20 open-ended questions, 6 about organizations´ characteristics (Summarized in Table 2) and 14 related to PM attributes and practices implemented by these firms (Summarized in Table 3) was designed. The same questions were asked in the same order to one member of each firm, ensuring reliability and simultaneously allowing some deviations during interviews.

Finally, a qualitative analysis, comparing the seven interviews (each one of almost 60 minutes), was performed.

Table 2. Details on interviewed companies.

Organizations' characteristics	*A*	*B*	*C*	*D*	*E*	*F*	*TCP*
Types of projects	*Offices and shopping malls*	*Offices and shopping malls*	*Logistic parks*	*Offices and shopping malls*	*Offices and shopping malls*	*Logistic parks*	*Offices and logistic parks*
Real estate or AEC business activities	*From project feasibility to renting*	*From project feasibility to renting*	*From project feasibility to operating*	*Project feasibility and project managemen t*	*From project feasibility to selling. Separated from contracted construction*	*From project feasibility to operating*	*From project feasibility to renting. Separated from contracted construction*
Years of experience.	*30*	*55, but 6 in non-residential.*	*7*	*30, but 8 in mixed-use.*	*3*	*52, but 7 in real estate.*	*3*
Organisational structure.	*Matrix.*	*Matrix with a construction and a selling team for each project.*	*Functional.*	*Matrix.*	*Matrix.*	*Matrix with a construction team for each project.*	*Matrix with a technical team for each project.*
Funding sources.	*Investment funds and crowd-funding.*	*Owner's equity and partners' equity.*	*Investment funds and lease contracts.*	*Investment funds.*	*Investment funds, mortgage banks, and investors.*	*Investment fund, issue of shares, and lease contracts.*	*3 permanent capital partners.*
Organization's strengths	*Experience with fast decision makers.*	*Functional designs with generous spatial areas.*	*High technical specificatio ns and specialized in logistics.*	*Reputation.*	*Experience and relations with related guilds.*	*Reputation, financial support and prices.*	*Low risk aversion, technical expertise, and a multidiscipli nary teams.*

Table 3 shows a comparative analysis between TCP, its competitors, and international references identified in the literature review in terms of PM attributes and practices performed. The last column shows how the performed PM practices and attributes can be related to competitive advantages. Note that, since external factors within the diamond model -e.g., legal conditions in Colombia- are similar for every company, the analysis focused on internal conditions -PM attributes and practices-.

Table 3. Competitive advantages identified in PM attributes and practices performed in TCP

PM Areas	*PM attributes and practices implemented by interviewed companies*	*Additional PM attributes and practices implemented by TCP*	*PM attributes and practices in both TCP and international literature.*	*Factors of competitiveness according to Porter's diamond model*
Preliminary studies	*They usually perform commercial and legal studies. Few companies perform technical studies.*	*TCP includes an analysis of utilities interceptions and sustainability studies.*	• *Early definition of inputs and outputs for critical project processes.*	***Government:*** • *Construction Licenses and regulations.*
Quality assurance	*Some companies do not perform quality-based evaluations on their contractors and materials suppliers.*	*During and after each project, quality of designers, suppliers, and contractors is evaluated.*	• *Defined actors´ responsibilities and their selection processes.*	***Related and supporting industries:*** • *Materials and designs costs.*
Users feedback mechanism	*Direct communications or a system for questions and complaints.*	*Customers satisfaction survey.*	• *Consistent communication and better information quality.*	***Demand conditions:*** • *Consumers' needs and complaints.*
Budgets estimations	*They estimate a single initial budget and financial model.*	*TCP estimates 2 budgets before project execution. The difference between the first budget and the actual project cost is less than 10%.*	• *Reduced unnecessary use of resources.* • *Consistent communication and better information quality.*	***Firm strategy, structure and rivalry:*** • *Efficiency.* • *Cost management.*
Change management processes	*Design committees between managers, auditors, and designers.*	*There is a workflow software that favours communication between stakeholders to approve changes.*	• *Consistent communication and better information quality.*	***Demand conditions:*** • *Consumers' needs and complaints.*
Controlling and planning software	*Some companies have an ERP and a PM software, which are not integrated. Some companies are still just using excel.*	*An ERP, a PM software, a software that integrates both of them (developed by the company) and a workflow software.*	• *Project management information systems.* • *Controlled processes.*	***Factor conditions:*** • *Information Technologies.*
Contractors type of agreement	*Many companies construct their own projects.*	*Use guarantee maximum price type of contract sharing savings with contractors.*	• *Reduced unnecessary use of resources.*	***Firm strategy, structure and rivalry*** • *Cost management.*

PM Areas	*PM attributes and practices implemented by interviewed companies*	*Additional PM attributes and practices implemented by TCP*	*PM attributes and practices in both TCP and international literature.*	*Factors of competitiveness according to Porter's diamond model*
Project management standards	*All companies are ISO 9000 certified and few companies implement PMBOK in an informal way.*	*OPM3®. There is an interest for the implementation of BIM.*	• *All of the PM attributes and practices mentioned in section 2.1.*	***Factor conditions, demand conditions, related and supporting industries, and firm strategy, structure and rivalry.***
PM standards perceived benefits	*Documentation, organization, monitoring and knowledge management. Standards are perceived as high administrative workload with few benefits in terms of project success.*	*Weaknesses identification, continuous improvement, control and monitoring, systematization, and employees´ empowerment.*	• *All of the PM attributes and practices mentioned in section 2.1.*	***Factor conditions, demand conditions, related and supporting industries, and firm strategy, structure and rivalry.***
Stakeholders' involvement	*Partners and employees are the only stakeholders involved in PM processes and practices.*	*Contractors and auditors receive an important training program on PM practices like earned value.*	• *Training and education.*	***Factor conditions:*** • *Personnel education.*
Company´s position about the mandatory nature PM standards	*They should be mandatory. But, they should not affect companies' operations and improve the quality.*	*They should not be mandatory because it depends on the organizational culture and the support from partners.*	• *All of the PM attributes and practices mentioned in section 2.1.*	***Factor conditions, demand conditions, related and supporting industries, and firm strategy, structure and rivalry.***
Risk analysis processes	*There is very little documentation to support risk analysis.*	*There is a qualitative risk analysis for each project.*	• *Controlled processes.*	***Demand conditions:*** • *Consumers' needs and complaints.*
Procurement method	*Each company uses a single management method.*	*There is a process for the selection of the procurement method: traditional, design and build, or project management, according to project needs and risk profile.*	• *Integrated processes.* • *Reduced unnecessary use of resources.*	***Firm strategy, structure and rivalry:*** • *Risk and cost management.*

5 Conclusions

Results of this research represent empirical evidence of the critical role that attributes and practices of standardized project management in a PMO can play for the achievement of organizational goals. Results show that standardization may lead to the creation and enhancement of new competitive advantages in an Architecture, Engineering, and Construction (AEC) organization.

The organization case study is an example of achieving competitive advantages through the implementation of a PM standard. PM practices and attributes observed in the company after the implementation of *AXIS*, the in-house managerial model created based on the OPM3®, are clear differentiating factors according to the comparative analysis performed with competitors.

This paper provides a simple methodology to associate PM practices with competitive advantages. In order to better explore the relation between PM standards and competitive advantages, further research and case studies are needed. It would be important to test these preliminary findings in other countries with a broader representative sample to validate the results of this research.

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Product Integration and Process Characteristics

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Abstract

This paper reports on a primarily quantitative study into the relationship between process characteristics of collaborative design processes and the level of integration reached concerning a building's architectural and climate installation design. This study furthers previous work of Prins and Kruijne (2011). To strengthen further evidence, we first improved the assessment criteria to measure the concept of 'product integration'. Using experts, we were able to obtain a reliable measure of what may be considered 'soft' architectural quality. Secondly, several process characteristics like intensity of collaboration and the very nature of collaboration between architects and climate installation engineers were assessed using a questionnaire. Logistic regression modelling was used to analyse data from 168 respondents who were sampled through professional organisations of architects and climate installation engineers and consultants. The moment the engineer got involved into the project, significantly explained the level of integration of the architectural design, together with 2 other process characteristics. The latter were whether or not the architect was engaged as project manager during the initiative phase, and whether the client expressed an ambition towards the integrative quality of architectural and climate design of the building. These findings thus emphasize the importance of the initiative phase of building projects in achieving high levels of product integration. These results are relevant for designers, project and design managers and clients aiming at generating architectural quality from collaborative design processes.

Keywords: Project Management, Architectural Design Management, Product and Process Integration, Architectural Value, Collaboration

1. Introduction

In recent years, several initiatives were taken to improve the collaboration between stakeholders in the Architecture, Engineering and Construction (AEC) industry (BNA, 2010). 'Product Integration' is mentioned amongst the desired outcomes of such collaboration. Yet, product integration of architectural design is an ill-defined concept. As part of the current study, we furthered previous work of Prins and Kruijne (2011) and improved the assessment criteria to measure the concept of product Integration, more in special the integration of architectural and climate design. Then we used this measure to meet the aim of this study of investigating which process characteristics of the design phase actually contribute to the integration of a building's architectural and climate design.

Process integration can be considered as the way parties effectively arrange and structure their cooperation. It is often assumed that product integration is best achieved by means of process integration between collaborative parties (Prins and Kruijne (2011). Intensification of cooperation, knowledge sharing and information exchange between parties during the building design and construction process and the related managerial activities and technologies might enhance process efficiency and effectiveness. It has been assumed (op. cit.) that both the entire process, and the individual –design- processes of involved architects, engineers, consultants and constructors might be more efficient and effective if knowledge and expertise of parties is shared at the earliest possible moment, for instance as a result of 'integrated procurement'. Other potential benefits of process integration listed in the literature are: higher efficiency including reduction of re-work and failure costs; shorter project time; sustainability; and innovation (Bozdogan et al., 1998; Glicksmann, 2000; Lewis, 2004; Nahm et al., 2004; Yum, 2005; BNA, 2010, Rekola et.al. (2012); Prins and Kruijne, (2011).

Integration of architectural and climate design of the building might be a specific goal of the design team, particularly for the architectural designer. However, research as of how to achieve integrative architectural product quality as a result of a collaborative process of architects and engineers is rather scarce (Prins and Kruijne, 2011). The design phase might be considered as the most crucial phases during the project in determining the building's integrative quality of architectural and climate design. Ove Arup (1972) explains the importance of this phase for the end result: "The goodness of a total design must be the same as the goodness of the finished structure, for the total design completely defines the latter. So in the end quality or value as nowadays seems the word most often used, still remains a question of architectural design". Although Arup attempts a more precise definition of architectural quality, intrinsic or 'soft' architectural values, including 'integration' are difficult to define and measure (Prins, 2009). In the current study product integration is defined as: the result of a conscious act in form of the activities of at least two professionals from different domains, directed at generating architectural quality as added value from their cooperation.

It is often assumed that in architectural design, process and product cannot be separated. It has been argued that a good process delivers a good product, or eventually that at least a good process facilitates object bound value creation (Prins, 2009). In project and design management handbooks (e.g. Allison 2001; Gray and Huges, 2001; Boyle, 2003; Maylor, 2010) it is considered self-evident that project and design management, if properly implemented, will have better results. Cost and time conformity and efficiency, as well as higher quality of the project are mostly referred to as resulting effects (Brown et al., 2000). However, scientific evidence supporting the relationship between project management and the resulting quality of the final project in the end is scarce, especially in case quality is considered a 'soft' architectural value in terms of product integration (Prins, 2009). This lack of evidence in a more general sense is also acknowledged by Rekola et.al. (2012).

Ahire and Dreyfus (2000) are one of the few exceptions to the rule. They examined the effects of design management and process management to the quality of products and processes within the manufacturing industry. Using a dataset of 418 manufacturing plants from multiple industries, they showed that both design and process management efforts positively contributed to both internal (f.i. scrap, rework, defects and performance), and external quality outcomes (such as complaints, warranty, litigation and market share).

Brown and Adams (2000) studied the effects of building project management in 15 UK cases. Remarkably, their results showed no efficiency gains in time or costs among different construction processes. Indeed, the implementation of project management practices seemed to even lower the delivered quality of building projects. They suggested that project management, as implemented in the UK construction sector, did not provide added value to clients.
Arge (1995) used a questionnaire to investigate differences between 10 design projects in Norway. Half of these projects were classified as poor, half were considered good product quality. From his study, Arge concluded that an ambitious client, and a direct and quite intense communication between client/user and architectural designer, is indicative to enhance the architectural quality of the resulting building.

Mc Adam and Canning (2001) and Munting and Cruywagen (2008) both showed the reluctance of architectural designers to formalised managerial procedures in quality management. They also showed poor implementation of formal –managerial- procedures in architectural practices. It is tempting to conclude that architects do not consider management as an effective tool for quality control of their final product and their practices. This might be due to the lack of understanding based on the 'language complexity' between managers and architectural designers (Buchiarelli, 2003; Prins, 2004, 2009).

Using a questionnaire approach, Prins and Kruijne (2011) studied the effects of process and product integration in 55 projects in the AEC sector. They particularly studied the influence of intensity of managerial efforts supporting collaboration between HVAC engineers and architects on the level of integration of architectural and climate design of the final building. Their results showed no significant association between intensity of managerial procedures supporting collaboration and the final obtained level of product integration in terms of 'soft' architectural quality. Their results contrasted with, the common notion that project –design- management, when properly implemented, will result in higher quality final projects. These results might be due to methodological weaknesses in their study, as the authors suggested. They suggested using a broader range of cases in terms of building types and practices. Another recommendation was, such consistent with Arge's (1995) findings, to more explicitly investigate the ambition of clients and designers for their desire to achieve for integration of architectural and climate design.

For a more extensive literature review the authors would like to refer to Prins and Kruijne (2011). This study furthers previous work of Prins and Kruijne (2011). To strengthen further evidence, we first improved the assessment criteria to measure the concept of 'product integration'. Using experts, we developed a reliable method measuring the level of integration of architectural and climate design of the building. Such may be considered 'soft' architectural quality. Secondly, several process characteristics like intensity of collaboration and the very nature of collaboration between architects and climate installation engineers were included in a questionnaire to investigate whether process characteristics of the design phase actually contribute to the integration of a building's architectural and climate design.

2. Research Methods

A two-staged study design is used. The first stage of the study concerns the conceptualisation of the level of integration of a building's architectural and climate installation design (product integration). Briefly, we first improved the assessment criterions from Prins and Kruijne (2011) to measure the concept of 'product integration' in several rounds. Thereafter, we confirmed reliability and cross validated the scale measuring product integration using data from the second stage of this study.

In the second stage, we aimed at investigating the influences of characteristics of the design process on the level of integration of architectural and climate installation design. To this end, an online questionnaire was conducted amongst the members of the BNA (Union of Dutch Architects), UNETO-VNI (Union of Dutch Installation Engineers) and NLingenieurs (Union of Dutch Consultants, Managers and Engineers). Initially, a banner with a link to the questionnaire was posted on their website, but to enhance response rates, all associated members received an email with an invitation to participate in the study. This resulted in a dataset of 168 respondents.

To measure the integration of a building's architectural and climate installation design (product integration), Prins and Kruijne used twelve criteria. We first asked a small group of graduate students in architecture to test the pre-existing set of criterions to decide whether or not the set of criteria needed further work. We developed a set of photos, consisting of 25 projects. Per project 3 or 4 photos were showed. First, 3 graduate students were asked to judge whether the buildings showed low, intermediate or high integration of the design of architecture and climate installations. Then the pre-existing set of 12 criterions was showed and the students were asked to indicate whether each of the 12 criterions applied or not. Subsequently, the students were asked to use the 12 criterion and to categorize the projects into one of three levels of integration between HVAC systems and architectural expression:

1. High: The HVAC system contributes to a significant extent to the architectural quality of the building. The HVAC system has aesthetic qualities of its own, as well as in relation to the architectural concept of which they are an intrinsic part.

2. Average: The HVAC system is designed to fit in with the building. While not being a dominant visual aspect, it is integrated in a proper way in the building with elegant technical solutions.

3. Low: The HVAC system has a purely functional design; it does not directly contribute to the architectural, i.e. visual, quality of the building.

It turned out that using the 12 criterions, students were able to distinguish among low, average and high integrative quality of climate and architectural design. Students were asked to think aloud and make their judgements explicit. Except for 2 criterions, all 3 students were able to apply all other 10 criterions. All 3 students could not distinguish the two remaining criterions: criterion 10 'No evident mistakes or jury-rigged solutions are apparent' and criterion 11 'There are no unfortunate solutions concerning HVAC system and building design'. Therefore, these criterions were combined and reformulated as 'There are no unfortunate solutions or evident mistakes concerning the climate system and building design apparent.' An additional criterion was formulated as the 12th criterion being 'A physical building element, which is not part of the climate system, is designed to be part of the primary climate system.' This was done so, because of the growing importance of the climate installation in a building's façade nowadays. The final list of criterions is summarized in Figure 1.

These are the criteria constituting integration between architectural expression and climate system.

1. The climate system is in harmony with the architectural concept.
2. The climate system contributes to the quality of the architectural concept.
3. The climate system itself incorporates elements what are aesthetically pleasing.
4. The climate system contributes to the functioning of the building.
5. A design vision can be elicited based on both the climate system as well as from the architecture.
6. The climate system is designed to be explicitly visible or hidden.
7. The climate system fits in with the architectural style of the building (from a historical perspective).
8. The design of the climate system is consistent throughout the entire building.
9. Aesthetic clashes between the climate system and other parts of the building were designed for this specific purpose.
10. There are no unfortunate solutions or evident mistakes concerning the climate system and building design apparent.
11. There is unity in the expression of the materials chosen for the climate system and the rest of the building.
12. A physical building element, which is not part of the climate system, is designed to be part of the primary climate system.

Figure 1: The used set of criteria constituting integration

The former procedure was now used in a study with experts from TU Delft. Only, the set of 25 projects and per project 3 or 4 photos was considered too time consuming and therefore was reduced to a set of 10 projects, which were judged by the researchers as differing in their level of product integration, and which were documented with a series of 4 exterior pictures. Twelve senior teachers of the Faculty of Architecture of TUD with a background in architectural design, architectural engineering and building physics or climate design were first asked to rank the buildings into the three pre-defined levels. Thereafter, they were asked to do the same using the set of twelve criteria from Figure 1. In addition to the original research, the respondents were also asked to rank the criteria according to their importance in the formation of their judgement of each project on a four points scale. We then assessed whether experts agreed upon the level of integration in architectural and climate design. Finally in a semi-structured interview they were asked to reflect on the definitions of the levels and the criteria used. Table 1 shows for each project how the 12 experts considered the level of integration in architectural and climate design.

Table 1: A detailed overview of the ranking of academics based on the set of criteria.

	Project 1	Project 2	Project 3	Project 4	Project 5	Project 6	Project 7	Project 8	Project 9	Project 10
	High average low	High average low	High average low	High average low	High average low	High average low	High average low	High average low	High average low	High average low
Expert 1	○ ● ○	● ○ ○	○ ○ ●	● ○ ○	○ ○ ●	● ○ ○	● ○ ○	○ ● ○	● ○ ○	● ○ ○
Expert 2	○ ● ○	● ○ ○	● ○ ○	● ○ ○	○ ○ ●	● ○ ○	● ○ ○	○ ● ○	● ○ ○	○ ● ○
Expert 3	● ○ ○	○ ○ ●	○ ● ○	● ○ ○	○ ● ○	● ○ ○	○ ○ ●	○ ● ○	○ ○ ●	○ ● ○
Expert 4	● ○ ○	● ○ ○	● ○ ○	● ○ ○	○ ○ ●	● ○ ○	● ○ ○	● ○ ○	○ ● ○	● ○ ○
Expert 5	○ ● ○	● ○ ○	● ○ ○	● ○ ○	○ ○ ●	● ○ ○	○ ○ ●	● ○ ○	○ ● ○	● ○ ○
Expert 6	○ ● ○	○ ● ○	○ ● ○	○ ● ○	○ ○ ●	○ ● ○	○ ● ○	○ ● ○	● ○ ○	○ ● ○
Expert 7	● ○ ○	● ○ ○	● ○ ○	● ○ ○	○ ● ○	● ○ ○	○ ○ ●	● ○ ○	○ ● ○	● ○ ○
Expert 8	● ○ ○	● ○ ○	● ○ ○	● ○ ○	○ ○ ●	● ○ ○	● ○ ○	● ○ ○	○ ○ ●	● ○ ○
Expert 9	○ ● ○	○ ○ ●	● ○ ○	○ ● ○	○ ○ ●	● ○ ○	○ ○ ●	○ ● ○	● ○ ○	● ○ ○
Expert 10	○ ● ○	○ ○ ●	● ○ ○	○ ● ○	○ ○ ●	● ○ ○	● ○ ○	● ○ ○	● ○ ○	● ○ ○
Expert 11	● ○ ○	○ ● ○	● ○ ○	● ○ ○	○ ● ○	○ ● ○	○ ● ○	○ ● ○	○ ● ○	● ○ ○
Expert 12	● ○ ○	● ○ ○	● ○ ○	○ ● ○	○ ○ ●	● ○ ○	● ○ ○	○ ● ○	○ ● ○	○ ● ○
	50% 50% -%	58% 17% 25%	75% 17% 8%	67% 33% -%	-% 25% 75%	83% 17% -%	50% 17% 33%	42% 58% -%	42% 42% 16%	67% 33% -%

There was no absolute agreement amongst the experts, such confirmed by a low intra class correlation coefficient of 0.29. However, it is not that experts judged randomly. Some experts might not assign exactly the same categories, but they consistently ranked certain projects as showing higher levels of integration than other projects. This is reflected in a high average agreement amongst the experts and compares to the outcomes of the semi-structured interviews. Experts mentioned that the criteria provided them with a structure to judge the level of integration. Indeed, the average level of agreement measured with Cronbach alpha is 0.84. For this reason, we consider the set of 12 criterions a reliable way to measure the level of integration in architectural and climate design. We included this set of criterions in the questionnaire and asked respondents to rate their project according to these 12 criterions (see further on for more details about the second part of the study that used a questionnaire to investigate design characteristics and subsequent level of integration in architectural and climate design). We did so, because we thought the set of 12 criterions could be considered a scale measuring the level of integration of the architectural and climate design. This would allow us to compute a summary score reflecting the level of integration in architectural and climate design per project.

Then, we might use this summary score to further relate the influence of certain characteristics of the design process to the level of integration in architectural and climate design. Instead of using a dichotomous scale for the assessment of these 12 criterions, we used a four points answering scale in the questionnaire. Respondents could rate the applicability of each criterion ranging from -- / - / + / ++. Analyses of 168 respondents who judged the product integration of their most recent project showed again that we had developed a reliable measure of the level of integration in architectural and climate design. This is reflected by the high value of Cronbach alpha, being 0.88. All criterions were contributing to the scale, as reflected by item-rest correlations well above 0.30. None of the criterions were redundant, since item-rest correlations were not higher than 0.70. Item rest correlations were between 0.49 and 0.69. To further validate our measure of product integration, we also asked respondents to separately rate the level of integration of the architectural design with the climate design of one of their recent projects using a ten-point scale. The correlation between this measure and the sum score obtained by adding the scores of the individual criterions (spearman correlation coefficient: 0.72) showed that we could use the sum score not only as a reliable measure, but also as a valid measure. Even a related score, obtained by recoding the 10 point scale into low (1-7) and high (8-10) showed a satisfying correlation (spearman correlation: 0.64) with the sum score of the 12 criterions.

The questionnaire we used consisted of four parts:

1. Demographic information about the respondent.
2. Level of integration of the architectural design with the climate design. This as a concept was introduced and the 12 criterions were presented along with some photos for illustration.
3. For the remaining of the questionnaire the respondent is asked to consider a project that the respondent considers to have a certain (unspecified) level of integration of architectural and climate design. The project should not have been realized for more than 5 years ago. Thereafter the respondent is asked questions about process characteristics, including the assignment of tasks, process organisation, coordination responsibilities and the level and use of BIM technologies.
4. The last part consists of questions about the obtained result. The respondent is asked to rate the level of integration of the architectural design with the climate design of one of their recent projects using a ten point scale; the 12 criteria are rated from – / -/+/++.

SPSS was used to statistically analyse the data. By using cross tabulation we investigated the relationship between the two categorical variables: the process characteristics and the level of product integration. Results of the cross tabulations were used to select process characteristics eligible for inclusion in logistic regression modelling. Logistic regression model is used to further investigate the correlation between the process requirements and the degree of integration (Field, 2009). $P < 0.05$ was used as a threshold for significance testing.

3. Results

To relate process characteristics to the level of integration between the architectural and climate installation design we first asked the respondents to consider one of their own projects that they judged to have some integration of architectural and climate installation design. They then provided some general information about this project, and finally judged their own project for the level of product integration using the twelve criterions showed in Table 1.

Table 2: Descriptive information process characteristics

Early involvement of the engineer in the process	Brief	Sketch Design	Preliminary Design	Final Design
	43 (25.6%)	38 (22.6%)	55 (32.7%)	32 (19%)
Previous collaboration architect - engineer	None	Same organisation	Same persons	In-house
	106 (63.1%)	33 (19.6%)	25 (14.9%)	4 (2.4%)
Frequent face-to-face meetings	More 1 in 2 weeks	Once in 2 weeks	Once in 3-4 weeks	Less than once month
	29 (17.3%)	57 (33.9%)	68 (40.5%)	14 (8.3%)
The existence and implementation of an information plan	At start and used	At start but not used	During design and used	No info plan
	35 (20.8%)	6 (3.6%)	22 (13.1%)	105 (62.5%)
	Architect	Engineer	Professional manager	
Project leader initiative phase	68 (40.5%)	7 (4.2%)	30 (17.9%)	
Project leader design phase	128 (76.2%)	42 (25%)	32 (19%)	
Project leader construction phase	58 (34.5%)	35 (20.8%)	50 (29.8%)	
The organisation of a project delivery system	Traditional	DB	Supply chain	
	106 (63.1%)	22 (13.1%)	40 (23.8%)	
The way the payment of parties are arranged	% Total construction costs	Based on working hours	Fixed costs (Lump sum)	Otherwise
	32 (19%)	24 (14.3%)	109 (64.9%)	3 (1.8%)
The formulation of the clients' specific ambitions towards integration	At start, aimed for	At start, not explicitly	During design, aimed for	No ambition
	45 (26.8%)	12 (7.1%)	36 (21.4)	75 (44.8%)
A shared vision among the project members towards integration	At start, aimed for	At start, not explicitly	During design, aimed for	No ambition
	60 (35.7%)	14 (6.5%)	38 (22.6%)	59 (35.1%)
Using Building Information Modelling (BIM) technology	2D	CAD with visuals 3D	2D and object-based 3D	3D
	66 (39.3%)	49 (29.2%)	30 (17.9%)	23 (13.7%)
Size of company (number of employees)	< 10	10-49	≥ 50	
	103 (61.3%)	30 (17.9%)	35 (20.8%)	

Table 3: Output of the Pearson Chi-Square

	Process Characteristics	Pearson Chi-Square Value	df	Asymp. Sig. (2-sided)
1	Early involvement of the engineer in the process	12.578	3	$p < 0.01$
2	Frequent face-to-face meetings	3.849	3	$p > 0.05$
3	The existence and implementation of an information plan	2.409	3	$p > 0.05$
4	The architect, as the project leader during initiative phase	7.183	1	$p < 0.01$
	The professional manager, as the project leader during initiative phase	0.637	1	$p > 0.05$
	The architect, as the project leader during design phase	0.051	1	$p > 0.05$
	The professional manager, as the project leader during design phase	2.635	1	$p > 0.05$
	The architect, as the project leader during construction phase	4.952	1	$p < 0.05$
	The professional manager, as the project leader during construction phase	0.345	1	$p > 0.05$
5	The organisation of a project delivery system	4.010	5	$p > 0.05$
6	The way the payment of parties are arranged	0.994	3	$p > 0.05$
7	The formulation of the clients' specific ambitions towards integration	19.371	3	$p < 0.01$
8	A shared vision among the project members towards integration	13.594	3	$p < 0.01$
9	Using Building Information Modelling (BIM) technology	3.984	3	$p > 0.05$

All process characteristics from table 3 with a significance of $p < 0.25$ were included in further logistic regression modelling. The thus selected process characteristics were: moment of involvement of the engineer ($p = 0.006$), relationship between the architect and engineer ($p = 0.086$), meeting frequency ($p = 0.188$), project management during the initiative phase (architect: $p = 0.007$, engineer: $p = 0.112$), project management during the design phase (professional project manager: $p = 0.105$), project management during the construction phase (architect: $p = 0.026$), the ambition of the client ($p = 0.000$) and the shared vision of the project team ($p = 0.004$). A backward selection method was used to develop the final model. The final logistic regression model (see Table 4) shows that (1) the moment of involvement of the engineer within the process, (2) the project management during the initiative phase and (3) the ambition of the client are important in predicting the degree of product integration. The involvement of the engineer during the formulation of the design brief is significantly and positively associated with product integration. The OR (Odds Ratio) indicates an achievement of almost five times more projects with a high degree of integration of architectural and climate design if the engineer is involved in the formulation of the design brief, relative to projects where the engineer is not present at that stage. So, his input during this phase, prior to the design phase, is critical in achieving a high degree of integration of architectural and climate design.

Also the party who is managing the project during the initiative phase is important in achieving a high degree of product integration. Both the presence of architect and the engineer are significantly related to the level of a building's integration of architectural and climate design. However, from the model (i.e. the OR) it must be concluded that if the architect takes responsibility for the management of the project during the initiative phase, more projects will achieve a high degree of integration relative to the situation of the engineer having the lead. Indeed, from Table 3 it can be learned that the involvement of a professional (project) manager neither during the initiative phase, nor during the design or construction phase made any difference for the level of integration of the building's architectural and climate design. Finally, the ambition of the client, actively achieved for from start, is significantly related to the level of product integration.

Table 4: Output of the Logistic Regression Model

Characteristics	B	S.E.	Wald	df	Sig.	Exp(B)	95% C.I. for Exp(B)	
							Lower	Upper
Involvement of the engineer			9.907	3	0.019			
Design Brief	1.591	0.583	7.440	1	0.006	4.908	1.565	15.395
Sketch Design	0.957	0.570	2.816	1	0.093	2.604	0.851	7.965
Preliminary Design	0.330	0.539	0.375	1	0.540	1.391	0.484	4.002
Project management during initiative phase								
Architect	0.990	0.375	6.958	1	0.008	2.690	1.290	5.611
Engineer	- 2.764	1.205	5.263	1	0.022	0.063	0.006	0.669
Ambition of the client			13.198	3	0.004			
Actively implemented from start	1.394	0.450	9.606	1	0.002	4.032	1.669	9.735
Not actively implemented	- 0.967	0.855	1.278	1	0.258	0.380	0.071	2.033
Formulated later in the process	0.159	0.457	0.121	1	0.728	1.172	0.479	2.868
Constant	- 1.705	0.627	7.407	1	0.006	0.182		

When a specific ambition regarding product integration in terms of 'soft' architectural value of the project was formulated before the design phase, it appears that it is four times more likely that the project result is considered a building with high product integration than if the client had not stated an ambition concerning the integration of architectural and climate design.

4. Conclusions and reflection

The concept of product integration in terms of 'soft' quality (intrinsic architectural value) between the architectonic design and the climate design of buildings as developed by Prins and Kruijne (2011), has been further validated in this study. Additional to the earlier findings, this study shows there is a reliable internal consistency amongst the criteria defined to constitute a building's integration of architectural and climate design, and all of them have strong correlations with this kind of product integration. All the criteria significantly added to the reliability of the concept and the measuring of product integration as defined in this research. Indeed the more criteria that are applied, the higher the level of a building's architectural and climate installation design is valued. We found a strong positive correlation with the sum score of the 12 criterions and a separate question in which respondents were asked to rate the level of integration of architectural and climate design of their project. Furthermore, this study provides empirical evidence that certain process characteristics important in achieving process integration were significantly associated with the level of a building's integration of architectural and climate installation design.

In our study the following process characteristics showed significant associations with the degree of resulting product integration:

- early involvement of the engineer within the project, i.e. in the design phase
- the architect managing the project during the initiative and design phase
- the client has expressed an ambition towards integration of architectural and climate installation design, and this has been achieved for from start onwards

These are remarkable differences compared to the earlier findings of Prins and Kruijne (2011) as they found no significant associations at all. The fact that Prins and Kruijne (2011) did not find any associations may be substantiated by the limited variance in typology of studied cases and firms. The typology in this extensive, pursued study is however broader, allowing for further associations, in line with the initial assumption of Prins and Kruijne (2011). Further, our findings are consistent with those of Arge (1995) and the reasoning Prins (2009) provides on the concept and creation of added architectural value.

Amongst the most remarkable findings is that this study showed no significant associations of the level of integration of architectural and climate installation design with process characteristics like face-to-face meeting frequency, the existence and implementation of an information plan, the involvement of a professional project manager, the project delivery system, payment arrangements between parties, the use of integrative systems like BIM, and the degree of product integration reached.

With a few exceptions, more sound empirical quantitative studies are rather scarce, looking into the effects of process characteristics in general and project and design management in special, on resulting quality. Such is even truer within the domain of architectural design when difficult to measure so called 'soft' or intrinsic architectural values are considered. To our best knowledge in this sense this study is rather unique in its attempt as well as remarkable in its findings. It would be too easy to state that our study indicate that the regular ideas as of how to manage collaborative design processes needs a total revision, since our study is limited to a special interpreted definition of product integration in terms of 'soft' architectural quality. Indeed the classical assumptions that a well-managed process will result in higher cost efficiency, less re-work and failure cost etc. is not contradicted by our findings. However the process and its efficiency is a means to an end. In case of architectural design the ultimate aim is a high quality building. Further research is needed to investigate whether we do need to re-consider traditional approaches. It is tempting to suggest that many classical managerial insights might need further work to ensure architectural design management becoming a more proven and effective discipline.

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Conceptualising e-business models for SMEs in the AEC sector: A product and services perspective

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Abstract

E-business can be as simple as using the Internet to send emails to communicate with customers/suppliers or to establish complex network relationships with trading partners. A business can be considered an e-business even if it doesn't buy and sell products over the Internet, as the term refers to business activities that are assisted by the Internet. Since early 2000, considerable literature has explored e-commerce/e-business in the context of construction enterprises. They have looked at enablers and barriers of business, issues associated to, implementation processes/models, technical platforms/architecture, supply chain integration etc. However, there is limited discourse into conceptualising the role of e-business in SMEs in Architecture, Engineering and Construction (AEC) firms. It is essential to understand the business of an SME, especially the nature of their core business, in the form of product, service or a mix of both, to evaluate the role of e-business. This is critical as mainstream literature suggests that while there are common processes relating to product or service innovation, a significant difference is also evident. In this context, understanding the nature of the core business provides the basis to conceptualise the intra organisational connections, through a product-service mix, that SMEs have with their trading partners, and to evaluate how e-business becomes relevant to specific dyadic and/or network connections. The aim of this paper is therefore to conceptualise e-business in construction SMEs, in terms of product-service mix, based on the extent of online driven connectivity between trading partners. The research aim is approached through qualitative review of literature. This research method is underpinned by constructivist paradigm, which accepts multiple realities of the world, enabling construction of pluralistic arguments. The concluding remarks suggest that e-business models can be conceptualised via the fusion of ‘Strategy Model’, ‘Resource Model’ and ‘Network model’.

Keywords: product, service, business model, supply chain, e-business models

1. Introduction

The Architecture, Engineering and Construction (AEC) sector is predominantly constituted of Small and Medium Enterprises (SME) (Australian Bureau of Statistics, 2012). However, external business environment, such as business cycles and volatile economic conditions (Giang and Pheng, 2011), along with internal inefficiencies (cost of production, redundant processes etc.) lead SMEs to fail (Collins, 2012). Although SMEs face numerous challenges mainly due to limitation of resources, they enjoy opportunities arising from their flexibility to respond to changes in market and to make changes to their processes. In this context some SME's have to exploit the opportunities offered by technologies (Anumba and Ruikar, 2002; Brewer, Gajendran and Runeson, 2013) specifically Information Communication Technologies (ICT) to create business models (Wirtz, 2011) to be competitive. It is important SMEs engage in organisational process (Ruikar, Anumba, and Carrillo, 2006) and develops capabilities that foster innovation (Gajendran et al. 2013; Murphy, Heaney and Perera, 2011).

In this context, understanding the business models, particularly the e-business models that impact SME's in the AEC sector is critical. Despite design of business models being firm specific, the structure of the industry and the project-based nature of operations, impact on the business model design. Supply chains are primarily focused on how the firm delivers its products and services to clients effectively. Therefore, the need to conceptualise the design and operations of a business from a supply chain perspective, is important (Cutting-Decelle et al., 2007). This paper provides a framework to conceptualise the e-business modes in the AEC sector. It deconstructs the business model analysis through the (a) Strategy model: product-service dimension (b) Resource Model: resource based view and (c) Network model: engagement with the customers and trading partners.

The proposed conceptualisation of e-business provides a further level of analytical capability to deconstruct e-business from a product-service perspective. This raises the potential for researchers and business managers to not only look at their e-commerce capabilities from a firm's internal and supply chain context, but also to deconstruct dyadic relationships from a product-service mix. This can provide better opportunities identify the appropriate and context specific technical tools and platforms for e-business adoption.

2. Theoretical perspectives on e-business development

Firms leverage capabilities gained from e-business to gain competitive advantage. Embracing the opportunities offered by e-business environments requires managers to think strategically (Chen, Ruikar, and Carrillo, 2013) and reconfigure their business resources-capabilities (Spencer, 2013). A clever blend of e-business technology with alternative business processes creating new forms of business models can lead to innovation (Wu and Hisa, 2008). In this context a business model is a facilitating construct that blends the technologies and business values (Writz, 2011) to provide structure to a business. Fitting e-business models can lead to relatively low cost business operations, enhancing the pace of business operations and improving information and communication flow among all participants (Eadie, Perera and Heaney, 2007).

2.1 Models for e-business design

E-business can be classified into a number of modes including Business-to-Consumer (B2C) and Business-to-Business (B2B) (Ash and Burn, 2003; Turban et al. 2010; Anumba and Ruikar, 2002):

- Business-to-Consumer (B2C) → online business selling to individual consumers. Building supply firms directly reach the consumer. Moreover, the large residential builders (e.g. project home firms) also can directly deal with their customers with B2C tools.
- Business-to-Business (B2B) → online business selling to other business. Most firms in the AEC sector engage with B2B relationships. In general all suppliers and sub contractors can engage with the General (main) contractor and consultants, making B2B a significant component of construction project business. B2B is classified into a further two subsets $B2B^s$ and $B2B^c$, where the latter is about a business dealing with another business which is a corporate customer (e.g. a project home builder) who then passes the products/services to end-customer (e.g. a house buyer) (Ash and Burn, 2003)

Business models are defined with respect to generating value for a business and actors, key processes (including distribution channels/information flows), the architecture of products/services, (Spencer, 2013; Petreovic et al 2001). In the context of this paper, based on Wirtz (2011) and Petrovic (2001), three-business model lenses are discussed:

1. Strategy Model – describing the core aspects of the business in terms of products or services delivered to the customers- i.e. the value delivered to customers by the firm.

2. Resource Model - describes the key resources and competences that are critical for business success. It will identify the sources and measures of resource/competency elements within and outside (supply chain) firm.

3. Network Model- is focused on the identification of partners and their roles, in terms of significance, in supporting the business goals. Network model can be more explicitly analysed via sub models of:

- Production Model - how resources are combined to transform the inputs into output.

- Customer Relations model - inform customers about the products/services (marketing).

The 'strategy model' in the context of e-business can be analysed further through the project-service literature. Identifying the nature of the core business and analysing its characteristics will enable a business to understand the extent of the 'product' and 'service' offered by their firm. The resource and network models can be explored via the supply chain integration agenda focused on exploiting ICT/e-commerce developments for improved communication, customer relationship management, demand management, production management etc. (Donk, 2008). The mutual aims of both e-business and supply chain management, are about performing effective business transactions between the trading partners through sharing of business information and developing/maintaining good business relationships (Brewer and Gajendran, 2011). Therefore, blending the alternative e-business models with supply chain paradigms (see Smart 2008) is critical in unearthing and exploiting the capabilities of a firm (Ash and Burn, 2003).

3. Conceptualising elements of e- Business models

3.1 Product and service perspective characterising core business for strategy model

One of the key issues in developing e-business models is to have a clear understanding of the core business in terms of 'products' and 'services' offered by the firm. SMEs in the AEC sector include Architecture, Quantity Surveying, General contracting, Specialist subcontracting and Trade subcontracting firms. The core business of these firms differs and characterising it in terms of 'product' and 'service' will enable refinement of the strategy model, which subsequently informs the resource and network models.

Table 1: Distinction between Products and Services

Products	Services
Can be resold	Reselling unusual
Can be inventoried	Difficult to inventory
Some aspects of quality measurable	Quality difficult to measure
Site of facility important for cost	Site of facility important for customer contact
Often easy to automate	Often difficult to automate
Revenue generated primarily from tangible product	Revenue generated primarily from intangible service

Source: Adapted from Heizer and Render (2011)

'Product' components in a core business is characterised by tangibility, consistent product definition, uniqueness/homogeneity, inventoried and low customer interaction. Services components are characterised by its intangibility, coproduction with customers, simultaneity, uniqueness/ heterogeneous and perishability (Heizer and Render, 2011). Table 1 classifies the key characteristics of products and services that can assist in identifying the nature of core business of AEC sector firms.

3.2 Resourced based view characterising core business for resource model

The resource base view (RBV) of the firm suggests that a sustained competitive advantage is achieved through a bundle of 'static' and valuable resources, which are heterogeneous and not perfectly mobile, that a firm can draw on. Such resources are valuable to the firm by neither being perfectly imitable nor substitutable without great effort (Barney, 1991). A firm's operational capabilities allow the firm to generate income at a given point in time. It represents the bundle of valuable capabilities captured within the firm's resource base that it draws on to operate and compete in the market (Helfat and Winter, 2011).

Firms, specifically SMEs, look outside their organisational boundaries to seek to buy resources and capabilities hat are not viable to be sustained inhouse. Some firms are quite strategic in sourcing such resources and capabilities in the market and embedding them in their supply chain to create value to their customers (Gajendran et al., 2013a). Such resources could be both products or services or a mix of both.

3.3 Supply chain conceptualisation characterising core business for network model

Network Model illustrates the business partners and their roles, in terms of significance, in supporting the business goals. This model can be more explicitly analysed via sub models (a) 'Production Model'- describing inputs resources and how they are combined to produce outputs, and (b) 'Customer Relations model'- describing the marketing and information flows to customers about the product/services Visualisation of the network model can be executed through supply chain conceptualisation. Managing a supply chain is about maintaining effective network and flow of resources (including material, people and information) beyond the functional/corporate boundaries of firms. Shared business interests/goals/processes and effective information exchange between various business entities are essential to achieve this aim (Oke et al 2013).

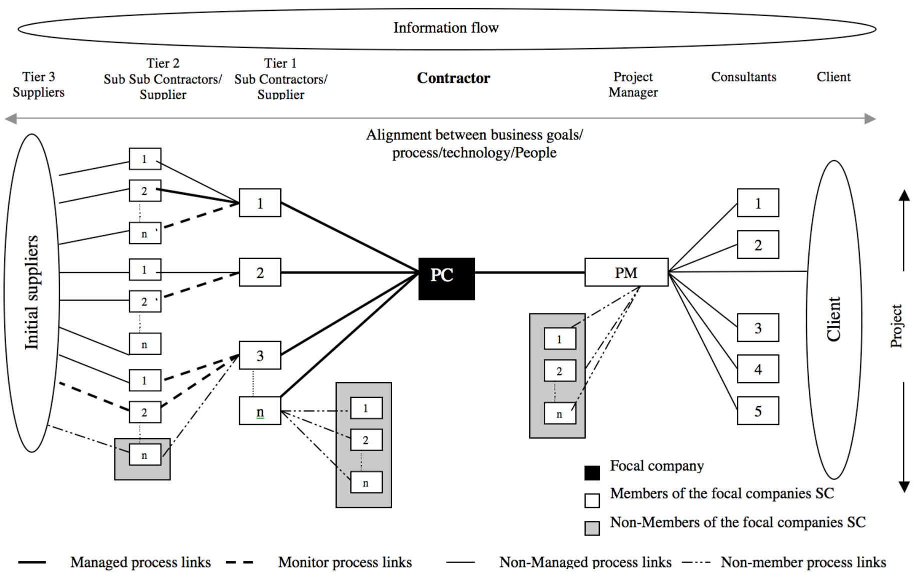

Figure 1: An illustration of Lambert and Cooper's (2000) model in the context of construction

The supply chain visualisation proposed by Lambert and Cooper (2000) provides the opportunity to depict numerous dimensions of supply chain operations from a multiple perspective. Figure 1, modified after Lambert and Cooper (2000) proposes a 'root and branch' model using a number of dimensions to aid the description, analysis and management of the supply chains. It provides a generic illustration of a construction project supply chain, mapping the chain from a General (main) contractor as the focal firm. Conceptually it allows all members to be linked, from client to final supplier, in layers or tiers. It enables members to visualise and link various functions/aspects/operations within a firm and across firms. This assists in determining the different informational needs of supply chain members and how they should flow across the members. The process links are based on how the supply chain network connections are managed from an operational perspective. Moreover, the extent of the element of 'product' or 'service' as part of the core business with trading partners and customers provides more room to analyse the e-business needs - which will assist in designing the e-business platform and tools.

As indicated previously, firms that produce and sell their products and services with e-enabled supply chains via effective flow of material, plant, people, finances and information will position the firm with significant competitive position (Lambert and Cooper, 2000). In information intense environments the implementation of a coherent supply strategy embedded in e-business is vital for competitive advantage (Gudnason and Scherer, 2012).

4. Analysis and discussion

Figure 2 provides a conceptual framework drawn from all the theoretical perspectives discussed in the above section. SME's in the consulting and contracting business are analysed through the analytical model in Figure 2 to elicit the generalised characteristics of core business and establish the resource base to construct the network mode. This analysis provides a framework for conceptualising e-business in different businesses.

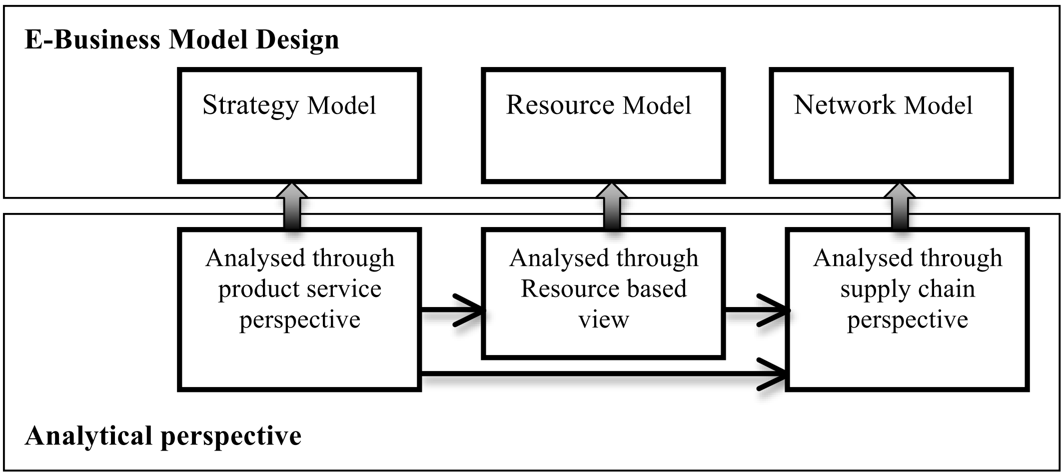

Figure 2: An analytical framework to conceptualise e-business models

Table 2 analyses (Figure 3), in a generic sense, the core business of different AEC sector business to identify the extent of the 'product' and 'service' components as part of constructing the 'strategy model'. It suggests that although core business of consultancy organisations (including architecture, QS, PM and engineering) is predominantly service oriented, a very small part of the business involves products.

Table 2: Extent of the 'product' and 'service' in the core business different AEC sector firms

<table>
<tr><th>Categorisation of AEC firms</th><th>Services</th><th>Products</th></tr>
<tr><td rowspan="3">Architectural / Engineering/ Quantity surveying / Project management consultancy firms</td><td colspan="2">The core business is predominantly service oriented in designing and managing the construction of buildings.</td></tr>
<tr><td>Core business is focused on applying intellectual and knowledge-based inputs to produce building designs, costing and associated documentation (specifications, Bill of quantities etc.) as outputs. The outputs are generally characterised by intangibility, not easily inventoried and difficult to automate.</td><td>A very small part of the core business involves products such as drawing, physical models, digital models, specifications, bill of quantities, which can be characterized as tangible, easily inventoried and easy to automate.</td></tr>
<tr><td colspan="2">E-business engagement can be B2B (e.g. design and construct /consortiums) or B2C (directly approached by client).</td></tr>
<tr><td rowspan="3">General (main) contractors</td><td colspan="2">The core business is dependent of how much of the trade operations are in house. However, most of the General contracting firms, primarily coordinate different trade activities and therefore are predominantly service oriented.</td></tr>
<tr><td>The core business is focused on applying intellectual and knowledge base to coordinate different actors to construct a physical facility. However, from a client's perspective General contractors do deliver a product that is tangible. However, this product (building) is usually constructed by other firms (e.g. specialist and trade subcontractors) employed by the General contractor.</td><td>Despite General contractors providing warranty to clients for a tangible product (the building), many firms may not have constructed the tangible physical product using their in house resources/competencies. However, in the management role, they may produce working drawings, quality control documents etc. In such cases General contractors produce negligible physical products.</td></tr>
<tr><td colspan="2">E-business engagement can be B2B (e.g. design and construct/Alliance/consortiums) or B2C (directly approached by client)</td></tr>
<tr><td rowspan="3">Specialist sub subcontractors</td><td colspan="2">Most of the specialist sub contracting firms (e.g. franchises), primary install/assemble, and maintain, specialist building sub elements such as lifts, air conditioning system, fire system facade system etc. manufactured by a separate firm – and are therefore primarily service oriented.</td></tr>
<tr><td>Their core business is primarily focused on applying intellectual and knowledge base to coordinate assembly of components and subsequent maintenance. But in some cases these firms erect support structures in a physical facility.</td><td>A very small part of the core business involves products such as assembly of support structures, which can be characterized as tangible.</td></tr>
<tr><td colspan="2">E-business engagement is primarily B2B</td></tr>
<tr><td rowspan="3">Trade subcontractors</td><td colspan="2">Most of the trade sub contracting firms' core business is constructing tangible elements of a physical building erected from basic materials or components. The level of product-service components will depend on the actual trade e.g. concreators, bricklayers and carpenters core business is characterised by more of 'product' element than electrical and plumbing trade subcontractors (who offer more of 'service').</td></tr>
<tr><td>Trade subcontractors' core business is primarily focused on applying knowledge and skill base to assemble components and erect structures and services in a physical facility.</td><td>Most of the trade subcontracting firms core business is offering to construct tangible elements of a physical building from basic materials or components. They can be inventoried with some aspects of quality being measurable.</td></tr>
<tr><td colspan="2">E-business engagement is primarily B2B (e.g. general contractors) and some level of B2C (directly approached by client).</td></tr>
</table>

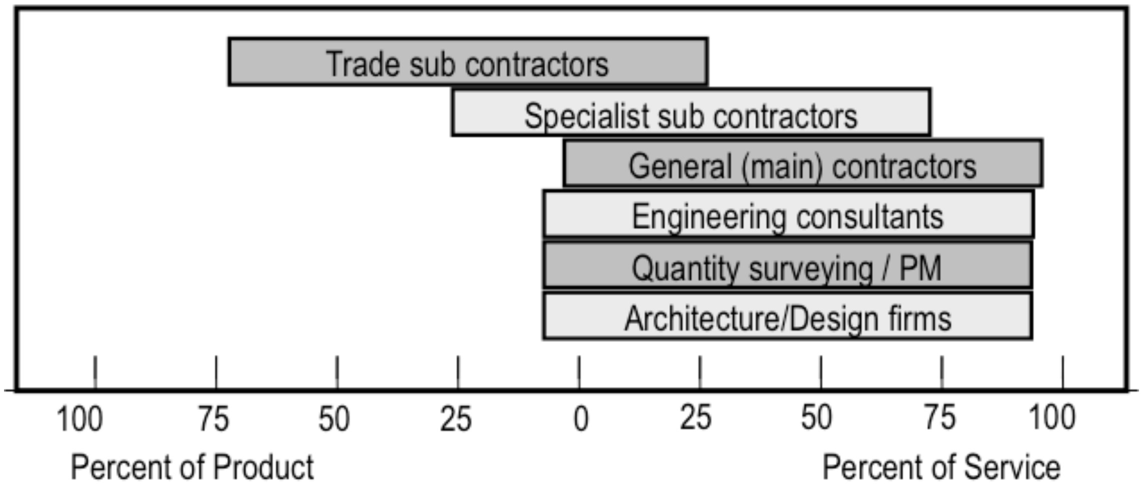

Figure 3: Hypothetical extent of the 'product' and 'service' in different AEC sector firms

The analysis also suggests that core business of most general (main) contracting firms is services; despite the fact they sell physical building to consumers. However, trade subcontracting firms' core business is predominantly 'products' in the form of erected building elements.

As part of the resource model, most AEC firms source for capabilities that are not available or not sustainable inhouse in the market. Competitive SMEs firms conduct constant evaluation of their boundaries to identify and engage with capable trading partners.

Figure 4 proposes potential opportunities that could be sensed and seized from fusing the supply chain concepts and electronic business concepts (Ash and Burn, 2003). Although this is focused on depicting a general contractor's supply chain, the e-business embedded supply chain framework can be used to analyse other firms. Each firm's core business, nature of inbound/outbound operations and resource level, will lead to a distinct supply network. However, Figure 4 illustrates how principal contractors can conceptualise the use of B2B platforms to manage the operations with tier 1 subcontractors (and project managers). The 'recourse model' of the general contractor will assist in finding the inhouse capability gaps and identifying the tier 1 trading partners in the market to engage in doing the core business. Firms can also use B2B platforms to assist in monitoring the operations of tier 2 firms and upstream members of the supply chains (e.g. consultants). Moreover, B2C platform can help contractors to improve customer relationship management. The extent of 'service' and 'product' element in each linked trading partner in the supply chain can assist firms to identify the best e-business platform to adopt.

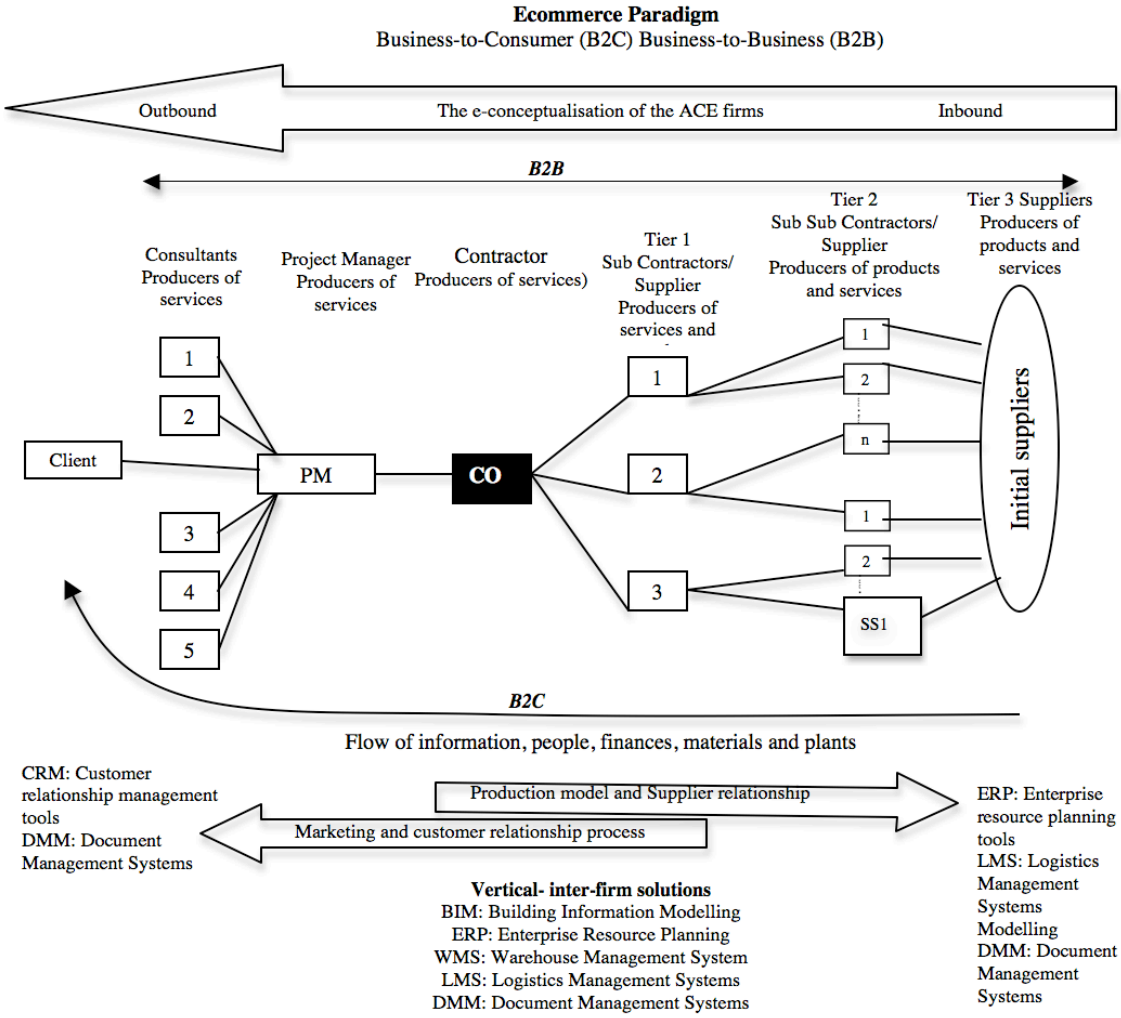

Figure 3: Supply chain perspective in analysing Network model for e-business (Source: Adapted from Gajendran, Brewer and Marimuthu, 2013)

Table 3: E-business information technology platform to that enable network connection

Type of E-business	IT/E-business Tools (Inter and Intra firm platforms)
B2C B2B	Customer Relationship Management Systems (Inter) Building Information Modelling (Inter & Intra) Online Document Management (Inter & Intra) Enterprise Resource Planning Systems (Inter & Intra) Warehouse Management Systems (Inter & Intra) Logistics Management Systems (Inter & Intra)

Table 3 (constructed the concepts borrowed from Ash and Burn, 2003) proposes various broad categories of information technology systems that can assist to integrate different e-business initiatives aligned to supply chain-based initiatives to conceptualise a 'network model' that reflects the core of business and resource models. The Customer Relationship Management Systems will be central for B2C initiatives and will be more critical for service based firms than product based firms. The B2B platforms can be focused on specific activities relating to the business, both project and service focused. They can include Online Document Management (Alshawi and Ingirige, 2003), Enterprise Resource Planning Systems (Su and Yang 2010), and Warehouse/Logistics Management Systems (Voordijk, Leuven and Lann, 2003). The Building Information Modelling (BIM) technology has the potential to impact the way business process links are made (Porwal, and Hewage, 2013).

5. Concluding remarks

This paper suggests engagement with B2B and B2C e-business can be suitably conceptualised via analysing 'business models'. Business models are defined with respect to the architecture of products, services and information flows generating value for a business and actors. In this case three sub modes of an overarching business model are identified to provide a broad consumption of e-business in AEC sector firms. They are (a) Strategy Model (b) Resource Model and (c) Network Model including (i) Production Model and (ii) Customer Relations model. The 'strategy model' analyses the nature of the core business to understand the extent of the 'product' and 'service' offered by a firm; which enables to identify the required resources, network connections and e-business platforms. The resource model uses 'resource based view' to analyse the firm and identify gaps in resources that need to be sourced from the market to become a part of the firm's supply chain. The network model explores the supply chain integration, fusing business and resource models. These business model lenses proposes an additional layer of analytical capability to exploit ICT/e-business developments to gain competitive advantage through improved communication, customer relationship management, demand management and production management.

The level of discourse into the nature of product-service mix in different construction SME's is limited in existing literature. This is a limitation in the literature analysis that impacts the development of a robust theoretical e business models for testing. Therefore, further qualitative research with primary data is needed to deconstruct the product service mix in the construction industry, that can provide better understanding of how e-business approach can be embedded in construction SMEs.

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The role of the architect in integrated contracts for social housing renovations in the Netherlands

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Abstract

The use of integrated contracts in the Dutch construction sector has increased in recent years. Integrated contracts presume facilitating a much more effective process than traditional delivery methods leading to reduced cost and time and higher quality. In first instance this type of contracts was only used for large and complex infrastructure projects and new buildings. In the last five years they have been used also in the social housing sector for renovation projects, giving positive project outcomes. In this kind of projects the supply-side actors work together in a team formed by an architect, consultants and construction companies; commonly referred as a consortium. There is a lack of knowledge about the formal and informal bindings between the consortium members, the specific roles of the consortium members and its influence on the project outcomes. The aim of the research project was to get an overview of the existing organizational typologies and the changes in the role of the architect (e.g. type of work, amount of work and work relations). The study is been based on a series of interviews with architects working with integrated contracts in social housing renovations. The findings indicate that in the majority of the projects analysed, the architect is contracted by the main contractor rather than by the social housing organisation. The use of an integrated contract has no important effects on the relation of the architect with the social housing organization and improves the relation of the architect with the main contractor, consultants and advisors, and other specialized contractors involved. The architect is switching from a designer role to a technical and aesthetic advisor role compared to design-bid-build projects.

Keywords: architect role, integrated contracts, renovation, social housing

1. Introduction

The use of integrated contracts in the Dutch construction sector has increased in recent years. It represented in 2011 8.9% of all public construction contracts published on the main Dutch tender database (www.aanbestedingskalender.nl) (Hardeman 2012). Integrated contracts in the construction sector is used to refer to contracts that include the design and construction works in a single contract, but that can also include maintenance, finance and/or operation (Chao-Duivis and Wamelink 2013). One of the main characteristics of this type of contracts is that the companies in charge of the construction, and in some cases maintenance and operation, are involved in the project from the beginning of design phase, what allow them to participate in the design decisions contributing with their practical knowledge. In general, integrated contracts are assumed to result in lower costs, better performance and lower risks as a result of a collaborative environment and output specifications (Akintoye et al. 2005; Blayse and Manley 2004; Leiringer 2006).

In first instance this type of contracts were only used in the Netherlands for large and complex projects (Boes and Dorée 2008). Still, in the last five years they have been also used in the social housing sector for new construction and renovation (Hal et al. 2011; Savanović et al. 2012). In fact, the use of this contracts in renovation had its special momentum in 2008, when the shared aim of the national government and social housing organisations (SHOs) for reducing the energy consumption of their housing stock was expressed in the "Covenant for energy savings". In the covenant it is declared an aim for upgrading to a B label the Dutch social housing stock or a least to upgrade it two level higher that its current status. In the Netherlands Social Housing accounted by the year 2008 for 32% of the total national dwelling stock (Pittini and Laino 2011). Since 1995 social housing organisations in the Netherlands are autonomous self-finance organisations (Ronald and Dol 2011). Therefore, they are not requested to comply with public procurement rules.

In projects making use of integrated contracts the supply-side actors work together in a team formed by the architect, the consultants and the construction companies; commonly referred in the Netherlands as a consortium or co-makers. Currently, there is a knowledge gap around the role of each of the consortium members and the formal and informal relations among them. The current literature is mainly focused on the dyadic relationship between client-consortium or client-main contractor (Bygballe et al. 2010). There is some research carried out last years about the formal and informal relations among the members of temporary multi-organisations (TMO) in construction, what can be related to the consortium structure (Blois et al. 2011, Lizarralde et al. 2011). The studies about TMO take into account all members involved: client, main contractor and specialized contractors. However, in the projects analysed in these studies the architect is always treated as another specialized contractor and no specific attention is given to the change of its function. The few studies about integrated contracts that refer to the role of the architect highlight that there is a change in its role in comparison to the traditional design-bid-build approach (Volker and Klein 2010, Wamelink et al. 2012).

The research question is how the role of the architect changes in social housing renovation projects making use of integrated contracts compared to design-bid-build projects, and how the formal and informal bindings are with the other involved actors?.

The research methods used and the research hypotheses are described first. This is followed by the presentation of the findings and the discussion of the hypotheses. Finally, in the conclusions the main findings are highlighted and the research limitations and recommendations for further research are outlined.

2. Research Methodology

A search among a series of websites listing innovative construction projects have been carried out in order to identify social housing renovation projects making use of integrated contracts that are completed or in their construction phase. This search included: *Agentschap NL* (Agency of the Dutch Ministry of Economic Affairs), *Energie Sprong* (construction innovation program of the Dutch Ministry of the Interior and Kingdom Relations) and *Passief Bouwen* (Dutch passive house organisation). Also an inquiry to identify this sort of projects has been addressed to experts of *SBRCURnet* (Dutch construction knowledge network organisation), *Vernieuwing Bouw* (Dutch construction renovation knowledge network organisation), *Noorderberg* (construction supply-chain integration consulting firm) and to several experts.

In total 21 social housing renovation projects making use of an integrated contract with involvement of an architect have been identified in the period 2005-2013. All the projects were tendered as Design-Build contracts and some of them included the possibility of Maintenance a posteriori. In the Netherlands the participation of an architect in a renovation project is not mandatory. Nevertheless, it is common practice to have an architect involved in case the façade is modified because he is the most competent professional to present the project to the *Welstandscommissie* (appearance committee), a committee that advices the municipality about how the design of a building fits within its environment, in order to obtain the construction permits.

The architects involved in these project have been contacted by mail and by phone to participate in the research, 13 accepted. The participating architects were interviewed making use of open and closed questions; an interview took in average 90 minutes. The 13 interviews are the main source of information of this study. This was complemented with the information published on the websites of the involved actors: SHOs, architect office and construction companies.

The renovation projects have been carried out mainly in row houses. The size of the projects differ from 24 dwellings the smallest to 290 the biggest and with an investment per apartment from approximately € 20.000 the lowest to € 120.000 the highest. A summary of the characteristics of the projects is presented in Table 1.

Table 1. Analysed projects summary

	Project location	*Number of Dwellings*	*Type of dwellings*	*Tender*	*Investment per dwelling*
1	*Leiden*	*252*	*Row houses*	*Not competitive*	*56,500*
2	*Leek*	*45*	*Row houses*	*Not competitive*	*80,000*
3	*Hoek van Holland*	*52*	*Row houses*	*Not competitive*	*120,000*
4	*Drunen*	*25*	*Row houses*	*Not competitive*	*45,000*
5	*Haarsteeg*	*32*	*Row houses*	*Not competitive*	*100,000*
6	*Almere*	*246*	*Apartment block*	*Not competitive*	*23,000*
7	*Zwolle*	*148*	*Row houses*	*Competitive*	*70,000*
8	*Biddinghuizen*	*80*	*Row houses*	*Competitive*	*40,000*
9	*Zwolle*	*24*	*Row houses*	*Competitive*	*108,333*
10	*Krimpen aan den Ijssel*	*240*	*Row houses*	*Competitive*	*80,000*
11	*Ulft*	*54*	*Row houses*	*Competitive*	*80,000*
12	*Ulft*	*115*	*Row houses*	*Competitive*	*81,739*
13	*Leeuwarden*	*290*	*Row houses and apartment blocks*	*Competitive*	*19,931*

Firs a series of six hypotheses about the comparison between design-bid-build projects and integrated contract projects have been formulated based on a literature review. The hypotheses refer to the type of work of the architects, the amount of time spent per project, the relation of the architect with the SHO and the construction companies, and design phase duration.

1. **The architect carries out a different type of work**

In the Netherlands the leading role in consortiums participating in projects making use of integrated contracts is mainly taken by the main contractor (Volker and Klein 2010) similar to the situation that have been reported from the UK (Greenwood et al. 2008) where integrated contracts are widely being used. The leader is expected to carry out the project management task (Wamelink et al. 2012), what in a design-bid-build approach often was done by the architect. This position means that the accustomed type of work of the architect will change.

2. **The architect has a lower amount of work per project**

As mentioned in the previous hypotheses the leading member of a construction consortium in the Netherlands is the main contractor. Not being responsible for the project management will result in a lower amount of time spent by the architect in the project.

3. **The architect is in a compromised position as SHO advisor**

In the new situation, where architect and main contractor are at the same side of the table, the tasks and responsibilities of each one are not always clear for the client (Sebastian 2011). If the architect is contracted by the main contractor the main contractor becomes the client of the architect rather than the SHO, and as such the role of the architect as advisor to the SHO could be compromised.

4. **The architect has a better relation with the construction companies**

Implementing an integrated process is one of the proposals made by the national evaluation reports of Lathan (1994) and Egan (1998) for the UK construction industry in order to improve the collaboration between the involved actors. Numerous comparative studies about the use of integrated contracts in large construction project have reported the predicted improvement in the collaboration between consortium members (Akintoye et al. 2005; Konchar and Sanvido 1998; Leiringer 2006). Smaller projects as social housing renovations are not expected to be different in this regard.

5. **The communication with the construction companies is less formal**

In projects making use of a design-bid-build approach the architect and the construction companies start their communication when the design is completely defined and they have clearly different responsibilities with regard to the SHO. In this set-up in which architects and construction companies need to take care of their own responsibilities the communication between them tend to be formal. In projects making use of integrated contracts the architect and the construction companies are sitting at the same side of the table, and from the point of view of the SHO they share responsibilities. Moreover, they are both involved in the design phase what means that they have a high level of communication during this phase what is expected to cause a lower level of formality in their communications (Hoezen and Volker 2012).

6. **The project has a shorter design phase**

In this research the design phase is defined as the period of time between the involvement of the architect until the start of the construction works. In projects making use of integrated contracts the construction companies participate in the design phase what allows architects to take faster design decisions as the viability (price and technical feasibility) of various design alternatives could be immediately evaluated. Moreover, compared to a design-bid-build approach there is no need for a works tender after the design is completed. The consequence of these two factors is that the length of the design phase could considerably be reduced as reported in previous research over two French social housing renovation projects (Salcedo and Straub 2014).

3. Findings

Two types of tender procedures have been identified among the analysed projects, the non-competitive (six projects) and the competitive (seven projects). See Figure 1.

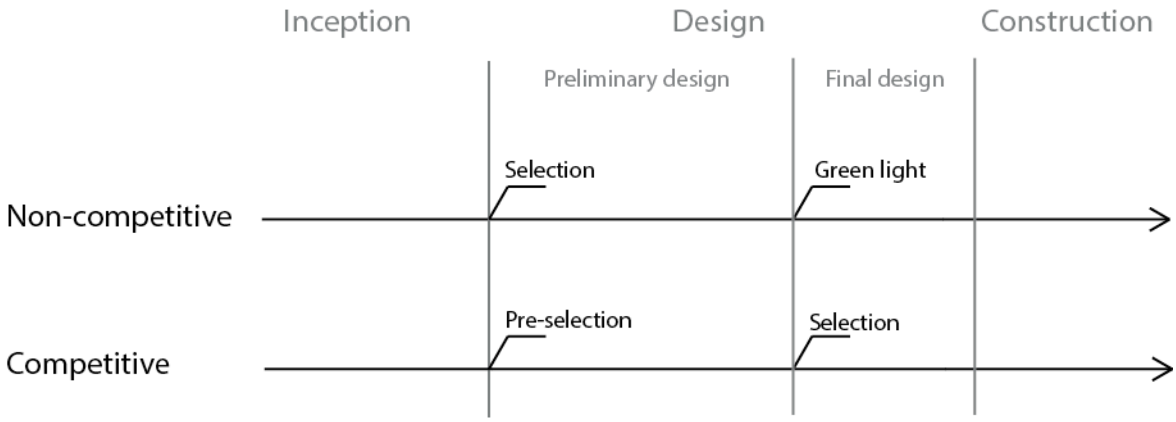

Figure 1. Time organization on non-competitive and competitive procedures

In the non-competitive procedure the selection of the awarded consortium is commonly based on non-project related criteria (e.g. capacity for team work, sustainability vision or capacity to innovate) and their previous experiences. The common practice is that only invited candidates participate in the selection procedure. In a couple of projects making use of the non-competitive procedure there was no selection procedure and the awarded candidate was directly appointed. The design work starts after the consortium has been selected. When the preliminary design is finished there is often a green light procedure, a moment in which the SHO decides if they go further with the project and when the project budget is definitively fixed.

In the competitive procedure there is a pre-selection and a selection phase. The pre-selection is based on non-project related criteria or are directly appointed. The pre-selected candidates are then invited to participate in the selection process, in six of the seven competitive projects three candidates per project were pre-selected. The selection is based on the evaluation of the preliminary design proposals, what means that previous selection of the awarded consortium most part of the design work has been already done. After the project is awarded there is still some design work to be done to fine tune the initial design proposal. In this study the size of the sample, thirteen projects, does not allow to make an statistical analysis. However, some differences can be identified between the competitive and non-competitive projects when analysing some of the hypotheses.

In the Netherlands there is no legal definition for a construction consortium and no common definition could be extracted from the interviews. Different names where used by the interviewees to refer to the consortium; eg. consortium, co-makers, co-creators or building-team. In some cases the consortium could be related to the TMO concept as defined by Blois et al. (2011). The TMO is composed by all companies involved in the design and construction. But in other cases not all companies involved in the design and construction were considered members of the consortium. For example in some of the analysed projects the companies that had a real influence in the design decisions; architect, main contractors, advisors and some specialized contractors (e.g. pre-fabricated façade maker, window maker) were considered as consortium members, while the other specialized contractors involved in the project were not considered members of the consortium.

Four different types of contractual arrangements with the architects have been identified among the analysed projects. See Table 2. The most common arrangement is that the architect office is contracted by the main contractor and this is synonym in almost all cases that the initiative on creating the consortium comes from the main contractor. Only in one of the ten projects where the architect was subcontracted by the main contractor the initiative of making the consortium came from the architect office.

Table 2. Projects per contractual arrangement

Contractual structure	***Number of projects***
Architects office subcontracted by main contractor	*10*
Architects office contracted by the SHO	*1*
Architects office co-owner of a joint enterprise	*1*
Architect employed by the main contractor	*1*

SHO, Social Housing Organisation / MC, Main Contractor / AO, Architects office / Arch, Architect

In none of the analysed projects the architecture office was acting as the main contractor and only one of the interviewed architects said it could be an option for his office. The financial risk of design-build projects has been said to be too big to be taken only by the architecture office. The limitation of the economical risk capacity had been already mentioned by Wamelink et al. (2012) on his proposal of design-build projects design-led.

Hypothesis 1. The architect carries out a different type of work

Nine of the thirteen architects considered that the type of work was different from comparable design-bid-build projects and eight of them had a similar reasoning for this. In design-bid-build the architect was in charge of proposing the design solutions with a detailed description while currently they were in charge of collecting the proposals of all the members participating in the design, facilitating the design choices and taking care of the aesthetic ensemble. An architect said:“ It is the same type of work but there is another ratio between making drawings and advice. You act more as an advisor than as a designer.”

Hypothesis 2. The architect has a lower amount of work per project

Only four of the thirteen architects indicated that the amount of work was less than in comparable design-bid-build projects. See Table 3. Three argued that the main contractor took some of the project management tasks that they were used to perform and one argued that the improved efficiency in the design decisions period had an influence in reducing the amount of work. On the other hand, in six interviews it was indicated that there was a higher amount of work but there was not an unanimous reason for it. Some argued the specificities of the project, the fact of being a pilot project or of being a renovation project, and others argued that they had some extra tasks as an intensive site supervision or being in charge of the communication with the tenants.

Table 3. What was the amount of work compared to previous similar design-bid-build projects

	Less	*Similar*	*More*
Architect - SHO	*4*	*3*	*6*

In the architectural profession the amount of work relates often to the time spent in the project, but to be certain they were requested also to rate the amount of time they being involved in the project compared to comparable design-bid-build projects. Five answered that the amount of work was less, three that it was similar and 5 that it was more, almost the same results. Not a clear difference between projects with a collaborative and competitive procedures could be highlighted from the results presented in Table 4. The picture does not give a clear indication about the changes on the amount of work.

Table 4. Time spent in the project compared to previous similar projects previous design-bid-build projects

	Less	*Similar*	*More*
Collaborative approach	*2*	*0*	*4*
Competitive approach	*3*	*3*	*1*
Total	*5*	*3*	*5*

Hypothesis 3. The architect is in a compromised position as SHO advisor

The results about how the relation between the architect and the SHO was compared to comparable design-bid-build projects does not reflect that the architect is in a compromised position as advisor of the SHO. See Table 5. Only in one case the relation was rated as worse. In all the other cases the architects were requested if they felt that the SHO had less trust on them, and the answer was always negative. Nevertheless, in 5 of the 13 interviews it was expressed that they think that their position as professional it is compromised because they are contracted by the main contractor and not by the SHO. An architect said: “The distance is a bit bigger. You feel that who pays decides and that has an influence. We knew the SHO and all the others seated on the table and we had a close contact but the communication went through the filter of our client. Before a proposal arrives to the SHO the financial feasibility is checked. It is a slightly different role towards the SHO.”

Table 5. How was the relation between architect and SHO compared to similar previous design-bid-build projects

	Worse	*Similar*	*Better*
Architect - SHO	*1*	*5*	*6*

Hypothesis 4: The architect has a better relation with the construction companies

The relation between the architect and the construction companies involved in the renovation project is considered to be better compared to comparable design-bid-build projects by 9 of the 13 architects interviewed. Any of the interviewed architects rated the current relation as worse and four rated it as similar. See Table 6. Three of the four architects that rated the relation as similar stated in the interview that they previously had already a good relation with the construction companies and the relation stayed as good as it was.

Table 6. Architect opinion about their relation with the construction companies compared to previous similar design-bid-build projects.

	Worse	*Similar*	*Better*
Architect – Construction companies	*0*	*4*	*9*

Hypothesis 5: The communication with the construction companies is less formal

A big part of the communication between architects and construction companies is done via the drawings and technical specifications (Styhre and Gluch 2009). In order to assess the formality of the communication between architects and the construction companies the architects were requested about the detail level of the drawings they handed in to the construction companies. Ten of the thirteen interviewed architects considered that the level of detail in the communications with the construction companies was lower than in comparable design-bid-build projects. See Table 7. It was said in the interviews that part of the drawings that in comparable design-bid-build projects were developed to a high degree of detail they were this time only elaborated up to a sketch level. For example in the case of making use of prefabricated façades the construction company in charge of that part of the project would elaborate the detailed drawing of the façade while the ensemble would be supervised by the architect.

When asking if the detail level of the communications with the constructor was the same one of the architects said: "I leaned a bit on the expertise of the builder. We did not need to detail everything because they are just as capable to do the proper job. We only interfered in the section of the roof. Because the roof was completely renewed the contour of the building was changing, there we did some detailing".

Table 7. Level of detail in the communication between architect and construction companies compared to previous similar design-bid-build projects.

	Lower	Similar	Higher
Level of detail	10	2	1

Hypothesis 6: The project has a shorter design phase

Unfortunately it was not possible to find a reference value for the average design phase time in a social housing renovation projects among the reviewed literature. In the analysed projects an important difference in time length could be observed between the projects with a collaborative approach and the projects with a competitive approach. The projects with a collaborative approach had a design phase in average more than 40% longer than the projects with a competitive approach. See Table 8.

Table 8. Time spent from start of work in the project until start of construction works

	Number of projects	*Time (months)*
Collaborative approach	*6*	*15.5*
Competitive approach	*7*	*9*

As outlined in the Figure 1 in the competitive approach the award of the contract is based on the preliminary design presented by the candidates. The time schedule of selection procedure is defined by the SHO what forces the participating consortiums to make their design proposals in a specific time frame. The consortiums participating in the analysed project with a competitive approach had in average 2.8 months to develop their preliminary design.

4. Conclusions

This research based on the analysis of thirteen social housing renovation projects making use of integrated contracts gives an indication of the role of the architect in this new set-up. The architect is in the majority of the cases contracted by a main contractor and is switching from a designer role to a technical and aesthetic advisor role. However, the change in role does not have a direct relation with the amount of work per project for the architect. The loss of project management tasks get compensated in some cases by other task like communication with the tenants or higher site supervision.

The new contractual position of the architect does not have negative effect, and in some cases it has even a positive effect, on the evaluation of the relation between the architect and the SHO. In any case the architects do not perceive that the SHO has a lower trust in their advice and the new set-up has a positive effect on the relation between architect and construction companies. The relation is rated as better and it could be also confirmed that the communication between architects and construction companies it is more informal than in design-bid-build approaches.

In regard to the design phase length it has been found a considerable difference between the projects with a collaborative approach and the projects with a competitive approach; the competitive approach projects design length is less than half the design length of the collaborative approach projects.

The research is based in the analysis of 13 projects, is thus a qualitative research, which results cannot be extrapolated. However, it gives an indication of what are the changes are to be expected for the architect when working in projects making use of integrated contracts. Further research is needed to discuss what can these changes could mean for the architectural profession and education.

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Managing Uncertainty to Improve the Cost Performance of Complex Infrastructure Projects

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Abstract

There has been a recent spate of high profile infrastructure cost overruns in Australia and internationally. This is just the tip of a longer-term and more deeply-seated problem with initial budget estimating practice, well recognised in both academic research and industry reviews: the problem of uncertainty. A case study of the Sydney Opera House is used to identify and illustrate the key causal factors and system dynamics of cost overruns. It is conventionally the role of risk management to deal with such uncertainty, but the type and extent of the uncertainty involved in complex projects is shown to render established risk management techniques ineffective. This paper considers a radical advance on current budget estimating practice which involves a particular approach to statistical modelling complemented by explicit training in estimating practice. The statistical modelling approach combines the probability management techniques of Savage, which operate on actual distributions of values rather than flawed representations of distributions, and the data pooling technique of Skitmore, where the size of the reference set is optimised. Estimating training employs particular calibration development methods pioneered by Hubbard, which reduce the bias of experts caused by over-confidence and improve the consistency of subjective decision-making. A new framework for initial budget estimating practice is developed based on the combined statistical and training methods, with each technique being explained and discussed.

Keywords: Uncertainty, Calibration, Data Pooling, Risk management

1. Introduction

Building and infrastructure construction is renowned for running over cost and over time. The cost performance of recent high-profile infrastructure projects in Australia are just one case in point: Melbourne wholesale fruit and vegetable market cost more than double the $230 million budget (Victorian Auditor-General's Report, 2012), Epping to Chatswood rail project in Sydney went over budget by $300 million (New South Wales Audit Office, 2010), Perth Arena cost more than 3 times the original estimate of $160 million (Western Australia Auditor General, 2010), ASIO central headquarters in Canberra cost more than $40 million over budget (ASIO, 2011). Of course the cost overrun associated with the Sydney Opera House (SOH) project is now legendary –from an initial forecast of A$7m in 1957, the project costs are said to have ballooned by a factor of 14.5 to an actual cost outturn in 1973 of A$102m. Why do the costs of a construction project escalate so dramatically and how might the cost performance of complex projects be improved?

The prevalence of construction cost overruns, particularly in complex infrastructure projects, has many and varied causes (Ramanathan et al, 2012). We all understand that designs change, clients vacillate, productivity varies, delays occur, economies cycle and markets fluctuate. Fundamentally, however, there is a particular flaw in the fabric of basic budget estimating practice when it comes to dealing with such vagaries. The flaw is well recognised in academic research and by an increasing number of industry reviews (see for example, Flyvbjerg, 2013; Dept of Infrastructure and Transport, 2012): it is a flaw in how cost estimating deals with uncertainty. Risk management was developed specifically to deal with the kinds of uncertainty inherent in a major construction project. However, the type and extent of the uncertainties involved in complex infrastructure projects have rendered the established risk management techniques increasingly ineffective. Leading experts Hubbard (2009) and Makridakis et al (2009) highlight the failings of risk management theory in that context: it neglects the biggest risks, lacks calibration, utilises tools that are seriously flawed and relies on outcomes which demonstrably fail to deliver reliable budgets.

This paper reviews the principal drivers of construction cost variability and characterises the key elements of how uncertainty is currently managed/mismanaged in construction cost forecasting. The SOH provides a salutary case study in how a range of factors can collude to repeatedly blow costs well beyond the latest cost estimate, and why risk management theory abjectly fails to cope with the nature of the problem. A radical reformulation of current cost forecasting methods is proposed. The reformulation responds directly to each key failing and proposes a series of procedural changes that will significantly improve the cost performance of large construction projects, particularly the more speculative and innovative projects characterised by the likes of the SOH development. Three procedural improvements are proposed: the use of actual cost data probability distributions to better inform the estimating process, more effective calibration of cost estimating practice and incentivised cost estimating performance, and the collective integration of multiple models and expert opinions of the cost budget forecast.

2. The cost performance of Sydney opera house

Almost every account of the SOH construction project, and it seems every case study on cost overruns, includes reference to what is universally considered the most extreme case of cost overrun in modern construction history. From an original cost and scheduling estimate in 1957 projecting a final cost of A£3,500,000 and completion date of January 1963, the project was completed ten years late and (commonly claimed) more than fourteen times over budget (Drew, 1999). But was the project quite the cost estimating basket-case it is proclaimed to be?

There is little dispute that the project was completed 10 years late, in 1973. The claim that costs escalated by a factor of more than fourteen, however, is contestable. The official listing of budget estimates (Drew, 2000) is presented in Table 1, column Actual Estimate. Using just the raw numbers, the final overrun would be more like 29 times the original estimate. However, the Australian currency was decimalised in 1966 and Table 1, column Dollar Equivalent uses the Reserve Bank of Australia, Pre-Decimal Inflation Calculator to convert Pounds into their direct Dollar equivalents. This is the basis on which a cost overrun of more than fourteen (actually 14.6) is generally claimed.

Table 1: A listing of SOH budget estimates in Australian currency values

Year	Actual Estimate	Dollar Equivalent	1974 Dollars	2014 Dollars
1957	£3,500,000	$7,000,000	$13,512,780	$100,979,981
1958	£4,880,000	$9,760,000	$18,709,460	$139,814,373
1959	£5,300,000	$10,600,000	$19,907,063	$148,763,971
1960				
1961	£9,300,000	$18,600,000	$32,922,046	$246,023,953
1962	£13,750,000	$27,500,000	$48,830,193	$364,904,330
1963	£14,799,529	$29,599,058	$52,222,532	$390,255,021
1964	£17,200,000	$34,400,000	$59,001,792	$440,915,915
1965	£24,700,000	$49,400,000	$81,939,000	$612,323,935
1966				
1967				
1968				
1969	$85,000,000	$85,000,000	$124,576,720	$930,952,381
1970				
1971	$93,000,000	$93,000,000	$124,149,398	$927,759,036
1972	$102,000,000	$102,000,000	$128,427,273	$959,727,273
1973	$98,709,085	$98,709,085	$113,926,736	$851,365,858
1974	$102,000,000	$102,000,000	$102,000,000	$762,238,267
Overrun	29.1	14.6	7.5	7.5

Comparing a dollar value from 1957 with a dollar value from 1974 however is suspect. If all dollar values are brought to the same time base of 1974 using the Australian Reserve Bank conversions, as presented in Table 1, column 1974 Dollar, the apparent cost escalation reduces to more like a factor of seven or eight (actually 7.5) – still a significant cost overrun, but less extreme than common claims. Interestingly, converting each estimate to 2014 dollar value, as presented in Table 1, column 2014 Dollar, the final project cost equivalent is A$7.6billion – only about 3 times the budget cost for the current transformation of Sydney's Darling Harbour exhibition and hotel precinct; slightly more than the current Barangaroo urban transformation of Sydney's Central Business District; and ¾ the budget cost for the current 33 kilometre WestConnex integrated transport and urban revitalisation corridor linking Sydney's west, city, south and airport. On the other hand, for a total seating capacity of 5,738 patrons the SOH converts to a cost per seat of A$133,000 in 2014 dollar equivalent, where the equivalent 2014 dollar cost per seat for the Sydney Recital Hall (completed 1999) is a mere A$44,000 and for the Oslo Opera House (completed 2007) the equivalent figure is also much lower at A$46,000 per seat.

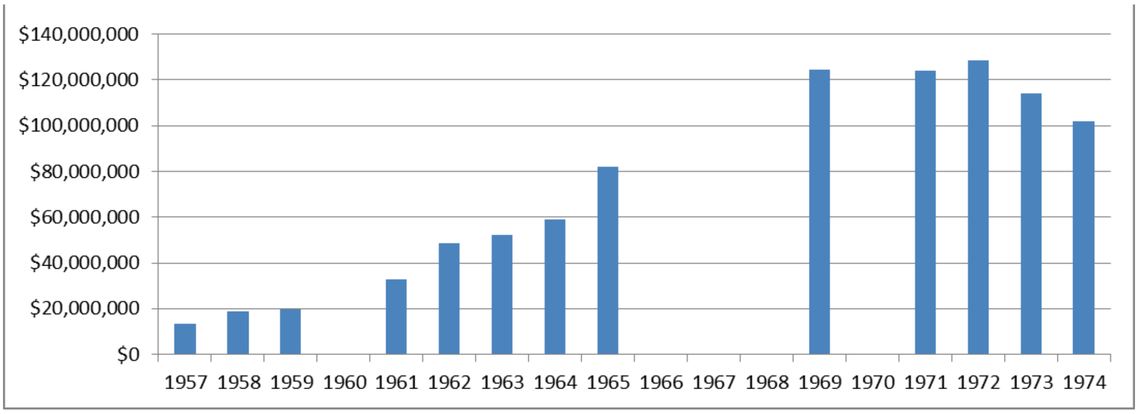

Figure 1: A graphical representation of SOH budget estimates over time in 1974 dollar equivalents

Figure 1 presents a graphical representation of Table 1, column 1974 Dollar. It is useful, in that light, to note that the overall project was delivered in three separate stages. Stage I: Podium was completed in 1963 at a cost of A£5.5m, or A$19.4m in 1974 dollar equivalent. That cost represents less than 40% of the prevailing cost estimate at that time. Stage II: Roof Shells was completed in 1966 at a cost of A$13.2m, or A$20.4m in 1974 dollar equivalent. That cost represents less than 35% of the prevailing cost estimate at that time. Stage III: Interiors was completed in 1973 at a cost of A$80.4m, or A$92.8m in 1974 dollar equivalent. When expressed in 1974 dollar equivalent terms, the proportion of costs is as follows:

Stage I:	Podium	14.6%
Stage II:	Roof Shells	15.4%
Stage III:	Interiors	70.0%

Of course any economic forecast will incorporate some degree of uncertainty (Buchanan, 2013). For a major infrastructure development such as the SOH, the degree of uncertainty is significant and does not appear to follow the pattern of development presumed in current risk management theory. To understand how such uncertainty might be managed more effectively, we first consider the major causes of cost overruns (and thereby the drivers of uncertainty) in general and then specific to our SOH case study.

3. The causes of cost overruns

The causes of project cost overruns have been considered by many industry and academic analysts, most notably perhaps Ramanathan et al (2012) and Love et al (2013). The causal determinants involve a combination of three elements (see for further details: Chapman and Ward, 2011):

3.1 Human estimating factors

Human estimating factors include such elements as optimism bias, aspirational preferences, calibration and strategic misrepresentation. In the context of SOH, there was certainly real and apparent strategic misrepresentation of the earliest budget estimates, as under-estimation was the only way to ensure political and public support for the project (Baume, 2014). Ultimately the fate of the SOH and the presiding State government were inseparable and the commissioning of the SOH played a key role in the re-election of the sitting Labor government in 1959 (Drew, 1999). There were also clear cases of optimism bias throughout the project, starting broadly with the appointment of Utzon as Architect, despite his total lack of actual building experience. Optimism bias more specific to the cost overruns started with the acceptance of Civil & Civic as the initial contractors on the project, despite a tender price substantially lower than the next best and their alleged reputation for deliberately under-pricing tender submissions (Murray, 2004).

3.2 Technical estimating factors

Technical estimating factors include the quality of the data, knowledge of the market and the choice of estimating methodology. In the context of SOH, the quality of the data available at the earliest stages was severely compromised by the client's insistence that a tender be called before the relevant design and working drawings had been anywhere near completed. Rework is the most predominant direct cause of cost variations (Love et al, 2010). Constant design and construction changes had huge impact on the overall cost of the SOH project. For example, the estimate revision following the choice of a ribbed ellipsoidal roof profile added almost 65% to the costs. Major design changes resulting from significant changes by the client in terms of seating capacities and general arrangements of the main halls more than doubled the estimated costs. Incorrect column placements for the major structural elements required massively reinforced concrete bases to be demolished using explosives, adding significant cost and time delays to the project.

The knowledge of the market is also shown to be highly problematic in the context of the SOH. As shown in Figure 2, the rate of inflation at the commencement of the project and for the foreseeable future at that time, was dropping and expected to remain extremely low. At the time of the initial budget estimates the rate of inflation was dropping to 0%. In 1963 when the project was expected to be complete the rate was still expected to be low and did in fact include a period of deflation immediately prior to that year. Despite a long period of low inflation rates, towards the end of the actual project inflation became rampant. The general rate of inflation soared to well over 10% per annum and the more specific building price index increased by 123% over the life of the project (Drew, 1999).

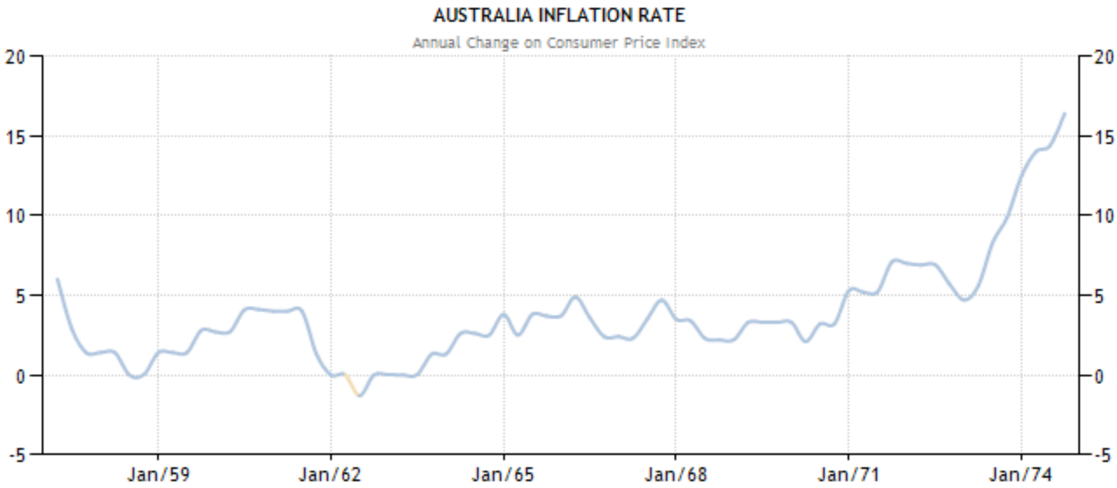

Figure 2: The Australian Inflation Rate from 1957 to 1975 (source: Australian Bureau of Statistics)

3.3 Business operation factors

Business operation factors include financial and contractual arrangements, supply chain management, process models and bespoke manufacturing. In the context of SOH, there was an unusual line of authority governing the key consultants and a multitude of very substantive changes in the constructing authority itself (Drew, 1999). A lack of clear and changing authority will always create problems for a high-profile and contentious project such as SOH, and those problems inevitably had a detrimental cost consequence. The period in which the SOH was built was one of low unemployment and high levels of unionisation in Australia. For a high profile project such as the SOH the broader climate of economic boom made it the centre for industrial action, with a multitude of strikes and work-ins (Watson, 2006). The industrial unrest was fermented by the use of novel prefabrication techniques, unusual materials (for the time) and problematic detailing issues, all of which also added significantly to the cost. It was a period of considerable change for the construction industry overall, in terms of changing workplace requirements, and demonstrably the workforce was inadequately trained for many of the technology innovations used.

4. Cost forecasting improvements

In the case of SOH, as for all cases of cost overrun, post hoc analysis always provides a range of actual and particular causes to account for the variation. Much has been said about such causes more generally and there is little doubt that more effective management of specific human estimating, technical estimating and business operation factors will tend to reduce their individual impact on the incidence and significance of cost overruns. That, at least, is the mantra of conventional risk management. However, when multiple causes are realised in a project together, characteristically they leverage on each other and will potentially still lead to cost blow-outs (Bakhshi and Touran, 2012). Take, for example, the issue of optimism bias. When taken in isolation, Flyvbjerg (2008) proposes the use of an adjustment percentage, or uplift. The case for an uplift to be applied is based on data such as illustrated in Figure 3.

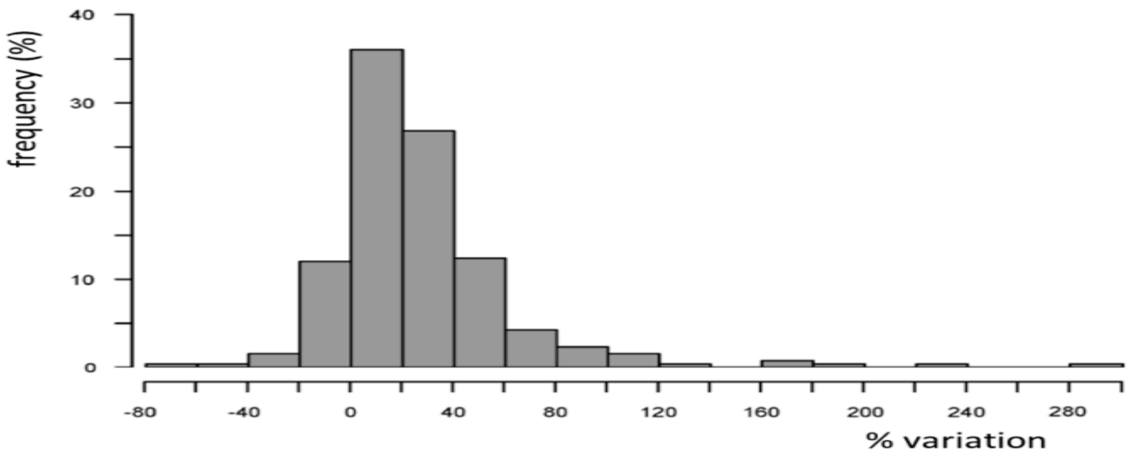

Figure 3. The % variation between initial and outturn costs for 258 infrastructure projects (source: Flyvbjerg et al, 2002, p.283)

The application of an uplift percentage will certainly better align the average estimate with the average outturn cost. However, it will do next to nothing to address the coefficient of variation. A successful application of the uplift would merely shift the Figure 3 x-axis slightly, but not change the more significant distribution shape. Cost blow-outs will still occur, as might be noted in cases in the UK such as the Scottish Parliament Building and the Millennium Dome, where cost overruns were experienced despite the requirement in the UK Treasury Green Book to apply an uplift adjustment – the Green Book is guidance for central government on how publicly funded bodies should manage risks and obtain the best public value. Indeed, a recent report by the UK-based Infrastructure Risk Group (IRG, 2013) recommends that optimism bias-based uplifts be avoided.

A further consideration of Figure 3 notes that the distribution shape for cost overruns is characteristically skewed (fat tail) to the right. The fat tail is indicative of a power-law relationship, and explicitly not the Gaussian distribution that underpins so much of risk management and current cost estimating practice. The misrepresentation of power-law distributions using mean and standard deviation measures as descriptors is exactly what Savage (2009) refers to as 'The Flaw of Averages', and so neatly illustrates in Figure 4.

What underlies multiple potential causes of cost escalation, and particularly the structural dynamics (interactions) that leverage between them and lead to cost blow-outs, is uncertainty. Uncertainty is distinguished from risk management in order to avoid at least two of the fundamental misconceptions associated with current risk management practice: that the principal cause of cost overruns can be controlled effectively from within the project; and that potential for cost-blow-outs reduce significantly as a project progresses and what was initially unknown or only partially known becomes better understood. Managing uncertainty is about managing the structural dynamics, not just the direct causes, and about putting in place a forecast that reflects the true nature of potential cost overruns, not some abstract misrepresentation of that potential.

Figure 4. The Flaw of Averages (source: Savage, 2009, p.12)

To more effectively manage cost uncertainty, a new framework for initial budget estimating practice is proposed based on a combination of statistical and training interventions. The framework revision involves three key elements:

4.1 The use of actual data distributions

One thing you can say with great confidence is that an absolute single-figure construction project budget forecast will turn out to be incorrect. Incorrect insofar as the outturn cost is very unlikely to equal the budget forecast exactly. Projects experience cost overruns and projects experience cost underruns, but to say that a project has come in on budget is really to say that it has cost less than the anticipated cost and any contingencies allowed for risk. An accurate P50 contingency allowance should still overrun costs on average 50% of the time. However, when building projects do overrun their costs, they tend to blow-out badly. In this sense even the concept of range estimates is insufficient as the top-end of any range is subject to the exponential tendencies of a power-law distribution. Current cost estimating practice ignores the power-law nature of cost uncertainty and potentially one of the most significant and effective improvements to cost estimating practice would be to develop and adopt actual data probability distributions. Actual data probability distributions are precisely that: a collection of data values (or distribution string) that retain their original values rather than being abstracted into some form of standardised curve or, worse still, being misrepresented in Guassian terms.

Cost data in exactly the form required for distribution strings is currently being compiled as part of the Australian Federal Government, Building Value project initiative (see: http://www.be.unsw.edu.au/programs/building-value/). Cost data expressed in probability distributions will promote a more effective declaration of construction cost estimates that include confidence intervals and/or other expressions of the uncertainty associated with a forecast. Adopting ranges to explain early-stage project uncertainty was also a key recommendation of IRG (2013), but in that report the presumption is still that a P10, P50 and P90 triangulation is sufficient to describe what inevitably is a far more complex distribution. Using an abstract triangulation of a power-law data distribution does not address the flaw of averages problem and abjectly fails to capture the true potential for cost blow-outs. With no measure of the potential uncertainty there can be little effective management of it.

4.2 Draw the data from broad-based sources and use multiple models

It is common practice in cost estimating for a single expert to derive an estimate and cost plan based on some reference set of similar, previous projects. However, as demonstrated in the current (poor) cost performance of complex projects, experts acting alone tend not to produce effective forecasts (Buchanan, 2013). Experts in groups often perform even worse again. Part of the problem is in how reference set forecasting is intended to function. A critical factor with all forms of reference set forecasting is the size and make-up of the set: too many projects and the similarities begin to disappear, too few projects and the statistical credibility is questionable. A data pooling method to validate the optimum size of a reference set for statistical analysis specific to the individual project situation has been proposed (see for example Yeung and Skitmore, 2012).

At the same time, in more general terms, the statistically most reliable reference set is actually the broad-based, heterogeneous model (Savage, 2009). Broad-based models do have their limitations however, particularly in the context of substantive uncertainty. In that context, the most robust approach is to use a combination of broad-based and specific models supplemented with expert opinion (Chapman and Ward, 2011). Extending the initial budget estimating framework to incorporate a variety of models and expert opinion would improve the consistency and effectiveness of the estimate quite markedly, and strengthen the cost performance of projects accordingly.

4.3 Apply the data within a methodical process of calibration

Love et al (2009) has argued that the causal determinants of cost variations can most usefully be considered in terms of a pathogen, rather than as something more explicit and extant. The notion of a pathogen recognises that factor interdependencies are highly complex, changing and critical to cost estimating accuracy (Bakhshi and Touran, 2012). The concept of a pathogen describes a latent condition, integral to existing construction practice, which sparks into effect in demonstrably varied and unpredictable ways. The pathogen framework helps move attention from the multifarious symptoms of a problem to their underlying causes. Considered thus, problem factors must be documented and reported over time so that latent pathogens can be identified.

To document and report the performance of cost forecasting is the first critical step in effective calibration of the estimating process. Experts in any context require frequent calibration to mitigate optimism bias, but an effective means of incentivising performance is what best fuels performance improvement (Hubbard, 2010). A strong possibility for cost estimating is the use of a Brier Score, originally developed for weather forecasters (Brier, 1950). The Brier Score has all the key characteristics of an effective incentive method, in particular it provides a verification scheme to privilege forecasts that are right when the estimator is confident in the estimate over those estimators who are correct but express less confidence. In this way the score is impossible to 'game' because the Brier Score will penalise whenever the actual forecasts are right or wrong more or less often than the level of confidence expressed in each forecast. Naturally, incentivisation must also be modified by the level of risk exposure. Taking the P90 budget position and coming in on budget, for example, should not attract the same reward as taking a lower probability position and coming in on budget.

5. Conclusions

A review of the SOH case study has exposed and illustrated a range of the individual factors that contribute to cost overruns. It is clear, however, that the critical factor is how multiple causes act in concert to blow-out costs along the characteristically fat-tail of a probability distribution. This structural dynamics represents the cost uncertainty, and conventional risk management techniques are not able to address cost uncertainty effectively when power-law distributions are at play.

To improve cost performance in the context of uncertainty, a series of statistical and operational interventions are proposed: the use of data distributions that comprise the actual data points rather than an abstract and highly simplified representation of the distribution; drawing the data from broad-based, heterogeneous sources and the combination of multiple models and estimate sources; and applying the data within a methodical process of calibration which includes for an appropriate and effective incentivisation framework.

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Improving the Technological Capacity of the Local Contractors through E-Business Technology Transfer – The Case of the Local Ghanaian Contractors

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Abstract

Technology transfer (TT) within construction has emerged as an important business activity across many developing countries across the globe including Ghana. For several years TT from developed countries has been viewed as a key element in addressing the low levels of technological development and know-how in developing countries construction industries. TT according to many writers and researchers involve mostly cross-border initiatives with the main purpose to improve the capacity of the local contractor. This paper therefore, considers TT as a mechanism for improving the capacity of the local contractor in developing countries. In this regard, TT could be viewed in the form of knowledge (soft technology), skills and tools (hard technology) which usually come from developed countries to developing countries through construction project activities. Therefore, the objective of this paper is to assess the influence of foreign contractors in supporting transfer of e-business technology to the Ghanaian construction industry. In view of this, a total number of five (5) semi-structured interviews were conducted as follow: one (1) foreign firm, two (2) expert interviews and two (2) local contractors (collaborators) representing one case study out of a total of three. This research involved an interpretivist approach based on qualitative data in order to have an in-depth understanding of the objective of this paper and have insight into how practitioners perceive the roles of foreign contractors in the transfer of e-business technology to improve performance in the construction industry in Ghana. This paper reports that content analysis shows the important role that foreign contractors play within the context of e-business technology transfer. The results also show that foreign firms undertake TT in an *ad hoc* manner and this exercise need to be streamlined. They further indicate several arguments on the need to address the identified barriers to enable the industry to harness the full potentials of e-business.

Keywords: e-Business technology, technology transfer, construction industry, developing countries, foreign firms

1. Introduction

According to Ayarkwa *et al*. (2010), the Ghanaian construction industry is characterised by multiple of small firms consisting of 1-60 employees. The industry had an estimated employment figure of 2.3% of the economically active population (Amankwa, 2003). It is noted that small construction firms are of strategic importance to employment and wealth creation in the Ghanaian economy (Dansoh, 2005). However, the Ghanaian construction industry is experiencing serious problems in respect to low productivity, lengthy pre-contract award procedures, corruption and delays resulting in time and cost overruns (Ahiaga-Dagbui *et al*., 2011). Ayarkwa *et al*. (2010) identified low technology capability. Similarly, (Ofori, 2012) note poor communication structure as one of the nagging problems confronting local contractors and the entire construction industry in Ghana. These identified problems are only likely to get worse if not checked and addressed. For government to achieve it agenda of delivering strategic infrastructure to meet Ghana's low middle-income status, there is a need for strategies to be put in place to address these identified problems immediately.

One innovate way to address these problems is through e-business technology transfer to the local contractors within the construction industry in Ghana. E-Business has the capability to enhance inter and intra organisation communications thus, eliminating problems connected to communication among key project partners. Timely communications essentially can address low productivity, lengthy pre-contract award procedures and delays thereby eliminating time and cost overrun issues. E-business minimises face-to-face contacts with government officials thereby preventing corruption in contract award process. Further, benefits like reduction of manual work and contract-related papers, routine administrative processes become simpler after some initial adaptation and training and reduction in contract processing time. These are key benefits that can be derived through the introduction of e-business to the Ghanaian construction industry.

This research was developed to assess the influence of foreign contractors in supporting transfer of e-business technology to the Ghanaian construction industry. The paper first presented a brief literature review followed by the research method adopted. It then presented findings of the research based on the themes technology, organisation readiness and continuous skills development. The paper concluded by providing future research direction.

2. E-business literature and practice

In recent years, the use of Internet technology for business has been on the increase mostly across manufacturing, retail, banking and many other business sectors. The benefits of using Internet technology to conduct business have been well noted and researched, the emergence of Internet technology has far-reaching ramifications on the way business is conducted (Gunasekaran and Ngai, 2008). This act of conducting business using Internet technology in conjunction with ICT infrastructure is referred to as electronic business (e-Business) and in some research documentations it is also referred to as electronic commerce (e-commerce). In contrast Ahmed *et al*. (2005) believes that e-business is an umbrella terminology that encompasses e-commerce and e-procurement activities and refer to the utilisation of network computing and the Internet to transform a firm's value chain (i.e. internal processes, suppliers and partner interaction, and customer relationships with the prime goal of creating value and competitive edge). From the work of Damanpour and Damanpor (2001), they are of the view that e-business and e-commerce is any "net" business activity that transforms internal and external relationships to create value and exploit market opportunities driven by new rules of the connected economy. Similarly, e-commerce is referred to as business transaction by electronic means through the Internet and/or dedicated networks (Anumba and Ruikar, 2002, Ahmed *et al*., 2005). According to Damanpour and Damanpor (2001), The Gartner Advisory Group, a research and advisory services firm, describes e-business in terms of a quantity rather than an absolute state of a company. They consider a business an e-business to the degree that it targets the market opportunities of conducting business under new electronic channels, which revolve around the Internet. This is an acknowledgement that e-business comes in many forms and can be implemented to a very small or large degree. It is also an acknowledgement that the "Internet" and the "Web" are essential components of e-business and e-commerce strategies and activities. Fundamentally, e-business can be described as the interchange of goods, services, property, ideas or communications through an electronic medium for purposes of facilitating or conducting business (Costello and Tuchen, 1998) cited in Cheng *et al.* (2001).

Laudon and Laudon (2002) cited in Ruikar and Anumba (2008) emphasised the use of the internet and other digital technology for organisational communication, coordination and the management of the firm. On the other hand, Wamelink and Teunissen (2003) studies on e-business have adopted the use of information and communications technology to change and improve business relationships as a primary measure. In the simplest possible term, however, e-business is an electronic way of doing business (Ruikar and Anumba, 2008). Therefore, companies must participate in external business relationships by using computer interactions (i.e. transactions, support, marketing, communication and collaboration) by either business-to-business (B2B) or business-to-consumer (B2C), if it is to be considered an e-business (Damanpour and Damanpor, 2001). In relation to this, Cheng *et al.* (2001) argue that e-business infrastructure is used to improve communication and coordination, and encourage the mutual sharing of inter-organisational resources and competencies. This was further corroborated in a general perspective by Muffatto and Payaro (2004) arguing that e-business is the process whereby Internet technology is used to simplify certain company processes, improve productivity, and increase efficiency. It allows companies to easily communicate with their suppliers, buyers, and customers, to integrate "back-office" systems with those used for transactions, to accurately transmit information, and to carry out data analysis in order to increase their competitiveness. To support the inter-organisational sharing of resources and competencies in a network structure, communication and co-ordination need to be maintained (Cheng *et al.,* 2001).

3. E-business in construction

As indicated in literature, e-business potentially can be deployed and applied across all economic sectors and non-economic activities. According to Hashim and Said (2011), few writers described e-business in a broader context; that is 'the facilitation and integration of business process'. However, in construction industry specifically, London *et al*. (2006) provide an extensive definition of e-business in the context of construction industry as reported by Hashim and Said (2011):

"E-business in construction involves any electronic exchanges of information in relation to the various stages of the design, construction and operation asset life cycle which includes:
Internal organisational driven activity for firm core and support business including industry specific and generic business software applications, websites, email and electronic banking.
Externally linked online web based portals involving:

- *Design collaboration and document management*
- *Online tendering*
- *Procurement, purchasing and invoicing*
- *Information*
- *Online or internal organisational facility management systems".*

It can be deduced from the discussions that there is no conclusive definition for both e-business and e-commerce. It showed that definitions are adopted based on the particular sector in question or where a particular research is being carried out. In this context, the definition provided by London *et al*. (2006) is relevant as it encompasses all the component identified in the discussion.

4. Benefits of e-business in construction

Assessment of academic literature identified the following common e-business barriers and benefits to construction. Low levels of e-business implementation within construction has been highlighted despite numerous benefits to the construction industry (Ruikar and Anumba, 2008, Eadie *et al.*, 2010a, Eadie *et al*., 2010b, Perera *et al*., 2011). Similar work done by Isikdag *et al*. (2011) from developing country perspective, highlight barriers such as technological infrastructure, security, lack of basic ICT skills and difficulty in reengineering of business process to support e-business activities. Najimu (2011) identified among other things, a lack of skills, training and security as barriers within the construction industry in Nigeria. This is as a result of the fragmented nature of the construction industry and the one-off nature of its products (Ruikar and Anumba, 2008). For example, Oyediran and Odusami (2005) note that one important benefit of e-business to the construction industry is the removal of geographical boundaries within the global construction environment. Ruikar *et al.* (2003) are of the view that the simplified business processes provided by e-business through ICT has significantly impacted the construction industry in many ways. The emergence of e-business in construction in most cases developed economies shows there is sufficient evidence of e-business activities such product promotion, service promotion, e-procurement, project management, project collaboration and online tendering within construction (Issa *et al*., 2003, Alshawi and Ingirige, 2003, Ruikar and Anumba, 2008).

The study is about e-business technology transfer from foreign contractors to local contractors in Ghana. To take this study forward a detailed literature review and synthesis was carried. The parameters arrived at for e-business technology transfer in the context of this research is as follows: Technology; Organisation readiness and Continuous skills development.

5. The project – case study for e-business technology transfer

This project is a 12km first class road project comprising a three (3) lane dual carriage way, two (2) over pass and one (1) under pass. In addition to the main project, pedestrian foot bridges located at four (4) different locations shall be constructed. The project is situated within a busy district in Accra, the national capital of Ghana. The main contractor is a foreign contractor and the nature of the project has necessitated project specific joint venture/collaboration between some indigenous Ghanaian construction firms for the delivery of specific contracts under the main contract. Under the terms of engagement, the foreign contractor is obliged to provide capacity training and technology transfer initiatives to the benefit of the local contractors directly or indirectly during the project period. The client (employer) is the Ghana government.

6. Methodology

The main method for data collection was semi-structured interviews. Interviews were conducted within an on-going project (see section 5) which is referred to as case study (CS) for the purposes of this research. The interviewees were senior managers working for either the main contractor (foreign firm) or local contractors. To gain multiple insights, two expert views were sought as part of the data collection. The first expert, an IT and procurement specialist was drawn from government procurement authority and e-governance project. This expert was selected to provide an insight into Ghana government e-governance project which has e-business component. The second expert, a foreign consultant with twelve (12) years working experience in joint venture (JV) arrangements and project development within construction, this expert provides consultancy services in respect of the case study project, as a result, was selected to provide insight into the JV as detailed in the project (see section 5). See details of category and number of organisations involved in this study in Table 1. Even though the interviews reflected a total number of five (5), they were conducted for over one-and-half hours per project staff. On the other hand, each expert interview was conducted for two hours. The interviews were conducted six (6) months into the physical implementation of the project so that a thorough assessment of capacity training and e-business technology transfer arrangement contained in the project details can be undertake as part of data collection process. The interview with the respondents was recorded using digital tape recorder based on the permission of the respondents. Following the completion of the interviews, the interview discussions were later transcribed ensuring that conversations were fully captured and also representing opinions and views expressed by the respondents. For the purposes of true reflection of respondent's opinions and views, the transcribed texts were sent to the respondents for verification. The transcribed data were subsequently analysed utilising NVivo 10 software package to filter and sort emerging themes for further analysis. As provided by the principles of using NVivo 10, the analysis started by coding of the data from a general perspective and then narrowed down through merging of similar and identified themes, concepts, ideas, topics, phrases and terms within the research area to enhance reliability and validity of the data. The final themes arrived at are technology, organisation readiness and continuous skills development.

Table 1: Category and number of organisations involved in this study

Description	Organisation Type	Role of Organisation	Personnel Type	Number of Interviews per Org.
CS	Foreign Firm	Main Contractor	Project Manager	1
	Local Firm	JV Partner	Project Manager	1
	Local Firm	JV Partner	Assistant Manger	1
Government Procurement Office	Ghana Gov't Procurement Office & e-governace	Expert View	IT & Procurement Specialist	1
Consultant	Foreign Firm	Expert View	Country Rep.	1

CS = Case Study

7. Findings and discussions

The following are the emerged themes from the semi-structured interviews based on the objective set out in this paper.

8. Technology

8.1 E-business enabling technologies

The project manager of the foreign construction firm undertaking the project as the main contractor confirmed that the firm uses e-business enabling technology to support their work both locally and internationally. For example, the project manager mentioned the use of internet technology in many ways. The project manager further mentioned that ICT and the internet are used in all aspects of the work they do. Designs are done using CAD technology and distributed via internet technology to partners even locally. When further asked how the local collaborators are coping with the technological demands, the project manager says:

"The local contractors have some challenges in the area of basic knowledge in ICT, financial issues which bother on general economic environment and the attitude of doing things the same old ways, these are key challenges the local contractors are facing".

The project manager further explained that the working environment appears a lot better. "We have developed continuous training programmes for the collaborators which are intended to enhance their capacity".

8.2 Project management and collaboration

The project manager of one of the local contractors involved in this case study agrees that the internet indeed has played a major role in the way they conduct their activities. "Information on design issues and solutions are made available to us on timely basis for comments and suggestions". "Often you tend to see great comments from professionals elsewhere working on another project". For instance, when the project manager was asked to describe how the internet technology and this joint venture have enhanced their work, the following were the responses the project manager provided:

"….this has speed up our work most especially communication process between all the parties involved in this project."

"….by and large we have avoided unnecessary delay hitherto associated with construction project activities in this country"

The second local manager expressed an opinion on how construction project is carried out in Ghana. The manager is of the view that those of them in this joint venture arrangement have improved on their capacities and also enhanced their firm's status.

"The key challenge is updating our capacity in a country where resources are scarce."

9. Organisation readiness

9.1 Capacity to accept and absorb e-business technology

Under this, two (2) respondents were unanimous in their responses; actually they were clear in attributing lack of technological know-how and application to the low capacity of the firms operating in the construction industry in Ghana. "The present situation of the construction industry in Ghana needs rethinking". A further probing of the issue, one of the local managers was asked to explain what is meant by low capacity; the participants were actually referring to barriers that affect absorptive capacity of the local construction firm. For example, the manager's views were expressed as follows:

"…inadequate trained professional and finance are major issues within the industry and it is affecting the entire construction industry in Ghana most of the people in the industry do not use computers let alone to think about industry related software. We do not have the financial capacity to employ people with such skills".

It is obvious from the findings that majority of professionals in the construction industry do not have ICT skills that are required to support any attempt to computerise their works and some expressed the fear of losing their jobs in the event of any such management decision hence prefer to keep to the usual way of working.

9.2 Culture

Under this, three respondents acknowledge the important role of culture. It could produce positive or negative results. For example, one of the local project managers pointed out that this joint venture exposed them to many things that have implications on their work. According to one of the local managers, most of us are identified by our work method, we use manual for everything we do, whereas the foreign firm does work in the office and on site using technology. For example a project manager from the foreign firm expressed the following views:

"I think to move forward it is important to take on board staff of the local firm and continuously let them understand the benefits of e-Business to the company; attitude to work has to change, staff can then be encouraged to start using ICT facilities and e-Business tools."

"…….by that the organisational culture will begin to change to conform to e-Business friendly environment and new identity can be found"

"The local firms naturally will begin to resolve challenges associated to the use of e-Business once they identify one".

9.3 Internet infrastructure

All the five respondents acknowledged that, the fundamental requirement for e-Business is the availability of internet in the firm. The foreign consultant observed as follow:

> *"The use of the internet technology is generally gaining popularity among the local contractors however, majority of them are still unable to access it due to high cost from service providers".*
>
> *"Those that have it are unable to explore the innovative capacities of the internet hence the common trend of inefficient working environment the contractors operate in today".*

9.4 ICT equipment hardware

Again all the five respondents were emphatic in their response that ICT equipment plays a major role as e-Business depends on the capabilities of ICT equipment and the internet to provide the necessary impact. From this the foreign consultant again observed as follow:

"The economic situation and non-availability of projects makes it difficult for contractors to invest in ICT equipment as they are not always in business. I think it is also a clear case that they lack the financial capacity to recruit qualified personnel".

9.5 Regulations

The procurement expert from government office agreed that legal issues in e-business transactions are key to the development of a strong platform for business transactions to take place. This position was corroborated by the foreign consultant as follows:

"From experience good legal system provides confidence for people to transact business in a secure environment in addition to legal limitations that may be required".

9.6 Political influence

Under the political authority theme, all five respondents were emphatic in their responses by acknowledging that, political influences have had negative impact on works procurement process in the construction industry. In many instances, tenders are skewed in favour of the contractor who is able to command sufficient political influence; projects are awarded on political affiliation lines making monitoring of such projects extremely difficult. Projects are eventually given out to contractors who do not have the resources to undertake such projects. Yet, the foreign consultant thinks otherwise, political influence or intervention according to the consultant may not necessary be harmful however, the consultant agrees that:

"there is more to be done to improve the procurement system in order to minimise human to human interface it all about getting our processes right and improve upon them".

The procurement expert from government office similarly thinks that political influence can be of benefit to the industry. For example, it can be exploited to restructure contractor registration framework to enable the system to allow only qualified people to enter the construction industry. The expert further expressed the following views:

"I think industry led skills development would help the industry promote the culture of quality work, infusion of technology most especially ICT will improve the industry's outlook and performance, political influence in my opinion could be of immense benefit" in improving our business processes".

10. Continuous skills development

10.1 Acquisition of new skills

When participant views were sought on sustaining the skills acquired as a result of their involvement in this joint venture, their responses did not vary as such the explanation points to the fact that they have to change their work culture gradually in order to conform to acceptable ways of doing business. The fact is globalisation and ICT have brought the business community closer than before so we cannot stay behind. Some of the proposals put forward by the participants are highlighted as follows:

"…. to it very important to have frequent update of managerial skills that we have acquired now so that we can improve on productivity and also manage our project profitably it is the only way to become proficient (Local Project Manager)".

"Basically, the main issue remain that we have to start automating our processes to conform to the use of ICT and especially the internet, so utilising ICT facilities effectively in the project management aspect should be our target. Secondly, there is the need to continuously improve on our skills through either self-learning or any other available means (Local Asst. Manager)".

11. Conclusion and way forward

This research aimed to assess the influence of foreign contractors in supporting transfer of e-business technology to the Ghanaian construction industry within the context of joint venture between foreign and local contractors. This research in particular assessed the technological capacity of the Ghanaian local contractor and the influence of their foreign counterparts in transfer of e-business technology capability to the local contractors. To establish how foreign contracting firms have influenced technological and capacity development of the Ghanaian local contractors, three (3) case studies were developed within the construction industry in Ghana. The first case study was conducted, this report represent the outcome of the first case study. The results of the research show the existence of technological and skills gaps in the Ghanaian construction industry. To further analyse these key problems the main issues that emerged from the case study where discussed within the context of technology, organisation readiness and continuous skills development. Further details from the discussion of the themes revealed that for success in e-Business technology transfer, barriers such as basic ICT skills and poor financial capacity of local contractors should be adequately addressed. The notion that a minimum capability standard to absorb or assimilate e-business technologies should be derived or arrived at as part of technology transfer process remains relevant. Therefore, issues concerning technology transfer process should be done in a structured and coordinated way as part of the JV arrangement. The research show that local contractors recognised that culture plays an influential role in shaping up organisational outlook and attitude of their staff in promoting change that has the potential to improve performance within the construction industry in Ghana. This underscores the willingness of the local contractors to learn new technologies as a means to support improvement within the construction industry in Ghana. Completion of all the selected case studies will further inform this scale and its way forward and future research prospects.

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Location Breakdown Structure (LBS): a solution for construction project management data redundancy

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Abstract

The evolution of construction Project Management (PM) practices is linked to the development of PERT, a network based control system for product completion. PM practices aim to control cost and time based on a hierarchy work breakdown structure (WBS). The work to be done on a project is defined in work packages. However, for construction projects, current use of WBS creates a significant amount of data redundancy, because all of the work is location specific. This paper argues that location is a more appropriate unit of analysis and thus the obvious conceptual framework for construction projects. Built environment production is explained in the Location Based Management System (LBMS). The LBMS components are unified and location allows the integration of many data mechanisms into a knowledge-base for a project. Location provides the container for all project data and is used as the primary work division through a location breakdown structure (LBS). The LBS provides the opportunity, used in conjunction with the WBS, to limit excessive location specific data repetition. This paper outlines the application of a WBS/LBS matrix as one method for improving construction project productivity. The WBS, once freed of location-repetition, can more efficiently describe the work being done which permits increased administrative productivity.

Keywords: Productivity, Location Breakdown Structure, WBS/LBS matrix; location-based thinking

1. Introduction

Work Breakdown Structure (WBS) is an essential component of Project Management (PM). The commonly accepted definition for WBS is: "…a product-oriented family tree subdivision of the hardware, services and data required to produce the end product which is structured in accordance with the way the work will be performed and reflects the way in which project costs and data will be summarised and eventually reported" (Kerzner, 2007). This product breakdown definition is also reflected in the Project Management Standards (PMI-PMBOK, 2013; ISO 21500, 2012; PMI-WBS, 2006; SA-AS4817, 2006;).

Interestingly, there is very little literature underpinning this definition (Kenley & Harfield, 2013). WBS emerged as a tool to ensure scope management from the earliest days of formalising processes for the management of projects. The WBS created a framework for network planning (CPM) and thus was a method for driving task allocation in the network planning of projects in the 1950s and 60s. It has subsequently been accepted as a fundamental aspect of PM with very little challenge (Weaver, 2007).

Project Management practice is grounded in the use of the WBS, a tool used to detail the work required to produce the final product or deliverables. This 'structure' is a way to define, or scope or contain the many inter-dependent actions and resources required to manage a project to completion. Thus, 'structure' is a well-entrenched concept in relation to project definition.

According to Archibold and Villoria (1967), project definition equated to a WBS, with seven substructures: Project Organisation, Network Plan, Calendar Time, Estimating, Chart of Account, Funding and Authorisation Control, and Report. These sub-structures have become the basis of project administration processes. Systems theory indicates that these constituent parts must 'mesh' into an adaptive whole. However, in practice this is very difficult to achieve for construction management systems (Norman et al., 2008; Rad, 1999; Moder et al., 1983). This problem of integration must reduce productivity, especially in PM processes

Currently, there is a dearth of PM literature considering project breakdown structures from the perspective of data efficiency and reuse. This is surprising because data redundancy should be integral to the design and development of an efficient WBS. One of the dominant themes of database research and design in records management (Ismail and Jamaludin, 2009) and data management (Andritsos et al., 2004) is a concern with data efficiency by minimising data duplication. However, data repetition can be avoided in WBS to enhance activity-based efficiency. Location is known to be a significant component of the WBS of all construction projects and is a source of data repetition (Kenley, 2004; Harris & Ioannou, 1998). Therefore, location can be stripped out of WBS and integrated together in a breakdown matrix.

The Location-Based Management system (LBMS) described by Kenley and Seppänen (2010) is an integrated network of management system components potentially involving all stages of construction, from design through to completion. The system components are unified and location allows the integration of many data components into a knowledge-base for a project. Location is the logical container for data which relates to the quantum of the project which enables efficient data quality limiting data redundancy utilising a location breakdown structure (LBS).

The balance of this paper focuses on data management efficiencies that are possible by focusing on location-based construction management techniques. Section two outlines the importance of articulating location for managing construction projects. Section three describes the features and advantages of a Location Breakdown Structure. Section four provides an outline of the differences between traditional and location-based project scheduling. Section five extends the concept of a project management breakdown matrix followed by the conclusion.

2. Construction: a location-based project

Construction projects, whether bridges, road or rail lines, high-rise or wide-rise buildings, all have one characteristic that is different from many other projects. Each of these involves products for the built environment and location is a major feature. All construction projects provide products for a specific location; often the actual construction takes place at that location. Thus, these projects are 'location-oriented', with location being both implicit and explicit for all construction management endeavours (Ibrahim et al., 2009).

Current PM practice is centred on managing a project through the WBS. The concept of WBS originates in network theory (Operations Research) as does much of the founding PM literature (Kerzner, 2007). The original purpose of WBS was to ensure product completion from a work perspective. The focus of the work perspective is on project completion as specified, within budget and on time. Definitions of the work to be done begins with project scope leading to project targets and deliverables calculated by methodologies for planning and control. The essential characteristic, location, of construction projects suggests the need to revisit PM basics in order to consider models that focus on location in managing construction projects data.

The Location-Based Management system (LBMS) described by Kenley and Seppänen (2010) is an integrated network of management system components potentially involving all stages of construction, from design through to completion. The system components are unified and location allows the integration of many data components into a knowledge-base for a project. This makes the LBMS rich in integrated data which parallels other initiatives such as BIM for integrated project delivery or the integrated project environments that are now emerging.

One important concept of LBMS is the Location Breakdown Structure (LBS). Utilisation of an LBS for construction projects, along with suitable project models and management strategies, can systematically improve project production efficiency of data. LBS is not a building information model (BIM) but rather a methodology for interacting with a BIM, placing demands on the BIM for both properties and characterisation (breakdown).

3. Location breakdown structure (LBS)

Ibrahim et al. (2009) found that the most frequently used decomposition criteria in the formulation of WBS for building projects are elements, work sections, physical location and construction aids. This indicates that location is embedded into the WBS hierarchy on construction projects. Indeed, Ibrahim et al. proposed a hierarchical decomposition of a building project based on these criteria. When they were doing their research, little was published on LBS. Ibrahim et al. noted that they were not aware of a standardised classification for the "location" criterion. They therefore simply adopted a classification based on floor level since this was identified as the definition commonly adopted by planners.

Location as the unit of analysis is at the heart of the LBMS. Location provides the container for all project data, and is used as the primary work division through a location breakdown structure (LBS)—rather than the more familiar work breakdown structure (WBS).

Location is the container for data which relates to the quantum of the project. The LBS is hierarchical so that a higher level location logically includes all the lower level locations. Each of the location hierarchies has a different purpose. The highest level is used to optimise construction sequence, because the structures of such sections are independent of each other and therefore it is possible to start them in any sequence or to build them simultaneously. The middle levels are used to plan production flow of structure (and often reflect physical constraints). The lowest levels are used for planning detail and finishes. This allows data to be collected at different levels within the hierarchy. The location contains the following types of data:

- Building objects or components such as elements and sub-systems
- Planned and actual building component quantities
- Building system production assemblies
- Planned and actual material costs
- Building system costs.

4. Scheduling a project

The Project Management literature, and indeed practice as defined in the Project Management Standards, considers projects as being capable of decomposition through hierarchical structures. Application of the reductionist concept of decomposition is the organising principle that enables the process of sub-dividing the total project into smaller parts. This process is carried out to ensure the smallest task is defined and is able to be managed within a complex system. The process of decomposition is based on a hierarchical tree through 'parent and child' segmentation of the total project (Stal-Le Cardinal and Marle, 2006). Each sub-division must fit into the defined project scope and completion deliverables. Thus, decomposition design can be from either a top-down or a bottom-up perspective, both based on rational choice theory (Weaver, 2007). To understand the different methodologies for decomposition, it is worthwhile recapping PM development.

4.1 Activity-based method

The lowest WBS level of decomposition usually contains ‘work packages’ (Norman et al., 2008). The work packages generally form the link to subsequent processes, most particularly scheduling. Detailed time scheduling will break work packages down further into component activities, a process that may involve further hierarchical decomposition.

Activity-based scheduling is the current dominant scheduling technique. It was first developed in the 1950s, but owed much to the theory of scientific management (Taylor, 1911) and the visualising techniques of Henry Gantt (1919). He used these to manage infrastructure projects such as the Hoover Dam in the USA. Development of modelling projects through a schedule for planning and controlling work continued in order to take advantage of the new technology of the 1950s, the computer. DuPont initiated research in 1956 which led to the seminal model developed by Kelley and Walker (1959). The underlying maths provides a topological map of discrete activities joined by logical relationships. Each individual activity is considered free to move in time as long as it maintains the logical relationship with its predecessors and successors. Such a model suits any project where activities are completely discrete and have no structural correlation with other activities.

Kelley and Walker (1959) coined the term Critical Path Method (CPM) because in the projects they were modelling, critical activities were easily identified. The technique relies on the construction of a logical network of activities. The term ‘activity-based’ describes this methodology because the underlying epistemology is that a project may be modelled solely with individual packages of works (activities) and their logical relationships. The focus of the method is therefore on the activity as the container for project data, and the logical network is constructed by linking activities. The methodology is elegant and powerful, and has clearly enabled a rich environment for improving project performance (Norman et al., 2008).

4.2 Location-based method

The LBMS was also borne within scheduling theory development (Kenley and Seppänen, 2010). Location-based scheduling is another methodology, but it is based on tracking the continuity of crews working on production tasks. This was done originally using graphical techniques, designed by Karol Adamieçki in 1896 (Marsh, 1975). However, as PM developed, location-based scheduling was considered outside of the mainstream engineering perspective in the US (Kolltveit et al., 2007). On the other hand, managing large complex construction projects data can be considered from different perspectives. For example, the logistics issues of building the 102 storey Empire State Building in 1930-31. A LBMS suited the complexity of 102 stories, constrained building site delivery, massive quantities of steel & stone from various different sources, plus 4000 workers. Location was also an important issue for USA Defence requirements of the 1940s and 50s which supported further development of location-based scheduling (Battersby, 1964).

The underlying epistemology for a location-based method is that a project may be modelled by including individual packages of works into a connected whole entity called a task, which represents the aggregation of activities in multiple locations. This family of methods involve repetitive activities which Harris and Ioannou (1998) gave the generic term *repetitive scheduling method* (RSM). Russell Kenley (2004) coined the term *location-based scheduling*, considering it more appropriate and descriptive of the character of the methodology.

Location-based topological models may be constructed by linking both tasks and activities through a complex network of logical relationships. While in its basic form the methodology is largely graphical, modern methods have shown that it is possible to incorporate the full range of CPM logical relationships, both within and between tasks. Furthermore, the presence of tasks and locations allows much more powerful relationships to be built providing much greater power and flexibility for modelling construction projects.

What emerges from this discussion is that traditional project management embeds location in the WBS of construction projects whereas location-based management of construction establishes an LBS to manage project data. This raises the question whether or not PM theory, and WBS decomposition, can benefit from the use of LBS in some direct way.

5. New project breakdown matrix: WBS/LBS

Turner (2000) considered the potential of 'breaking down' a project from a different perspective. He suggests a Product Breakdown Structure (PBS) which is indicative of project objectives and a major structural container focused on responsibility and personnel in an Organisational Breakdown Structure (OBS). He suggests the WBS is actually a two-dimensional matrix (PBS X OBS) formed by the intersection of the two hierarchical breakdowns at corresponding levels of breakdown. Thus, the WBS is actually a 2D container for managing a project.

This important concept, considering the intersection of two differently focused breakdown structures, has received little attention by PM researchers (Kenley and Harfield, 2012). Yet potentially this concept of the 2D model as a container reveals a significantly different view of the WBS from the conventional definition of a hierarchical tree (Kerzner, 2007; Colenson, 2000). This matrix-like view provides a hint for alternative ways to break down project data providing the possibility of productivity gains through more efficient data management.

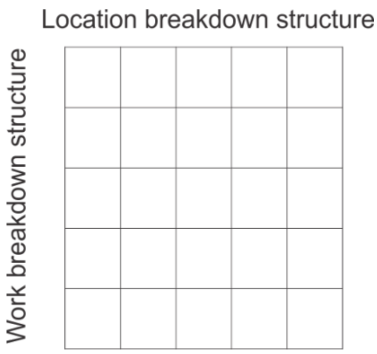

Figure 1: Project Breakdown Matrix

The key to changing the way we think about the management of projects is to change the way we decompose their structure. The problem with current practice is that the WBS is a single hierarchy structure which must meet conflicting demands. It is therefore proposed that breakdown structures strip out location from the hierarchy to create a matrix, as shown in Figure 1.

Breaking down a project in this way clarifies the advantages of location-based management. The WBS, once freed of location-repetition, can more efficiently describe the work being done. Then the repetition of each level of the WBS across multiple locations can be handled by the matrix using the LBS providing a mechanism for removing data redundancy. In fact, this technique can be applied in any situation and using any technical platform, it does not need to be a specific location-based tool.

The opportunity is to use location-based techniques in any management system to strip out the location hierarchy from the WBS. An example of the application of this opportunity is demonstrated by Moine (2012). He argues for a 3D WBS as represented in Figure 2. This 3D model consists of:

- Activities (ABS, Activity Breakdown Structure), "Install / build", as defined actions or processes;

- Products (PBS, Product Breakdown Structure), "components", that is to say, equipment, materials or engineering works to finer levels of the tree. On the upper floors, the PBS is composed of functional systems (SBS, System Breakdown Structure); and

- Areas (GBS Geographical Breakdown Structure), "somewhere", which can be geographical or functional according to the phases of the project.

Then the WBS results from the crossing of GBS, PBS and ABS (Moine, 2012). One of the key benefits of this approach is that schedules can be rapidly built, by exploiting repetition of activities.

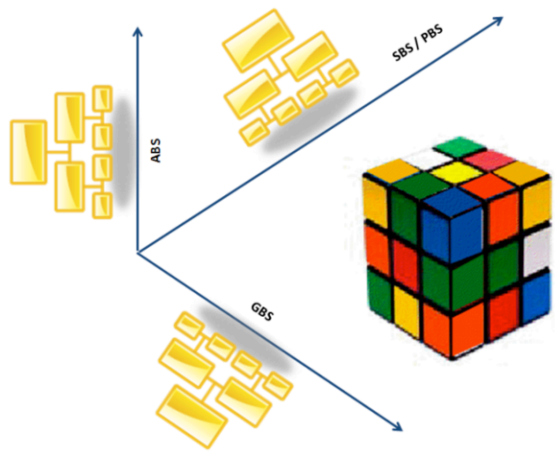

Figure 2: 3D WBS (from Moine, 2012)

Breaking down a project in this way clarifies the advantage of location-based management. The advantages of a LBS/WBS matrix are:

- **Production efficiency**
  Managing resources to ensure continuous production tasks flow through locations.

- **Finer hierarchy structures**
  Waiting time can be buried in a schedule due to the use of an implied location breakdown with too course a structure. Mapping production using an LBS can make these issues much easier to spot and enable the waste to be removed or converted into a buffer.

- **Process efficiency**
  Current administration of projects is becoming increasingly onerous because of the increasing amount of data that can be easily transferred. The Project Breakdown Matrix enables repetition in processes and forms to be stripped out of the administration systems.

6. Conclusion

This paper has argued for an acceptance of the primacy of location in construction project management (PM). Currently project management administration is overloaded with data, because the simple fact of location repetition within a variety of processes. The Location-Based Management system (LBMS) described by Kenley and Seppänen (2010) is an integrated network of management system components potentially involving all stages of construction, from design through to completion. The system components are unified and location allows the integration of many data components into a knowledge-base for a project.

Location is the unit of analysis of the Location-Based Management system. Because location provides the container for all project data, and is used as the primary work division through a LBS rather than the more familiar WBS. This paper has suggested a matrix of WBS and LBS for improving project productivity. If all PM systems extract the LBS from the WBS, then data redundancy will be reduced. Indeed, the mere act of doing so forces recognition of the role of location and empowers the project manager with additional tools and techniques.

A Location Based Management System (LBMS) provides the conceptual foundation for mechanisms that provide data management efficiencies through identification and utilisation of location in work package tasks. Because LBMS articulates the primacy of location for construction, it provides a framework for location-based thinking. For example, schedule compression can be very difficult to achieve. Often it is not possible to remove time from a schedule when problems have arisen. However, location-based thinking can reveal the existence of parallel work opportunities which enable overlapping work. Whilst a good manager might realize this, location-based thinking makes the opportunity much easier to identify.

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Sustainability non-price incentives and rewards: a collaborative procurement perspective

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Abstract

Construction scholars suggest that procurement processes can be used as mechanisms to change construction industry practices. This paper discusses industry changes as a response to the calls for integration of sustainability ideals into construction practices. Because major infrastructure construction has been identified as a key producer of greenhouse gas emissions (GHGE), this study explores collaborative procurement models that have been used to facilitate mitigation of GHGE. The study focuses on the application of non-price incentives and rewards that work together as a binary mechanism. Data were collected using mixed-methods: government document content analysis was complemented with data collected through focus groups and individual interviews with both clients and contractors. This report includes examples of greening procurement agendas for three Australian road authorities relating to collaborative procurement project delivery models. Three collaborative procurement models, Alliance Consortium, Early Contractor Involvement and Public Private Partnerships provide evidence of construction projects that were completed early. It can also be argued that both clients and contractors are rewarded through collaborative project delivery. The incentive of early completion is rewarded with reduction of GHGE. This positive environmental outcome, based on a dual benefit and non-price sustainability criteria, suggests a step towards changed industry practices though the use of green procurement models.

Keywords: sustainability, collaborative procurement, non-price incentives and rewards, GHGE reduction

1. Introduction

Procurement mechanisms are a well-documented method for provision of the global issue of economic reform in the construction sector (Miller et al., 2009; Langford et al., 2003). To achieve this objective, mechanisms such as funding support for development of organisational structures to improve production efficiency have been implemented in a number of countries (Guthrie et al., 2012; Raisbeck et al., 2010). In Australia, especially related to infrastructure, federal and state government departments have the role of change agents in the construction sector. However, in a market economy, with governments as major infrastructure clients, the issue is more complex. Currently most government clients prefer market-based solutions rather than government intervention, expecting non-government organisations to also be pro-active in changing industry practice (Kajander et al., 2012; Varnas et al., 2009; Kenley et al., 2000). For example, regulations and building or material standards are traditional methods in which both public and private organisations take responsibility for implementing construction sector change.

Kenley et al. (2000) suggest that economic reform based on construction sector sustainable practices is a government social responsibility objective. Similarly, Fernando & Guppy (2006) argue that governments must change their procurement practices to ensure social as well as economic accountability. This obviously global shift towards considering the impact of climate change has added environmental sustainability (conserving and enhancing the community resources for future generations) to the list of government social and economic responsibilities in many countries (Kajander et al., 2012; Shi et al., 2012; van Wyke, 2006).

Within the construction sector, progress has been made in the uptake of sustainability as an organizing principle for both public and private organizations. For example, a number of sustainability rating systems have been co-developed and are either locally or globally implemented. CEEQUAL (all infrastructure), INVEST (transport), BREEAM (buildings) and LEED (buildings) are all currently gaining acceptance through all phases of the construction process (Gutherie et al., 2012). However acceptance and implementation of these initiatives is not universal.

Some scholars suggest that the slow pace of industry change may be linked to contractors who have not developed sustainability practices because they seldom move outside of contract specifications (Lam & Yu, 2011). In countries such as Australia where government agencies are the principle client for infrastructure (buildings and transport facilities) the expectation is for government to be change leaders (Kenley et al., 2000). For example, government procurement non-price sustainability contractor incentives and rewards can be used as positive mechanisms to change construction practices (Kenley et al., 2012). This has begun in Australia in order to meet Kyoto Protocol commitments. The Australian government has policy directives for all levels of government responsible for construction to consider ‘greening’ their procurement processes for improved environmental impact (Infrastructure Australia, 2012). The balance of this paper will report on some steps towards “greening procurement” of infrastructure construction for three Australian transport authorities.

The next section provides the background to the study, based on the implementation of the Australian Greenhouse Gas Emission (GHGE) policy agenda. It begins with a discussion of sustainable industry change through collaborative project delivery models. Three models are considered: early contractor involvement (ECI), alliance consortium (AC) and public/private partnership (PPP). These models provide a framework for the application of sustainability incentive and reward mechanisms. Section three outlines the research methods and types of data collected. Analysis and discussion of the concept of greening the major roads procurement process provides examples from three Australian states in section four. Finally, a conclusion based on GHGE reduction and collaborative project delivery models is offered.

2. Greening procurement through collaborative project delivery models

The dominant scientific view of a direct relationship between greenhouse gas emissions (GHGE) and human behaviour related to long-term negative environmental effects has led to increased significance being attached to sustainable industry practices (O'Hara, 2009). This is especially true for the construction sector, a sector that produces a high level of GHGE (Hill, 2001; Hill and Bowen, 1997). The simple equation of reduced infrastructure construction time equals reduced GHGE is one principle associated with changing industry practices. It is expected that client and contractor collaboration throughout the construction phases will reduce both project duration and GHGE. This Australian transport authority sustainability change agenda is a foundation for greening government procurement.

Often in construction literature, procurement models based on collaborative team work is termed 'relationship procurement', however 'relationship' is inter-changeable with 'partnering' or 'alliance' (Walker & Hampson, 2003). However, Akintoye and Main (2007) do mention collaborative procurement as a specific type of relationship procurement. For the purposes of this paper, collaborative procurement has been chosen as a more effective classification of the procurement delivery models presented.

Table 1 Comparison between elements of traditional and collaborative procurement models

Collaborative Procurement	*Traditional Procurement*
Collaboration	*Adversarial*
Problem-solving	*Competition*
Innovation	*Sanctions*
Trust	*Contractual penalties*

Collaborative project delivery models, as opposed to traditional models, enable a client/contractor binary benefit due to key characteristics (Davis, 2007) as indicated in table 1. Trust is the important feature of collaborative procurement. A relationship based on trust means that decisions can be made allowing for innovation and problem solving through working together to refine and re-define project objectives. It is therefore assumed that contractors working within a collaborative procurement project delivery model are motivated to move beyond initial contract specifications. The outcome sought is for the contracts to align sustainability as a positive feature of client social accountability with contractor business objectives (Broome, 2002).

Through collaborative processes, numerous incentive and reward mechanisms can be built into the procurement process in order to translate policies and strategies into pro-active initiatives. Kenley et al. (2000) provide a list of types of incentives and rewards. Incentives are explained as "commitments to encourage future behaviour" and rewards are "recognition of past performance" (pp5). Both rewards and incentives are aimed at a desired industry-wide attribute of "environmental consciousness" (pp8). Although the authors make a distinction between the meaning of rewards and incentives; this paper will treat these terms as a binary unit as opposed to the commonly accepted practice of treating rewards and incentives as synonyms.

A binary unit means that both rewards and incentives are available to clients as well as providers. This difference is based on the view that greening procurement practices can be created through a collaborative framework to provide positive outcomes for both clients and contractors (Broome, 2002). For example, client defined incentives encourage contractors to develop strategic and innovative environmental and production efficiency attributes. Contractors that gain a good reputation earned by successful project sustainability performance will be rewarded with future projects. As a binary unit, client incentives are reinforced by client rewards based on contractors continuing sustainable practices for all their projects. Therefore, incentives and rewards work together as a binary unit through a collaborative framework, which in turn provides a dual benefit for both clients and providers.

Three project delivery strategies based on collaborative procurement models and non-price mechanisms are becoming industry standard for Australian infrastructure projects: early contractor involvement (ECI), alliance consortium (AC) and public/private partnership (PPP). Contracts for these project delivery strategies involve contractors in the early stages of planning, design and funding. An important non-price feature of ECI, AC and PPP delivery models is their co-operative decision-making processes to achieve the sustainability objective of the project, namely GHGE reduction (Uttam et al., 2012), based on non-price binary mechanisms.

Each of these descriptors (ECI, AC and PPP) have been used in the literatures to describe a project delivery strategy, a client/contractor relationship, a contract or a performance payment system (Rose and Manley, 2012; Gollagher and Young, 2009; Walker and Hampson, 2003). Close examination of each type does provide degrees of complexity, however, for this report each descriptor simply means a procurement model used for the purpose of meeting the obligations for 'greening' procurement related to major roadworks in three Australian states.

3. Research approach

This research is based on the premise that sustainability non-price criteria in procurement can be used as mechanisms to change construction industry practices (Kenley at al., 2000). A binary unit of rewards and incentives suggests that both clients and providers can benefit from greening procurement initiatives. In the first instance the Australian government Kyoto Protocol greenhouse gas emissions (GHGE) targets linked to greening government infrastructure procurement can reduce GHGE. In the second instance driving construction industry change to facilitate new sustainability practices for social and economic outcomes is the result of adoption of collaborative project delivery models.

Data were collected using mixed-methods (Creswell, 2009). Policy, regulation and contract document analysis for three Australian state transportation authorities formed the basis of approximately 90 per cent of documents available. Related types of documents were obtained for federal government agencies that are part of the transport infrastructure sector. Additional data concerning procurement processes for major roadworks were obtained through focus groups and individual interviews. Input from contractors included personal interviews, seminar materials and searching Australian based organisational Internet websites (Fellows and Liu, 2008).

Synthesis for analysis of the different types of data is based on distilling relevant knowledge from the literatures focused on sustainability, construction management, and government procurement. This report offers a small portion of a larger project to provide some insights related to the importance of the incentive/reward mechanism to ensure implementation of green procurement practices for major roads infrastructure projects in Australia (Kenley et al., 2012).

4. Three Australian major roadworks examples

Scholars agree that the selection of the appropriate project delivery model is the most critical decision in determining the success of a project (Miller et al., 2009). Three examples of collaborative project delivery including indications of successful implementation of a green procurement model are presented below. Together, the projects will demonstrate how non-price incentives and rewards work together as a binary mechanism and are delivered through collaborative procurement models to achieve a dual benefit for clients and providers. By achieving infrastructure project rewards through reduced project duration, clients and contractors achieve their social and economic responsibility by reducing GHGE. In addition non-price incentives assist the greening procurement agenda to affect industry change objectives.

4.1 New South Wales: RMS + AC

The state government of New South Wales requires public organisations to be carbon neutral by 2020. This means Roads and Maritime Services (RMS) must achieve zero net greenhouse gas emissions (GHGE) by 2020. A number of initiatives have been developed by RMS as part of their objective to 'green' their procurement processes. For example, RMS is a national leader in the development and implementation of a nationally developed carbon calculator. The TAGG Greenhouse Gas Assessment Workbook for Road Projects & Carbon Gauge (the electronic version) that became available in June 2011. The TAGG Workbook/Carbon Gauge contains quantification methods designed to be compatible with the international Greenhouse Gas Protocol Corporate standard. The TAGG methodology is intended to be a practical tool as well as an instrument of environmental sustainability education. It provides a method for estimating GHGE as well as providing the opportunity for a better understanding of how GHGE can be reduced (Dilger et al., 2011).

NSW RMS has incorporated Alliance Consortium (AC) delivery approach as part of their 'green' procurement initiative. Collaboration is developed through constituent organisational members from both the public transport authority and private services providers. AC teams form a type of 'virtual' organisation that is outside of everyday workings of their parent organisations which allows flexibility and innovation. Based on the collaborative perspective of AC, the state transport authority as the client aims to share construction risks by co-operating with project providers such as designers and contractors. Scholars have identified the importance of supporting governance structures to promote a truly collaborative "no-fault-no-blame" project culture through clearly defined group decision-making processes with Key Performance Indicator incentives (Miller et al., 2009; Wong et al., 2000). The AC procurement model also targets building roads and effective business relationships based on learning and innovation (Lam and Yu, 2011). Group decision-making to institute innovation and performance measurement are examples of procurement processes based on trust and co-operation that underpins successful project completion (Davis, 2007).

An example of a success story is the Ballina Bypass Alliance set up by the NSW RMS to upgrade 12km of the Pacific Highway. The challenges included seven different treatments to manage soft soils complexity, environmentally sensitive waterways and a high-risk highway as a building site. The $640m highway opened seven months early; attributed to high quality project management. Moreover, successful application of performance incentives in AC projects in a market economy encourages clients and contractors to work together towards a common purpose (Bresnen and Marshall, 2000). The addition of AC to the RMS greening procurement initiative paved the way for construction industry change.

As a government change leader RMS has utilised AC teams working towards the common goal of sustainability. Incentives and rewards for GHGE reduction can become mandatory for infrastructure construction projects. In addition, changing models of procurement to move beyond adversarial construction project relationships within a market economy has the potential to change industry practice. This RMS example indicates how green procurement supports changing industry practice.

4.2 Victoria: VicRoads + PPP

The state of Victoria has one of the most ambitious Australian GHGE reduction targets. The stated aims to reduce greenhouse gas emissions to 30% below 2000 levels, with a target of zero net emissions by 2020. As a change leader, the public road authority, VicRoads, focused on policies and practices to reduce environmental impacts from the road system early in the century <http://www.vicroads.vic.gov.au/Home/Moreinfoandservices/Environment/SustainabilityAndClimateChange.htm>. VicRoads developed one of the first government procurement policies to reduce GHGE focused on both road construction and vehicle use.

In line with these priorities was early implantation of the INVEST tool. INVEST aims to encourage inclusion of innovative ideas that will contribute to improving sustainability in road projects. There are 11 categories for sustainability for the INVEST tool, each having Key Performance Indicators (KPIs). Credits are awarded based on the KPIs giving a sustainability score and ranking for the project, thereby establishing benchmarks for sustainability practices.

Similarly, VicRoads have developed expertise in Public-Private Partnership (PPP) as a collaborative project delivery strategy. PPP is an agreement between public sector client and a private sector provider. Each party is encouraged to utilise their specific areas of expertise; public authorities for governance and contractors for operations (Langford et al., 2003). The flexibility necessary to solve problems of major infrastructure construction over the long-term is a key advantage for all parties using this project delivery strategy. Issues of sustainability and other non-price elements can be seen as opportunities (Kenly et al., 2012) rather than burdens (Rose and Manley, 2012) during the course of complex infrastructure projects.

The EastLink freeway in Melbourne is an example of the successful use of PPP as a collaborative project delivery model. The Victorian government awarded ConnectEast a 39 year life-cycle concession to finance, design, construct, commission, operate, deliver customer services, toll, maintain, repair and return the road to the state of Victoria. The project is labelled as a 'world-first' for a project of this type using the PPP delivery strategy. The important feature of the life-time service provision is the embedded Key Performance Indicators.

The PPP delivery model aims to eliminate contractual penalties through the successful application of non-price binary mechanisms within Key Performance Indicators (KPSs). The road was built by Thiess and John Holland; construction being completed under-time and with reduced GHGE which definitely meets incentive KPIs for social and economic rewards.

4.3 Western Australia: MRWA + ECI

The state of Western Australia has set a Carbon Reduction Target of 5-15% reduction of 2010 levels by 2020. The road authority, Main Roads Western Australia (MRWA), is moving towards their commitment to this goal through application of a 'greening procurement' policy. MRWA is developing a sustainability framework by integrating a nationally developed sustainability rating tool into their practices. The Infrastructure Sustainability (IS) Rating Tool created by the Infrastructure Sustainability Council of Australia (ISCA) – formerly known as the AGIC – assesses projects and stakeholder practices along the entire supply chain across 15 categories of sustainability. Scores are calculated and provide a rank to establish best practices. MRWA follow sustainability guidelines provided by these rankings to establish non-price criteria that are heavily weighted for sustainability innovation <www.isca.org.au/is/about-is/is-rating-tool>.

Integration of non-price binary mechanisms is also facilitated by a collaborative project delivery model, Early Contractor Involvement (ECI). ECI is predicated upon co-operation and trust, since the understanding that the practical knowledge of experienced contractors can be of benefit to designers of roads at an early stage. For example, their input allows the client to address changes in approvals and land purchase that would otherwise become lengthy, complicated or unachievable in a later construction phase (Cocks et al., 2011; Song et al., 2009). MRWA is a leader in the application of ECI for major roadworks. The common type of ECI delivery strategy consists of two phases. The first phase involves collaborative procurement through targeted input from the client and greater contractor influence on project direction: sharing the financial risk during the first stage. The second stage can be carried out through more traditional models (D&C or CO) with less risk of variations to the project.

A MRWA example of a successful ECI delivery strategy is the Great Northern Highway Kimberley project (2007-2009). This $116m project was based on a two phase delivery model; ECI plus D&C. Re-defining road alignments based on constructability knowledge of the contractor was the outcome of the first stage of ECI. Project levels of GHGE were reduced because of the road re-alignment. This collaborative project delivery solved a major problem because contractor knowledge concerning requirements for the specific terrain was not in the knowledge domain of their project partners, MRWA (Cocks et al., 2011). The ECI delivery model provided a collaborative relationship based on trust and co-operation (Davis, 2007) as an example of greening procurement objectives. Both public and private partners achieve a binary benefit by meeting their social and economic objectives of GHGE reduction.

5. Conclusion

In a country such as Australia that has specified affirmative action to mitigate the negative effects of climate change, government procurement can be used as an implementation devise. This paper has provided some evidence that collaborative procurement models that include contractor involvement at an earlier stage in major road construction can be linked to GHGE reduction. Three models were considered: AC, PPP and ECI. Each collaborative procurement model provides effective business relationships founded upon group decision-making to facilitate learning and innovation. Co-operation in this way allows for trust and risk sharing as opposed to adversarial relationships, which also provides the flexibility necessary to solve sustainability problems.

The age-old question of whether or not construction industry practices can be changed provided the impetus for this study. The NSW RMS, VicRoads and MRWA examples illustrate industry change. The major factor was project delivery based on collaborative procurement models resulting in reduced greenhouse gas emissions (GHGE) supporting non-price sustainability outcomes to become embedded into industry practice. These three road authorities were also change leaders in the development and implementation of sustainability rating tools and guidelines for Australian infrastructure projects.

The study also explored and identified incentive/reward mechanisms as a binary unit that can be built into the green procurement process. The findings of this study suggest that collaborative procurement is the most obvious framework to facilitate non-price binary mechanisms. Collaborative procurement models enable market-based solutions for both clients and contractors to achieve their social and economic objectives of GHGE reduction. This dual benefit also means that the road authorities are likely to comply with State GHGE targets for 2020 by greening their procurement models. through co-operative project delivery processes that support.

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The Viability of BIM for UK Contractors

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Abstract

The UK Government Construction Strategy set out BIM level 2 as a minimum requirement for all government construction projects by 2016. According to Cabinet Office report, value gained and efficiency in public sector projects needed to be improved significantly. Therefore, this paper examines the potential benefits of BIM implementation for UK contractors and consulting organisations. Twelve significant benefits were investigated and ranked such as project coalition co-ordination; and clash detection particularly during the design stage. This study struggled to provide tangible evidence for cost savings through the use of BIM, but almost all participant contractors and consultants have a strong assumption that BIM does generate cost savings. The study also showed that the benefit, which BIM could bring to the commission/handover stage and facility management, has not yet materialised according to UK contractors' standpoint. This research emphasises the significance of the social/cultural factors rather than the less influential technical issues for BIM implementation. In contradiction to some literature, most organisations argued that no 'legal and contractual issues' have arisen with the use of level 2 BIM. However, it is unanimously agreed that level 3 BIM will give rise to many legal and contractual issues that will then need to be addressed. Most of the organisations involved in this study are already utilising BIM at level 2. However, it is revealed that there is a need for increased awareness down the construction supply chain and other relevant stakeholders. There is also a need for greater efforts and willingness to embrace process change and other consequences for introducing BIM within construction projects.

Keywords: BIM implementation, UK construction strategy, contractors and consultants

1. Introduction

In May 2011 the UK Government's Chief Construction Advisor proposed that all Government construction projects must use BIM (Smith, 2012). In turn, the Government issued the UK Construction Strategy report which stated it will require a "*fully collaborated Level 2 BIM as a minimum for construction projects by 2016*". The report specified that the key instigator was the fact that the value gained and efficiency in public sector construction projects needed to improve significantly (UK Cabinet Office, 2011).

The USA National Institute of Building Sciences (NIBS) (2008) defined BIM as "improved planning, design, construction, operation and maintenance process using information model of a facility throughout its lifecycle". The development and implementation of BIM is a gradual process as demonstrated in Figure (1) which reflects four levels of BIM related applications (Bew 2012). Construction projects' stakeholders will reach different BIM maturity levels at varying points in time. Though most of these organisations have achieved BIM Level 1, it is clear that there is an incentive now to push for higher levels to secure public projects. However, what needed to be addressed are the implications and challenges facing these organisations during this period of change.

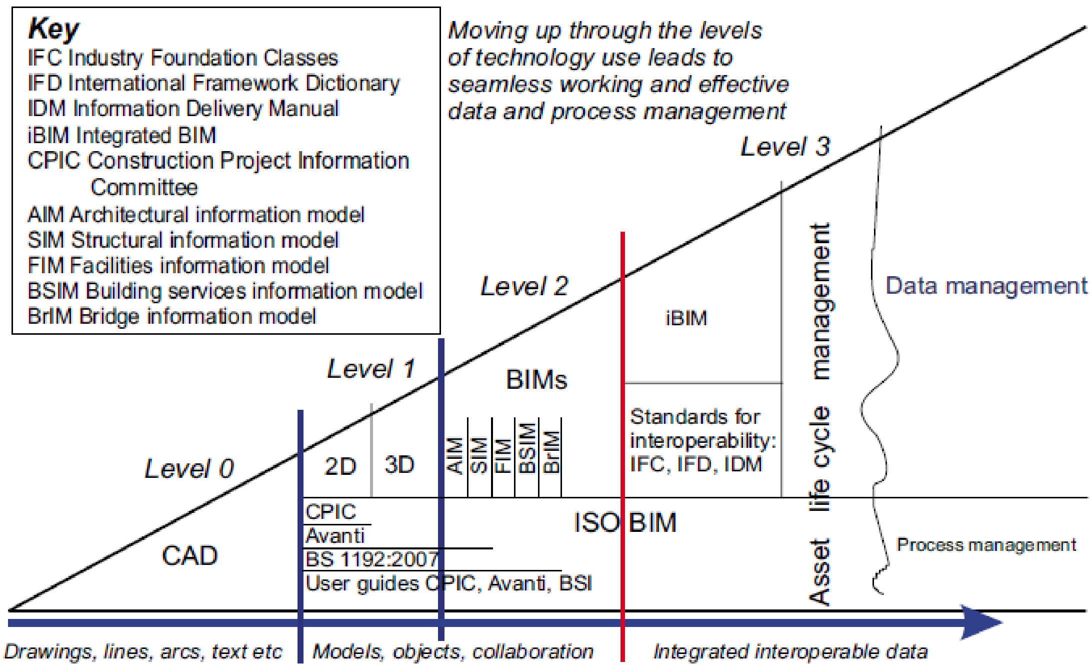

Figure (1): BIM Maturity Levels (Source: Bew, 2012)

2. Potential Benefits of BIM

It has been assumed that BIM may be able to realise some of the visions of both Latham and Egan reports published in 1994 and 1998 respectively, both emphasising the efficiencies that can be achieved with integration and collaboration for the fragmented construction industry (Light, 2011). According to the National Building Specification (NBS) annual survey of 2012, more than 80% of respondents were in consensus that BIM improves coordination (Hurst, 2012). Arguably, one of the considerably noteworthy benefits of BIM is its collaborative nature which allows for a better coordination of works.

Clash detection is one of the most common benefits of BIM. For instance, Figure (2) demonstrates different aspects of BIM utilisation in Iceland and Scandinavia, and it is clear that 'clash detection' is the most popular use for BIM in Scandinavia (Jensen and Johannesson, 2013)

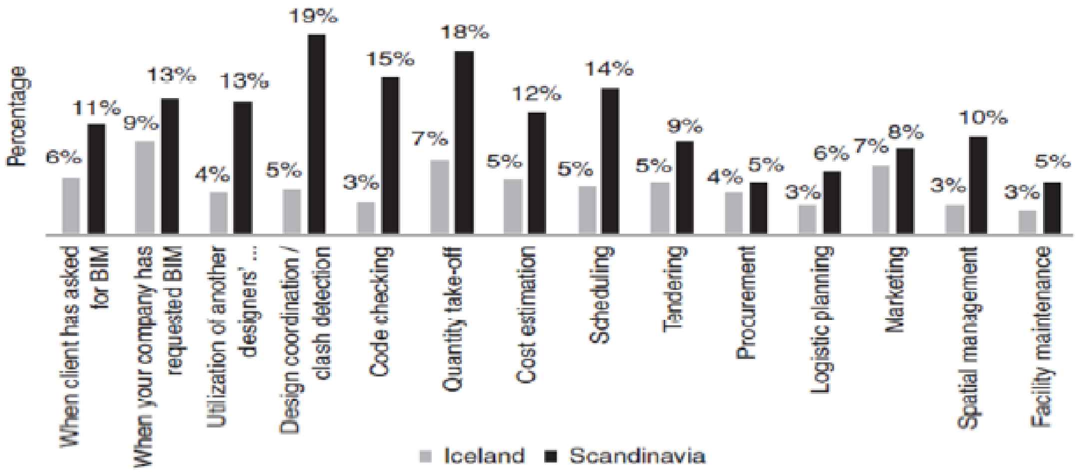

Figure (2): Utilisation of BIM for Different Activities (Source: Jensen and Johannesson, 2013)

From a health and safety perspective, contractors can visualise the construction site to identify and anticipate potential health and safety hazards of site activities which also improves the drafting of method statements and risk assessments for the construction stage of the project (Kucharek, 2012). Lane (2011) identified that some UK main contractors use BIM for assessing site logistics, visualising projects during inductions and for determining delivery points on site, leading to efficient processes to be achieved such as just-in-time delivery schedules.

BIM can also be used for early cost estimation and take-off concurrently as the initial design and detailed design are developed (Eastman et al., 2011). This effectively means, BIM can be used to make more informed and accurate decisions for investment appraisal, value engineering and total required budget.

Eastman, et al. (2011) claims that because of high level of coordination of cross disciplinary parties during the early phase of the project, the exact details of the construction elements are finalised within this early design stage. Therefore, that allows for an increased use of off-site prefabricated construction elements. Breen (2012) supports this view and suggests even more complex off-site fabricated units can be ordered since the information needed for their order is available in the early stages of the project. Moreover, with the use of the 3D BIM model, the project team are able to 'see' how the building is assembled together, allowing any contractor ordering prefabricated units to be sure that they will fit into the building (Lane, 2011).

A study by Breen (2012) shows that BIM has transformed the construction processes for a major UK contractor in terms of 'design for manufacture and assembly' methods. That contracting organisation have steered towards 70% off-site manufacturing of building elements, which has reduced their on-site workforce by 60% and the construction programme by 30%. In addition, when off-site manufacturing is used, the level of construction waste is greatly reduced which in turn means more cost saving for the construction project (Eastman et al., 2011).

However, pre-fabrication is not always the ideal solution. This is because if a pre-ordered construction element with a set lead time (for manufacture and delivery) is subject to design changes, this will be a problematic situation and may cause costly delays, acting as a detriment to the project rather than benefit (Eastman et al., 2011).

According to the UK BIM Industry Working Group (2011), BIM is a vital ingredient to improve performance trends and productivity of the construction industry. For instance, the National Building Specification Report (NBS, 2013) highlights that at least 64% of respondents of the survey agreed that BIM improved productivity.

Figure (3) extracted from the BIM Working Party Strategy Paper summarises the key benefits of BIM against the RIBA plan of work stages (Bew, 2012).

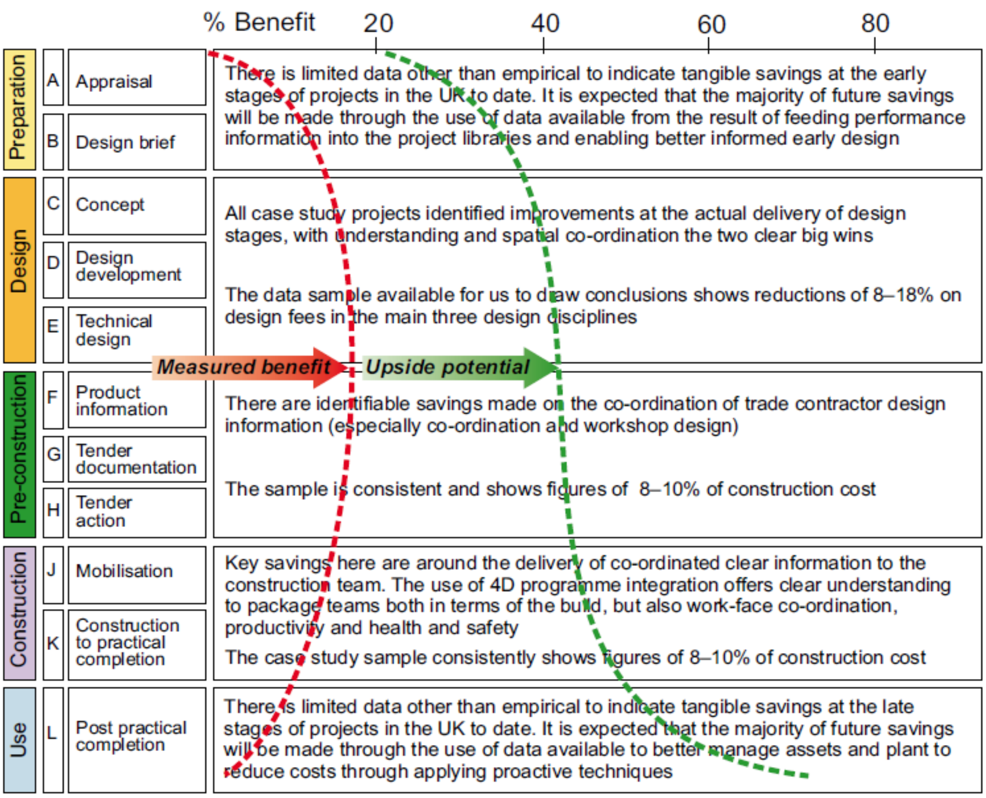

Figure (3): Matching BIM Benefits with RIBA Project Phases (Source: Bew, 2012)

3. Potential Challenges facing BIM

Evidence from the National Building Survey (2012) has indicated that there is a lack of understanding in relation to BIM and its true definition and meaning. Whereby, 80% of those questioned agreed that the industry 'was not yet clear on what BIM is' (Hurst, 2012). According to the RICS members' survey by BCIS (2011), 95% believed that the reason for the lack of BIM adoption was due to insufficient training and education (Pittard, 2011).

The perception of BIM being merely a software, off-the-shelf, product cannot be further from the truth argues Pittard (2011). The Technical Director for a leading UK consultancy organisation regards cultural change within the construction industry as one of the most important aspects to consider when implementing BIM (Lane, 2011).

Two-thirds of those who participated in the National Building Specification BIM Survey (2012) indicated that BIM is very expensive to implement within the organisation (Hurst, 2012). Although there are costs associated with the adoption of BIM, one must not underestimate the cost savings and efficiencies that BIM can yield as discussed in section 2 previously.

The procurement method is pivotal to how effective BIM is implemented in a project. The construction procurement that facilitate early collaborative involvement of all key stakeholders in the design stage are ideal to maximise the effective use of BIM (Eastman et al., 2011). Integrated project delivery systems are seen to manifest BIM attributes while the traditional method of procurement has been found to potentially impede the effective implementation of BIM due to the lack of early involvement (Eastman et al., 2011)

BIM has stirred some controversy within legal circles for issues such as intellectual property rights and legal liabilities (if there is no suitable framework in place to regulate the process. Since the nature of the BIM entails contributions from various participants, there arises a liability risk of infringing third party intellectual property rights (Udom, n.d.)

The 'trailing edge' of the industry, namely some small-scale suppliers and subcontractors, are the parties that need help and clear targets for handling the effects of BIM. Therefore, 'small, but important steps' should be taken by clients and/or main contractors to effectively communicate with SMEs the technological, legal and cultural changes that will arise from the BIM process (CIOB, 2011).

4.Analysis and Discussion

This study conducted eight interviews including five main contractors and three UK based consultants. Through these interviews the paper examined the potential benefits of BIM implementation for UK contractors and consulting organisations. Twelve significant benefits were investigated and ranked (Table 1). The following subsections investigate and discuss the six top ranked benefits according to UK experts' views.

Table (1): Ranking of Potential Benefits of BIM

	No benefit Score = 0	Little benefit Score = 1	High benefit Score = 2	Very high benefit Score = 3	Don't know Score = 0		
Potential benefit of BIM	**Frequency of Potential Benefit**					**Total Rating Level**	**Ranking**
Coordination	0	0	0	8	0	24	**1**
Clash detection	0	0	0	8	0	24	**1**
Understanding	0	0	3	5	0	21	**2**
Collaboration	0	0	3	5	0	21	**2**
Planning	0	0	4	4	0	20	**3**
Risk reduction	0	0	4	4	0	20	**3**
Productivity	0	0	5	3	0	19	**4**
Take-offs & estimation	0	0	6	2	0	18	**5**
Cost savings	0	0	3	4	1	18	**5**
Off-site manufacturing	0	1	5	2	0	17	**6**
Sustainability	0	0	7	1	0	17	**6**
Handover	0	2	4	2	0	16	**7**

4.1 Construction Planning

All eight interviewees agreed that BIM will contribute 'high' or 'very high' benefits for project planning. The responses highlighted that BIM can improve planning by the ability to model the logistic operations and rehearsing different scheduling scenarios before commencing work on-site.

This is due to the fact that a 4D BIM model can; not only be linked with the construction programme, meaning a contractor can actually observe the effects of different methodologies and sequences in 'real-time' on the programme; but also objects/components of the building can be linked to respective tasks and resources required. Hence, one can visualise the site's development and can therefore plan the deployment of resources more effectively. However, this depends on what stage a contractor is appointed onto a project because if the contractor is not involved in the early stages of the project, these benefits will not be realised.

These opinions are in consensus with the claims made by Breen (2012) which stated that contractors could simulate different construction sequences in order to select the optimal project scheduling.

4.2 Collaboration

The interviewees agreed that BIM facilitates 'high' to 'very high' collaboration between the different stakeholders. This resulted in better multidisciplinary solutions being generated that accounted for the interfaces between building elements. Some organisations experienced the use of BIM in team meetings which enhanced the collaborative nature of these meetings. For instance, there is an increased level of understanding when parties are inter-communicating since they are exposed to the same information i.e. one shared model, meaning that there is less room for misunderstanding and the use of outdated data and information.

However, it was highlighted that there is still room for increased collaboration, especially at level 3 BIM. Moreover, some respondents revealed that some parties have resisted full collaboration because of legal concerns.

These results are in consensus with the explanation of Sacks, et al (2010) that the collaborative nature of BIM leads to coordinated design; as well as the claim made by Maturana (n.d.) that BIM can be used in team meetings and subcontractor coordination meetings.

4.3 Understanding

BIM contributes to an improved understanding in different aspects for construction projects as indicated by the interviewees who rated that as 'high' to 'very high' benefits. This is mainly through the 3D BIM model which provides a comprehensive appreciation of the intended outcomes for even those who lacked a technical background from the stakeholders. This also helps in eliminating the barrier to positive and valuable contributions. Better understanding potentially results in a fit for purpose project or building that better meets the needs and requirements of stakeholders.

The interviewees indicated that the traditional 2D modelling, in contrast to BIM, hinders vital input and involvement from clients, end-users and other non-professional stakeholders because of the difficulties and struggles they face to comprehend 2D drawings.

This reinforces the claim made by Breen (2012) which stated that better understanding is achieved through BIM 3D model, ultimately leading to more informed evaluations, comments and decision making by a range of stakeholders.

4.4 Clash Detection

The study demonstrated that all experts, who were interviewed, rated the level of benefit of coordination from the use of BIM to be 'very high benefit' .It was revealed that many of the clashes detected with BIM are always overlooked with traditional design methods. Many organisations have not carried out empirical studies to be able to associate the number of clashes detected by BIM and the corresponding cost savings for construction projects.

However, one of the organisations involved in this interview survey indicated that for one project through the use of BIM they managed to detected about 100 clashes which saved them around £350,000, meaning each clash saved an average of £3,500. This average saving is in contrast to the one stated by the BIM Journal study (2012) which is around £10,500. Nevertheless, this figure depends on a considerable range of factors such as type and size of clashes and building components, complexity of design, … etc.

4.5 Coordination

The study showed that 100% of the interviewees rated the level of benefit of coordination from the use of BIM with the highest rate, 'very high benefit'. It is argued that one of the most valuable coordination benefit derived from BIM is design coordination. Design changes with BIM become more efficient and smoother process because different components are linked together and are updated accordingly. For instance, BIM enables minute design details such as connection details to be coordinated effectively.

These results are in line with other literature and research such as Pittard (2011) who argued that traditional methods made the task of coordination a less easy task and can be time-consuming. These interview responses are also in consensus with the claims made by Sebastian (2011) and Eastman (2011) which state that BIM can aid the coordination of the design process between different project stakeholders.

4.6 Risk reduction

The interviewees believed that BIM had a positive impacted on reducing risk, rating it as either 'very high benefit' (50% of them) or 'high benefit' (the other 50%). Their opinions could summarised as follows: (a) because BIM produces a more coordinated work flow and environment, this reduces the risks of design and construction stage; (b) because BIM enables better modelling of the life-cycle of the building, safety measures are better planned for, which reduces H&S risks; and (c) although there arises some legal and contractual risks with BIM, others argued that because BIM increases the level of communication and understanding between parties, these risks as well as risks of misunderstandings would be reduced.

The responses from the interviewees regarding health and safety are echoed by Lane (2011), who stated that BIM allows contractors to visualise the site to identify and anticipate potential H&S hazards of site activities, which also improves the drafting of method statements and risk assessments.

5. Conclusions

This research demonstrated that all those organisations participated in the survey were on Level 2 BIM as well as being on track for UK BIM requirements by 2016. In this study it was evident that most BIM benefits addressed in the literature were endorsed by the interviewees such as clash detection, coordination which were ranked the highest benefits of BIM as presented in Table (1). While other possible benefits were challenged such as the benefits to the handover stage of the project, which was ranked the least BIM benefit; followed by sustainability and off-site manufacturing benefits.

The study found that BIM enabled construction contractors to use the virtual environment to model site logistics which reduces health and safety risks. In addition, BIM was used to 'rehearse' different sequences and methodologies beforehand, in the virtual environment, to execute the optimum methodology at construction stage.

On the other hand, productivity with BIM was supposed to be reduced at the initial stage of a project. However, productivity gains were made through increasing the use of off-site manufacturing and reducing the time for design development (since different design documents can be generated from BIM 3D models).

Quantity take-offs and cost estimation through BIM was found to be an area that is not fully implemented in the industry. Nevertheless, its potential of time savings and accuracy of output was recognised.

In terms of cost savings, all participating organisations except one struggled to provide tangible evidence for cost savings, which is the reason why this factor did not achieve a high score as one of BIM benefits. Nevertheless, all interviewees had a strong assumption that BIM does generate cost savings.

With regard to off-site manufacturing, it was a disputed area; some argued it is 3D modelling, which was in existence before BIM, that enabled the increase in its use; while others asserted that early availability of detailed and accurate information through BIM was the determining factor.

In terms of the benefit to the handover stage, it was demonstrated that BIM is not fully implemented in the industry at the facilities management and operational stage. Hence why documents such as O&M manuals merely have a 'potential' to be incorporated in BIM at this stage. This is mainly the reason why the benefit BIM brings to the handover stage achieved the lowest score.

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The Challenges of Accommodating New Technology in Construction

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Abstract

The construction sector has a major role to play in delivering innovations to achieve UK low carbon energy targets and this research will contribute to understanding challenges that arise on building projects when new technology is included in the design. Innovative, sustainable technologies are already available for use in the construction of buildings, but their integration within construction projects is patchy. One of the factors potentially holding back this integration is the complicated collaboration and adjustments required between the many actors working on a single project. This research seeks to explore the accommodations made by a network of project actors when interacting with a new technology.

The research presented is part of a larger project which uses a Social Construction of Technology approach (SCOT) to understand the challenges of incorporating new technology into buildings. Drawing on case studies, the research explores the different accommodations made to both building design and project practices by multi-firm actors as an innovative technology is included within a building project. The case studies follow Building Integrated PhotoVoltaic (BIPV) technology as it is incorporated within building projects. The research focuses upon the dynamic interactions between actors, innovation and the building as a whole.

Empirical data is gathered at key project stagesfrom actors who are either directly involved with or affected by the introduction of the BIPV into the project. The paper situates the problematic in the literature of innovation diffusion and sets out the research objectives, theoretical lens and research design which inform this research. Although the research is on-going, initial emerging themes of the research are highlighted illustrating the complexity of the process. It is anticipated that the key findings of the research will illuminate how actors negotiate the challenges of adopting the new BIPV into the building project and what effects these have both on the final building and on the project actors working practices.

Keywords: accommodations, innovation-diffusion, projects, Social Construction of Technology, sustainable technology

1. Introduction

Often characterised as conservative, slow moving and resistant to change, the construction sector has been shown to be highly specialised, complex and full of innovative practice (Larsen, 2011). A key challenge for the sector is to improve innovation diffusion[1] thereby meeting the challenges of both construction sector reform (Egan, 1998; Wolstenholme, 2009) and carbon reduction targets (Dept for Communities and Local Government, 2013). There are many organisational and technical factors which influence innovation diffusion such as; policies, organisational structures and operationalization of technology, but this research focuses specifically on project level accommodations made as new technology is integrated within a building project.

When a new technology is specified on a building project, it potentially impacts both the way that the part of the building incorporating the new technology (the technical assemblage) develops and the standard ways of working (practices). Although a building changes throughout design, construction, commissioning and use, the inclusion of a new technology within a build potentially introduces new challenges for the project teams. This research explores the process of accommodation within a construction project and will ultimately contribute to current understandings of product diffusion and uptake of sustainable technologies.

Using Social Construction of Technology (SCOT), this research will follow a low carbon technology – Building Integrated PhotoVoltaic (BIPV) panels, through several new build, commercial construction projects. This approach will be used to identify the actors involved in accommodating a new technology, the meaning they give to that technology and the adjustments they make both to the design and to practices.

This research will build on suggestions that the specificity of the construction sector, the context within which decisions are taken and the relationship between groups of actors involved will affect how different firms accommodate new technology.

2. Sustainable technology and innovation diffusion

Sustainable technology lies at the heart of the sustainability agenda both in terms of the infrastructure it delivers and the legacy of the built environment it leaves. For the UK to make the transition to a low carbon economy, innovative low carbon technologies will need to be installed in new buildings. Innovative, sustainable technologies are already available for use, but anecdotal evidence suggests that their inclusion in buildings is patchy. This research aims to

[1] Although the terms innovation, diffusion and uptake have separate literatures, this research considers the process of incorporation of an innovative technology on projects and the implications of this. The term innovation diffusion is used to describe that process.

make a contribution towards understanding innovation diffusion of sustainable technology in the construction sector.

The inclusion of Building Integrated PhotoVoltaic (BIPV) within non-residential new building projects is the focus of this research. BIPV is a low carbon technology which is integrated into the façade or roof of the building and as such can be considered as part of an assemblage within the building. Its inclusion within the design has implications for different groups of project actors – for example: client, facade engineers, HVAC engineers, electrical designers, and installation contractors. The technology is sufficiently developed to allow its inclusion in flagship building projects, but is not sufficiently widely used to be considered as a standard building component.

3. Literature Review

The literatures on innovation and diffusion are inter-connected and entwined and rather than dealing with them separately, this review looks at these combined literatures and identifies themes around the uptake and diffusion of new technology and the development of standard practices. The innovation diffusion literature spans different objects and levels of analysis; this section provides a brief indication of this range and then focuses on the project level.

The review draws attention to particular issues of innovation diffusion within the construction industry and outlines how this research will address them.

3.1 Generic models versus empirical research:

Generic models have been developed to predict or improve innovation diffusion but have often failed to take into account what happens with respect to complex inter-relationships and dependencies. Much of this literature focusses on identifying universal models and seeks to identify best practice (Tidd, 2001). In the case of BIPV, models would predict the development of the BIPV market and manufacturing output, rather than the effect of the technology on the project actors.

Models have been refined and amended, from linear models which tend to address simple product innovations (Ryan & Gross, 1943; Rogers, 1976) to more sophisticated models which incorporate market effects of push and pull and supply chain integration (Graves, 1987; Rothwell, 1994). Despite this increasing sophistication, the call for increasing integration of information and design, has drawn attention to the importance of networks, the effects of social interactions and how integration affects working practices (Rogers, 2004; Freeman, 1996; Fleck 1988). The use of theoretical models within the Construction sector raises the question of how closer integration of systems and practices affects working practices within both intra and inter-firm project teams.

A response to these and similar observations concerning the iterative, processual and complex nature of innovation has been to explain and explore variations in innovation diffusion

(Tushman & Anderson, 1986;Abernathy & Clark, 1985) , whilst others draw attention to how different innovative technologies require different accommodations within firms (Henderson, Clark, 1990). These literatures leave unanswered the question of how innovation diffusion affects different project actors within a complex building project differently.

In summary, there is a disparity between development of generic models of innovation diffusion and what actually occurs during the process. Linear models of innovation diffusion fail to take into account the specificities of different sectors (particularly the multiple and complex relationships within the construction sector) and so the diffusion of BIPV within the construction industry cannot be understood simply by adopting these models.

3.2 The construction sector and inter-firm dependencies

The specific nature of innovation diffusion varies across individual sectors and firms. Different firms involved within a project may have different priorities and sensitivities (Pavitt, 1984; Malerba 2002). The construction sector involves temporary multi-disciplinary, multi-firm projects and this makes the study of innovation diffusion in the sector particularly challenging.

Characteristics of the construction sector (the involvement of many interrelated firms, project-led work, long lead times and changing client requirements) have been the subject of extensive innovation and diffusion research (Nam & Tatum, 1988; Winch, 2003). The relationships between project actors is a defining feature of the construction sector and needs exploration and understanding as to how this way of working impacts innovation diffusion (Gambatese & Hallowell, 2011; Isaksen & Tidd, 2006; Harkola & Greve, 1995). Characterisation of innovation tends to examine innovation within single firms. The uptake of innovations, and their effect on the firm have been described and explained (Henderson and Clark, 1990) and strategies, organisation and interventions which affect innovation diffusion have been defined. Although this draws attention to how these elements may play a role in supporting or hindering accommodations to design and practices, it does not explore variations in the impact of an innovative component on project actors across several firms.

A further characteristic of innovation diffusion in the construction sector is the tension between the perceived negative impact of innovation on the project (in terms of both efficiency and success) and the benefit of technological innovation on the building. This has been explored using the concept of tight and loose couplings (Dubois & Gadde, 2002), which explain the logic of operations within the construction sector and goes some way to understanding how the different groups involved with the specification of BIPV may view the technology and solve problems arising during its incorporation into the building design.

In summary, the construction of a building relies on interactions between many firms with complex relationships and dependencies. Authors recognise that innovation diffusion should be understood in relationship to these and that the inclusion of different innovative technologies will require different accommodations within firms. So to explore how project actors accommodate the inclusion of BIPV within a project, a clear understanding of their inter-relationships and interactions is necessary.

3.3 Impact on project level actors

Studies in innovation diffusion highlight the role of the individual within the firm and how ways of working within firms contribute towards innovation diffusion (Kissi *et al.,* 2012; Larsen, 2005; Valente & Davis, 1999), but do not address the impact of innovations on the individuals or their ways of working. When considering the incorporation of BIPV within a building, the actors affected may include manufacturers of panels, façade manufacturers and installers, mechanical and electrical engineers and commissioning teams. Each of these groups may be affected differently by the technology and may have different priorities in accommodating it.

Research on enhancing and modelling innovation in projects focusses on optimisation of practices within firm based project teams, rather than on understanding the dynamics between project actors (Gambatese & Hallowell, 2011). Similarly Dewulf and Bouwen (2012) explore how differences are narrowed between project actors through interaction strategies, whilst Soudain et al. (2009) explore accommodations made between project marketing and project management at the start of a project. These researchers limit their work to comparison of limited groups or discourse analysis at a particular point in a project rather than considering the project as a whole.

Little is known about how innovation diffusion affects different project actors within a complex building project differently. In order to understand better the effects of innovation diffusion in construction projects, this inter-dependence should be examined more closely and the accommodations project actors make in dealing with a new technology highlighted. In the case of incorporation of BIPV within a project, an exploration of the accommodations made by inter-dependent project actors over the course of the project is required – for example, the efficiency of BIPV will be affected by landscaping around the building and architects will have to adapt their ways of working to take this into account.

3.4 Design accommodations

The process of innovation diffusion in construction projects can be explored by understanding the way that the new element disrupts everyday ways of working and looking at resulting accommodations that are made by project actors. Variations in how technology is adopted and used by different organisations has been studied by Whyte (2003), who calls for further research into interactions between actors in the adoption of IT.

The introduction of a new technology into a build will have both intended and unintended consequences and this will affect innovation diffusion. Harty (2008) explores the relationship between inter-firm project teams and their interactions with the technologies. He distinguishes between those which can be contained within an implementer's control and those which overflow outside of it. This characterisation of innovation helps to identify the importance of understanding actor relationships with respect to the technological innovation and resulting accommodations.

In terms of BIPV, decisions made at the start of the project in terms of number and density of panels used will affect design of electrical ducting and siting of invertors, which will directly impact project costs. The way that these conflicts are resolved and how the design accommodates the requirements from different actors is key to understanding the process of innovation diffusion for this technology.

The discussion above highlights the need to understand the interplay between the project actors, the technology and the design of the part of the building which incorporates the technology and this will be addressed by this study.

3.5 Socio-technical relationships

The proposed research is concerned with actors, the way they interact with a new technology, how the new technology is shaped by these interactions and how that interaction impacts working practices. It is therefore appropriate to use an approach which includes in its analysis: the accommodations, the object and the actors. Socio-technical studies have highlighted the networks involved in the design and construction of complex buildings (Valente, 2012) and have been used to to understand the tension between innovation and project efficiency (Jacobsson & Linderoth, 2010). Schweber and Harty (2010) recommend the use of social-technical network analysis to explore the changing relationship and form of artefacts and practices. They suggest that Social Construction of Technology (SCOT) may be a useful approach in considering such issues.

The incorporation of BIPV within a building project invites research to understand the interactions between the development for the artefact (in this case the BIPV assemblage within the building) and groups of project actors and indicates the appropriateness of using SCOT as the theoretical lens for this research.

4. Research details

The proposed research is concerned with actors, the way they interact with a new technological assemblage and how that technological assemblage is shaped by these interactions. Firstly it addresses the question of what impact the new technology has on the building design: in terms of how the technical assemblage (the technology and the part of the building which incorporates it) changes throughout the design and through to handover. Secondly it asks how project actors change their ways of working when a new technology is specified into a build.

In answering the first question the research will investigate; how the building design related to the new technology changes over time, how and why design changes are negotiated and the types of design changes that occur. In answering the second question the research will investigate; how the project actors change over time, how they negotiate the way of working and how they understand the technology and if that understanding changes across the project.

5. Theoretical lens

The approach of the Social Construction of Technology (SCOT) focuses on 'relevant' social groups (a group of individuals who share the same set of meanings attached to the artefact), how they frame a technology (what elements do the social group have in common forms a technological frame) and how they interpret it. In early studies the approach has been used to understand the development of Bakelite, light bulbs, bicycles and refrigerators (Bijker, 1999; Pinch & Bijker, 2012) and latterly has been extended to study assemblages of technology, rather than just a single object (Bijker, 2009). More recently it has been used to understand the tension between innovation and project efficiency (Jacobsson & Linderoth, 2010) where the use of technological frames assisted the analysis of barriers to innovation diffusion.

As an approach SCOT calls for an exploration of the complicated relationships between objects and actors and considers that technology is constructed through its social context. Thus SCOT puts the technology at centre of the analysis, identifies groups of relevant actors involved in its development and explores how each group frames the technology, their actions and reactions to conflicting requirements and how these shape the technology and society (Bijker, 2009). The process of design and construction is examined in terms of how different sets of project actors/stakeholders define the problems of the new technology and propose different solutions (**Error! Reference source not found.**)

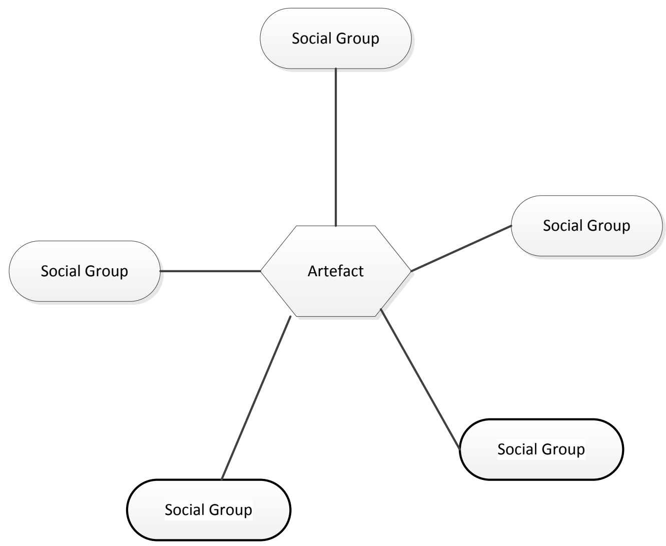

Figure 1: The relationship between an artefact and the relevant social group (Bijker et al, 2012; p.29)

As with the development of more simple artefacts like the bicycle, construction involves the successive fixing of different aspects of the design (from procurement to construction and commission) see **Error! Reference source not found.**. This complex process will not be the result of total consensus about every detail and many of the decisions taken will impact the development of the building design. This process of problem definition and solution are repeated through the project until closure occurs. The use of SCOT focuses attention on these negotiations; it also accommodates constraints such as power balance and common interests through the use of technological frames.

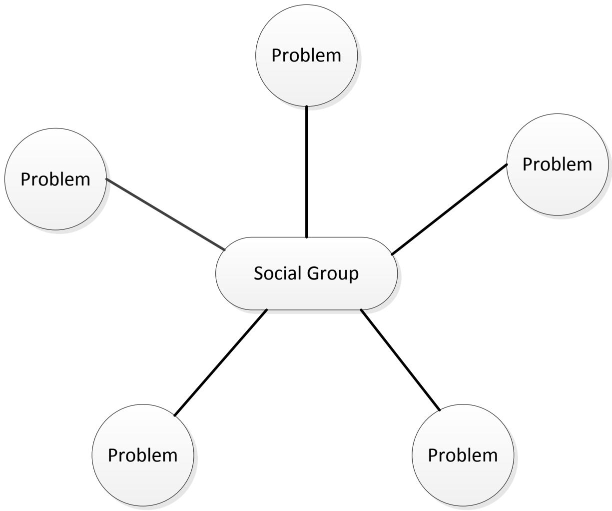

Figure 2:The relationship between one social group and the perceived problem (Bijker et al., 2012; p.29)

6. Research design

The use of SCOT calls on the researcher to identify the relevant social group associated with the technology and explore their relationship with the new technology. Drawing on case studies, this research explores the different accommodations made to both building design and project practices by project actors as BIPV and explores how this is enacted in practice.

6.1 Sampling

The exploration follows the technology into several BIPV projects with the aim of identifying the network of actors and artefacts involved. Empirical data will be collected in two forms: semi structured interviews and documents. Semi-structured interviews will use SCOT to explore how the technology is incorporated into the constructed building and this will draw attention both to the impact of the new technology on the ways of working and to variations in those accommodations made by different actors within the same project.

Project documents and in particular drawings will be used to identify design/practice changes which inform the interview process. For example; changes to drawings which involve the fixing of BIPV cells will highlight possible points of discussions between designers and these invite discussion of any resulting accommodations.

6.2 Data Analysis

Coding of data will establish relevant social groups, their technological frames, identification of problems and conflicts and accommodations to practices and design. Documents will be used to explore the evolving design and their evolution will be used to identify the changes made to the design and meeting notes are used to understand the background of these changes.

As an illustrative example of the application of SCOT to BIPV in terms of the relationship between the façade and the relevant social groups see **Error! Reference source not found.** below:

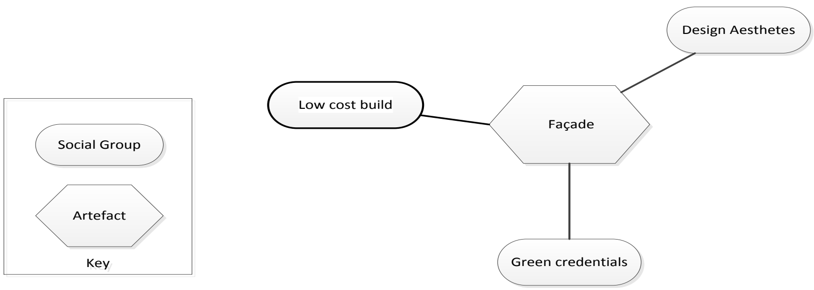

Figure 3: Substantive model for BIPV relationship between façade and relevant social group

The different actors or social groups will have different problems associated with the design and different commitments for choosing the solution. As an illustration of those concerned with developing an aesthetically pleasing design are shown in **Error! Reference source not found.** below.

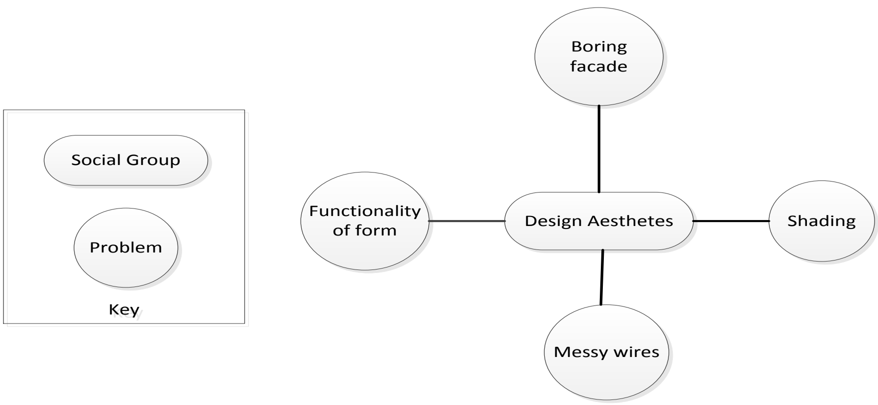

Figure 4: Substantive model for BIPV showing the relationship between Aesthetic designers and the perceived problems

The types of accommodations made on each project will be identified and an exploration made of whether any comparisons can be drawn out from the data. These may be in terms of the types of accommodations made, but details will emerge as the research progresses. This is a departure from previous work, which uses SCOT to demonstrate interpretive flexibility by highlighting differences between case studies

7. Concluding comments

The use of SCOT as a method highlights four aspects of the incorporation of a new technology into a project which are often overlooked. First, it provides for a systematic analysis of the different understandings and expectations associated with the new technology and the groups who hold them. Secondly, it explores the problems associated with introducing the technology and the way in which those expectations inform different team members' engagement with the technology. Thirdly, it identifies continuing cycles of problem definition and solution – which is appropriate to the process of design and build. Finally provides the basis for a systematic comparison across projects using the same technology and to look at similarities and differences with solutions and ways of working.

Although the research is on-going, initial findings identify at least four groups with distinct expectations and understandings of BIPV cells. These include Low Cost Build, Design Aesthetes, Green Build Credential Seekers and Low Energy Use groups. Relevant Social Groups (RSGs) are complex and are not purely defined by the actors' role. Actors may be members of more than one group: in this example, the "Low Cost Build" RSG includes client and main contractor, whilst the "Design Aesthete" RSG includes the client, architect and planners).

Problems presented to the RSG by the inclusion of the technology shape the design in unexpected ways which have implications for other RSGs. For example, wiring requirements impact both the Design Aesthetes RSG (how to conceal cables and where to site invertors) and "Low Cost Build" RSG (additional plant rooms and cabling costs), whilst satisfying the "Green Credentials" RSG.

Early substantive models around the development of solutions around the façade show how continuing cycles of problem definition and solution come together and how the assemblage of the panel within the façade develops - for example how panel connection, invertor location and and wiring routing impact on space allocation and generation efficiency.

In time, it this research will provide a systematic comparison across projects and will show similarities and differeces of how actors negotiate the challenges of adopting the new BIPV into the building project and what effects these have both on the final building and on the project actors working practices.

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Understanding industrial practices of construction project data management

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Abstract

The construction project management is heavily built around document control and relating events such as change orders, submittals, transmittals and requests for information (RFIs). These functionalities are usually forming the core of electronic data/document management systems (EDMS) that are widely used by contractors and construction management consultants. The content of EDMS, i.e. documents in the form of individual files and their details can have contractual role and implications.

Building information modelling (BIM) is gradually having its impact widely over construction practices and processes. Basically this means that a growing share of buildings construction projects are designed and documented by using BIM applications. BIM applications can form spatially organised access to project data and documents which, if widely applied, can change the world of EDMS solutions. However, still at present the well-established EDMS solutions and relating practices are a rather separated infrastructure from the world of building information modelling. it is worth noticing that a part of practical BIM interoperability is still file based. This means that digital building models are shared and accessed using files, and, in many cases it is EDMS solutions that are used for this purpose.

This paper shall present results of a research effort where the use of EDMS was studied in 20 building construction case projects. The gained results explain content and characteristics of current practice. It is considered that useful knowledge can be learned from the present used of EDMS in building construction projects. This understanding can help us to move towards more advanced solutions.

Keywords: construction project, project management, document management system, BIM

1. Introduction

New digital infrastructure around us is in many ways affecting all businesses including real estate and construction sector. Various applications of Information and Communication Technologies (ICT) have already in a stunning manner and pace taken over mechanical business and public service data operations, provided extensive networking capabilities and now are developing to capture softer side of life such as social perceptions (Bughin et al, 2013; Schmidt & Cohen, 2013). Real estate and construction sector is not isolated from this general development trend, rather the progressive companies seem to be the ones that are showing the way ahead. Underwood and Khosrowshahi (2012) have identified how the investments have grown on long run amongst top contractors although recent economic crisis have had its effect in this development. This is indicating that companies are considering their ICT infrastructure as a valuable asset that requires continuous investments and development rather than being an object for discrete improvement efforts.

The extensive ICT infrastructure and its access are also effecting operations of construction projects in a profound manner. BIM technologies and their applications are providing completely new kind of cooperative environment for construction project planning and execution. It has been shown that effective and open communication between stakeholders is essential for successful project outcome (Yu et al., 2006). Basically, this starts with data exchange which plays a great part of communication in an AEC industry. Furthermore several studies underline the importance of good documentation and information management in managing project and its tasks (Al Qady and Kandil, 2013; Egan, 1998). Data exchange, documentation and information management can been seen as examples of *project communication ingredients* that are serving processes such as building engineering, project planning and control, decision making, and, institutional learning.

The objective of the research behind this paper was to achieve better understanding over some important ingredients behind the present construction project communication practices. In this research, the use of an electronic data management system (EDMS) in various building development projects was studied. The research effort was targeting better understanding of present practices and their characteristic. It is considered that such knowledge can be useful in developing and implementing more sophisticated systems.

2. Digital technologies in the field of building construction project data

Widely approved standardized models and relating applications for managing construction projects and project information are lacking in the construction industry (Arnold and Javernick-Will, 2013; Shen et al., 2010). For this reason, a large variety of different electronic data management systems (EDMS) exists and is being used by construction industry professionals. Many of them are company specific solutions reflecting that kind of institutional culture.

Increasingly, these solutions are integrated with the surrounding ICT systems and tools. Examples of those are cost estimation packages, scheduling tool, applications of BIM technologies and ERP systems.

Benefits of using EDMSs in managing building construction related data are pretty well known. The improved quality of documentation, simpler and faster data access, productivity of information related tasks and less documentation errors are examples of obvious benefit to be gained (Hjelt and Björk, 2007; Nitithamyong and Skibniewski, 2006). Sulankivi (2004) states that monetary benefits are not always easy to prove but qualitative benefits are clearer. The transition towards wider use of digital technologies has been considered as a basis for improved project communication (Abudayyeh and Rasdof, 1991).

The discussed benefits look lucrative and one might expect to see fully implemented solutions in place, but data exchange is still considered as inefficient (Arnold and Javernick-Will, 2013). There are remaining technological, logical and cultural shortcomings that all require special attention for realizing benefits in full scale. More specially, examples of such shortcoming are usability and complex folder structure, time consuming nature of the system use, mixed use of paper documents versus digital data and different end user needs (Björk, 2006).

The commercial EDMS solutions have been develop to meet needs and expectations of different companies and their end users. This has resulted in wide spectrum of functionalities because of which the final EDMS solution can be a rather complex one. It is obvious that the more features an EDMS contains the more complicated it becomes. Level of challenge to learn and use any EDMS solution corresponds with the number or features and functions of the system (Bäckblom et al., 2003). Furthermore, double storing in separate locations has turned out to be a practical problem. A project wide EDMS solution is not enough, another solution that is usually user specific one, is then in a redundant manner used for data storing. The use of various and overlapped systems causes unnecessary data re-entry and interoperability problems (Arnold and Javernick-Will, 2013).

The electronic data management systems are still made for file based information exchange. Files are kept in folders and are managed through a web browser interface. Files are located in the service provider's server. All the project information is stored in files. Revisions are normally controlled by the users. The latest revision gets the latest date and an old revision is deleted or moved to another location. In Finland, EDMSs like this are often created by printing service companies. Therefore, ordering prints is made easy and even encouraged.

More sophisticated systems support collaborative working with models. These systems supporting data extracting and its reuse directly from the models are called model collaboration systems or model servers (or BIM servers) (Shafiq et al., 2013). A model server is a special database system that can host model based data and by which multiple users can share and manage their models and work collaboratively around them (Jørgensen et al., 2008). With these servers, models are possible to e.g. merge, view, comment and check for collisions. Also, revisions are possible to manage automatically so that users get information about the latest uploads and users are warned if they modify the model simultaneously. (Shafiq et al., 2013)

Transition towards full-scale adoption of BIM servers still has some technical and non-technical barriers. One of the reasons is said to be the insufficient understanding. Gu and London (2010) define that there is a need for guidance on how to start, what kind of tools are available and how to handle legal, procurement and cultural challenges. Shafiq et al. (2013) state that the implementation is yet limited because the technology is still developing, users are not aware of these systems and their benefits, and functionalities and performance have not evaluated on real construction projects. He claims that the technology for multi-model collaboration is available, but a comprehensive tailored solution for the purposes of the construction industry is still needed.

The discussion above enlightens aspects and developments regarding digital technologies for construction project data creation and management. The overall digital infrastructure is developing in full speed all the time and the younger generation of building construction professionals are well prepared to take advantage of that. EDMS solutions have been developed over several decades throughout the digital era and they have wide use in different lines of businesses. It seems, that in construction sector the EDMS solutions that can be classified as document management systems have become rather popular. This is now seen as an interesting research object that can explain characteristics of construction project data management. Such knowledge can be useful for the development of more sophisticated systems.

3. Research data about the use of EDMS in building development projects

Behind this paper is a case study with a sample of fifteen building development projects. The content and the usage of the EDMS were studied using quantitative research methods. This data was collected manually from the content of the EDMS covering e.g. its actual structure and number of files in different folders. Furthermore data access reports provided by the EDMS system were important data sources. Additionally, the researchers obtained qualitative success estimates of each studied project. These were prepared by professionals who had been involved in the projects in question. It was considered that these estimates would provide interesting reference points.

The studied case projects were mainly renovations or changes in existing university premises. The projects were located in six Finnish cities. The studied construction operations were directed to research laboratories, teaching classes, workspaces, hospital facilities and sports buildings. Only two of the projects can be classified as new building construction. These are small entrances which connect previously existing buildings together. Durations of the projects varied a lot where the shortest project time was 162 days and the longest one was 1031 days. In the terms of size and total cost the studied projects varied also a lot: 1) range of the size was between 7 and 11 024 gross square meter, 2) range of the costs was between 180 800 € and

13 899 000 €. The projects were started and completed within the period 2009 – 2013. Only fully completed projects are included in this research. Three projects were removed from the study due to this criterion and, finally, 15 projects were fully included in this research.

The studied EDMS solution is a product by Buildercom Ltd. This system is rather widely used by Finnish companies. The studied system is web-based solution and it used via web-browser. It has four different language options for the user interface (Finnish, Estonian, Swedish and English). Basically, the system itself is a functional platform for accessing and managing project data, and, the end user organisation is defining the folder structure for categorizing data and for facilitating data management.

Inside the studied EDMS was a basic folder tree platform for the content administration and accessing it. The end users of the system can then customize the folder structure to meet their project management approach and processes. Likewise, *the building client company* that was the financing body behind the studied case projects has introduced a unified project document classification system. This is particularly serving the needs of project management and governance. The folder tree is composed of three-level structure and contains 7 top-level folders which cover all subfolders. One of the top-level folders contained general project information and was named as Common Project Files. All of the other folders were named after the different projects stages. They contained information from the early preparation to the defects liability period. This is the basic platform that was also used in the studied case projects (Figure 1).

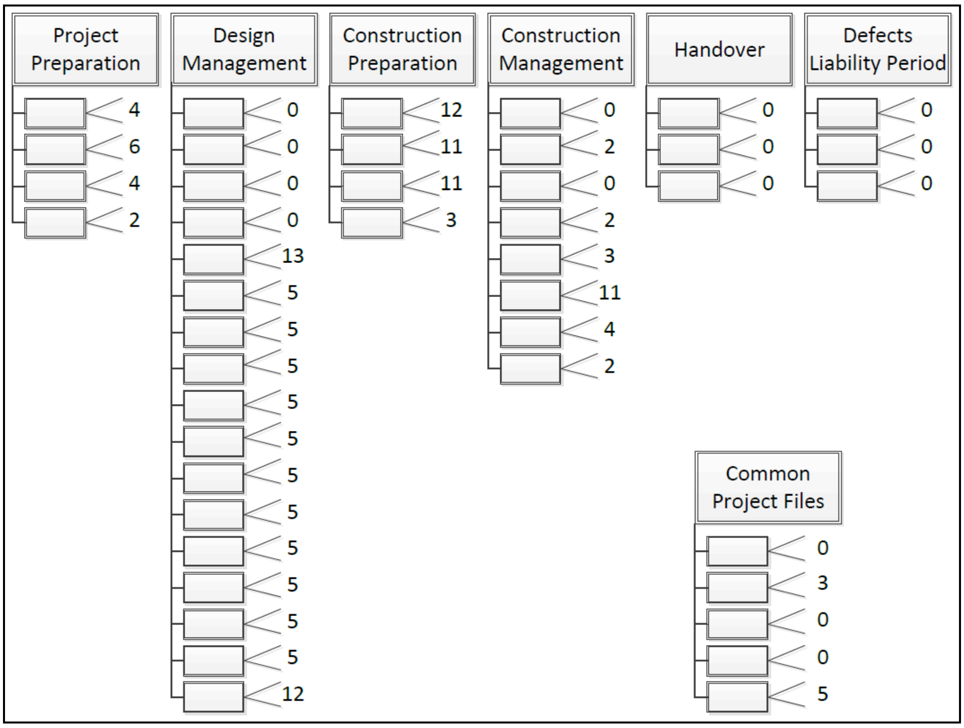

Figure 1: Folder structure of the studied EDMS. Figures show the number of third-level folders exist under the each second-level folder

In the figure, second -level folders are presented as boxes and third-level folders under them are presented as number. As you can see, most of the folders are situated under the Design Management folder. Three top-level folders, Handover, Defects Liability Period and Common Project Files instead contained just few subfolders. The total number of subfolders (second- and third-level) was 208.

The name of the top-level folder tells much about the content below it. Common Project Files folder contained folders for contact information, rules, instructions, rights to use, photos and authority related files like building plan. Folders for project goals, schedules, client and client's representative related files and costs were instead included in Project Preparation folder.

Design Management folder contained specific folders for every design party. Specific folders for sketching drawings, unfinished drawings, production drawings and native file formats were under these folders. In addition, there were folders for design schedules and meeting memos, background data and building information models. Construction Preparation folder instead contained folders for tender documents and contracts.

Construction Management folder contained folders for files related to construction schedules, meeting memos, quality assurance, safety, environment, supervision, contractor's documents, photos, variations and additional work. Folders for files related to measurement and inspection records, conveyance and economical inspections exist in handover folder. Folders within the Defects Liability Period folder were related to inspections and memos over that period.

4. Findings of current practice and their value

4.1 The overall usage of the EDMS

As mentioned earlier, every studied project included basic folder tree. In addition, in some projects extra folders were added by the users. We focused on studying the usage of the folders within the basic structure. Those were the ones where most of the files were uploaded.

The EDMS investigated in this study was fairly extensive. It was created to be used in projects of various sizes, and therefore it contained all the folders that could be used in very large and diverse projects. However, when used in small or medium size projects or in projects that are less diverse, it could be too extensive. This can also be seen in the way the system was used. Most of the folders within the studied projects were used very shortly. The actual use of the folders is presented in figure 2.

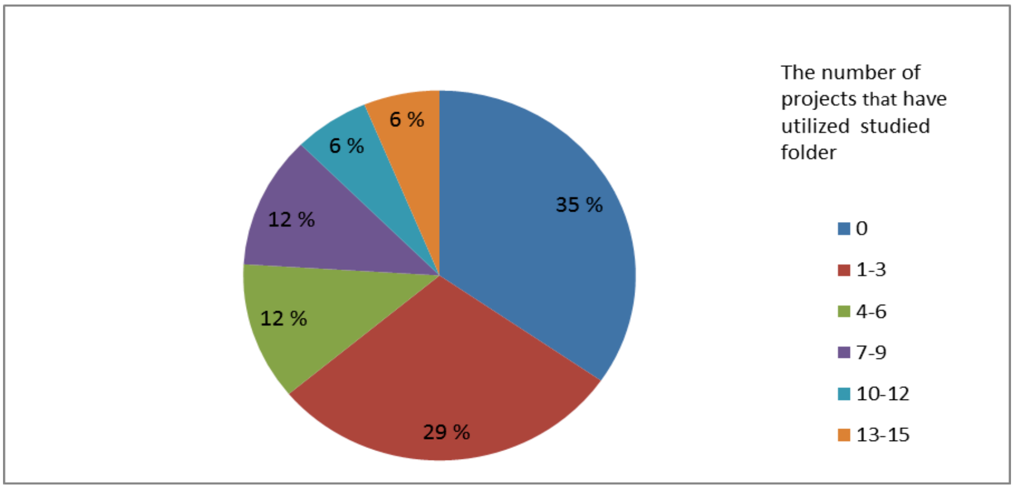

Figure 2: Shares of individual folders according to their utilization. The utilization means number of the projects that have used an individual folder in question.

Figure 1 is pointing out that over 60 % of all folders have been used in less than or equal to three projects and only 6 % were used in every, or almost every project. In fact, almost 80 % of all the studied folders are such that they have been used only in less than half of the projects. In addition, 35 % of all folders have not been used in any of the projects. In other words, they remained completely empty within these projects. Typical empty or only partially filled folders were related to small or specific areas. They were named as e.g. a kitchen, cooling, a sprinkler and an audio-visual system. Also folders related to defects liability periods, fire safety and geological work were used very limitedly.

Although there were a lot of empty or slightly filled folders, there were also folders that contained a lot of files. The largest number of files within a folder in one project was 395. There were few folders that contained large number of files in almost every project. The content within those folders was often related to contact information, production drawings, tender documents, minutes and memos, final inspections and conveyance. Almost all production drawings and tender documents were related to few main parties: architects, construction engineers, electrical engineer, automation engineers and HWAC-engineers. However, files within the EDMS were not divided similarly between the studied projects. A folder that was packed with files in one project could have been empty in other projects.

Even though the EDMS contained a lot of folders, in some projects users had even created additional ones. The client company had given instructions in relation to the creation of new folders. According to these instructions, it is allowed to create additional folders only under the third-level folders in the folder tree. Furthermore, users had to be in touch with the client company in such cases. However, it was found that some end users had acted against the set instructions and created folders even for the root level (first-level). These additional folders are not counted in in the figure 2, which partially explains why in certain cases the studied folders were found to be almost empty ones.

4.2 Number of files

Number of the files in the studied projects depended much on the size of individual projects. Many of the projects were such that the construction was completed but the liability period was still valid. The EDMS can be supplemented after this study, and it is even expected that it will be complemented during the liability period. The project is locked only when the necessary files are stored in the EDMS. None of the studied projects is locked yet. However, most of the project files are in the EDMS after the completion and only completed projects were chosen in this study.

On average there were 1 354 files uploaded in these case projects. The number of files within the projects varied between 141 and 5 230. When the number of files was divided by the cost of the project, the differences between the projects became smaller, but the differences between the separate stages of the projects still remained substantial. Total number of files can be seen in the figure 3.

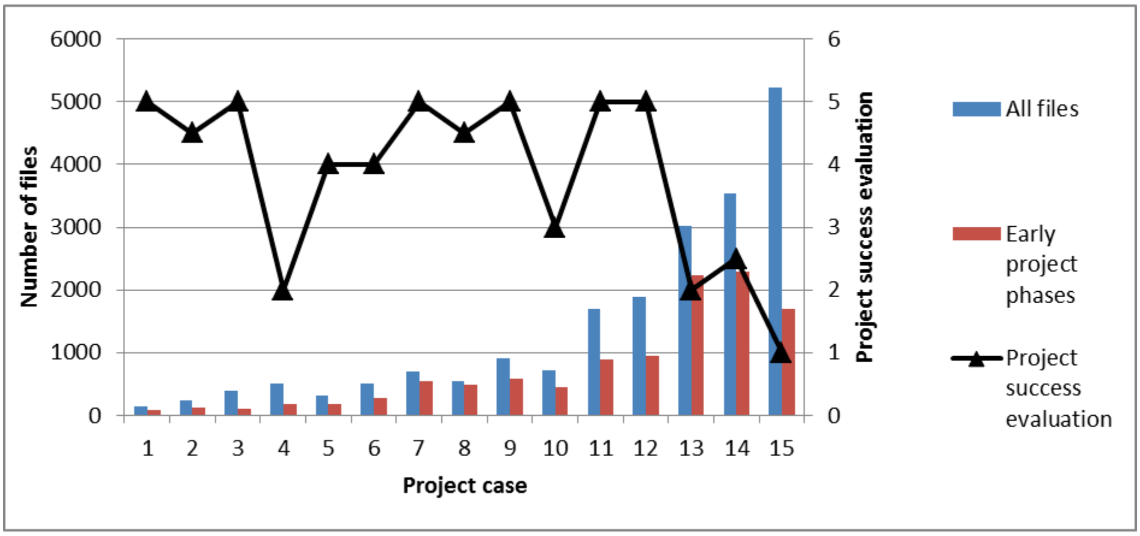

Figure 3: The number of files in different projects and the project success ratings (1-6) provided by the experts involved with case projects. For each studied project the first column presents the total number of files and the second column present the number of files for early project phases (folders: Project Preparation and Design Management).

The EDMS were used in different ways in different projects. Differences between the projects also affect the number of the files. The number of files varied significantly at different stages of the project. In Figure 4 the number of files at the different stages of the project is presented. Although there was a lot of variation between individual folders, a clear pattern of usage amongst top-level folders was evident. Majority of the files were placed in two top-level folders which were Design Management and Preparation of Construction. These main folders contained 708 and 404 files on average, while all the other five main folders contained only 49 files in average. The smallest amount of documents were in the Defects Liability Period folder which contained in average only 3 files. The main explanation for the low usage of the Defect Liability

Period folder seems to be that in most of the cases, a project was completed pretty recently and the liability period was still valid at the time when the study was conducted. Files concerning the liabiltiy period are most likely to be added later on. The number of files in different top-level folders can be seen in figure 4.

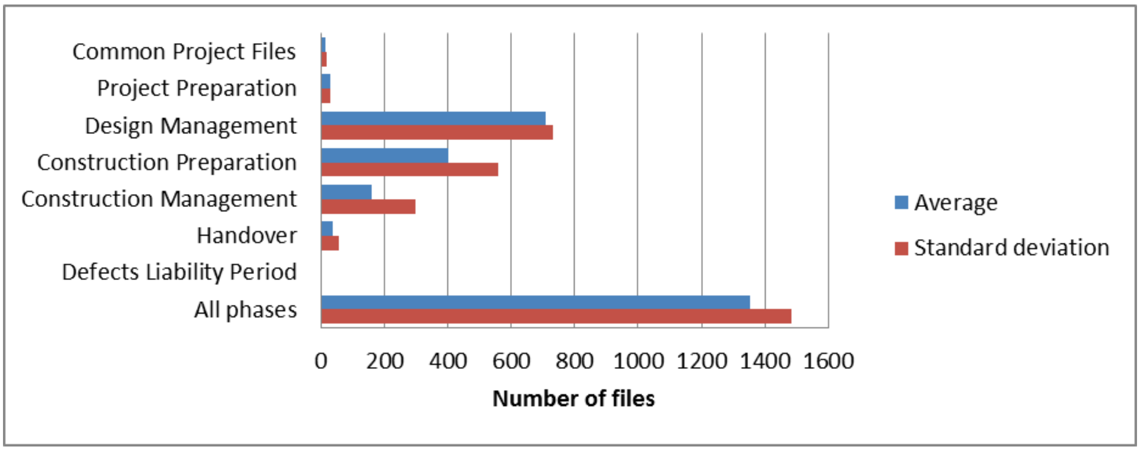

Figure 4: The number of files in the different top-level folders and their standard deviation.

4.3 Data access practice

The number of files uploaded to the EDMS seems to reflect the overall activity of the project partners, but it doesn't yet explain how the files are actually used. Therefore, the use of the files was another specific research subject. From the EDMS log record it was possible to get data about files access e.g. the requests for paper prints. More generally the EDMS system has recorded variety of users' actions which are: "open", "view", "freeze", "upload", "modify", "download", "remove", "move" and "to the file basket".

Our research focused in three specific file accessing actions. Those three were "open", "view" and "download". "Open" means that the file is opened using a certain software package. "View" means that the file is viewed in a browser and "download" means that the file is downloaded to the user's computer. These three observed actions are important because they can express how much users have used uploaded files online. Figure 5 shows the number of online access and the number of paper prints divided by the total number of files regarding the case projects.

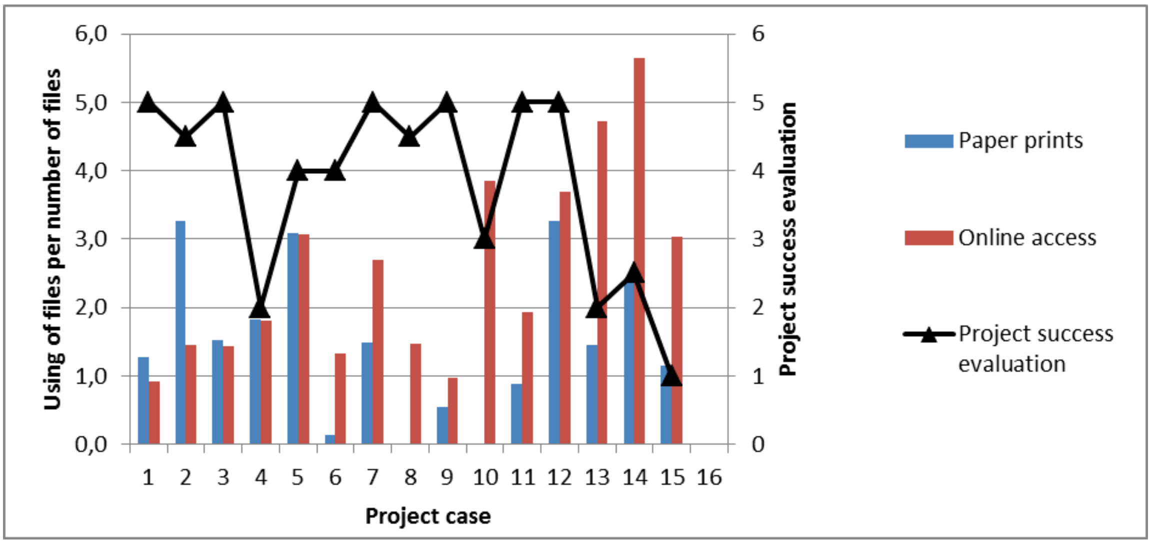

Figure 5: the number of online access and paper prints divided by the number of files in every studied project (Average 1.5 paper prints and 2.5 online accesses per file). Project success evaluation (1-6) provided by the expert involved with case projects is included in the figure.

As seen in figure 5 the deviation between the projects was relatively high even though the numbers of online observations and paper prints were divided by the total number of files. The total number of online observations varied between 130 and 20000 and the total number of paper prints varied between 10 and 8300.

According to the printing information, every file was printed 2.5 times in average. This information explain the prints that have been made through the printing system. Printing system is a service which enables print ordering from a printing house through the EDMS. Typically these prints are made of production drawings even though there is a lot more content in the EDMS.

5. Conclusions

This paper focuses on analysing the use of the electronic data management system (EDMS) in fifteen building development projects. The research data was collected from the log record of EDMS that was capable to provide details of the EDMS content and its usage. The obtained data was analysed using statistical methods. In addition, an evaluation of the project final success was prepared by an expert who was involved in the studied projects. These estimates were used as comparison points to the data from the studied system. All case projects were from the same client and the same system was used for managing project data in all of these projects.

As stated earlier, case projects varied significantly in terms of project cost. The size of the project had a clear effect on the use of the EDMS an also on the success evaluation. In the biggest projects the number of people and companies that used the EDMS was clearly higher than in smaller projects. In addition, the relative number of files and paper prints was smaller in the biggest projects.

The research shows that EDMS system was not used as expected according to the planned system structure. A lot of minimally used or completely unused folder existed in the EDMS, especially this was the situation in the small size projects. In addition to this, some users have created extra folders for better meeting their needs. These unnecessary or additional folders can make an EDMS more complex and could make it more difficult to use. It seems obvious, that the EDMS system needs to be flexible together with smart features that can make the system itself easy to use particularly regarding data access.

The use of the EDMS between different projects was rather uneven. The size of the project did not always tell about the use of the EDMS. There were projects of similar size in which the number of files and online access were very different.

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Innovation in the Construction of Mega-Projects

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Abstract

Often the construction industry is criticized for a lack of innovation. The same industry designs and builds the largest projects of the world, megaprojects such as bridges, tunnels, dams, harbours, airports and industrial plants. This discrepancy begs the question whether the lack of innovation is a true description of the construction industry. We can distinguish between product (design) and process (construction) innovation. To find an answer, a design/build megaproject can provide the necessary details for a case study as one party becomes responsible for design and implementation. Participant observation was used to detect, define, analyze and categorize innovations at the BangNa Expressway Project in Thailand, with 54 km one of the longest bridges in the world. The result is an impressive list of innovations of product and processes that were new at the time of construction to the world, sector or company. One example is a doubling in the speed of superstructure erection (and another consequent doubling during the project). This process innovation was only possible because of the project size. In a highly competitive industry, process innovation must lead to a decrease in price and therefore only a sufficiently large project can carry the investment cost associated with some innovations. In addition, the analysis shows that many innovations are so small that they hardly can be detected although they are ongoing continuously.

Keywords: Construction innovation, megaprojects, product innovation, process innovation, organisational innovation

1. Introduction: a research framework for innovation

Many years ago, in 1798, Malthus published "An Essay on the Principle of Population". Using the idea of diminishing returns in production of agricultural goods, he proved that with time an equilibrium will prevail where the population of a country is sustained at the edge of starvation. In consequence, economics was dubbed as the "dismal science". Malthus used a production function where the output (Y) is based on labour (L) and capital (K), Y = F (L, K). However, starvation is not the standard in many countries and this is due to a factor that Malthus did not consider: technology (T). Technology was then included in the production function, Y = F (L, K, T). Taylor (1995: 773) defines technology in economics "... *as anything that raises the amount of real GDP that can be produced with a given amount of labor and capital.*" For technology advance (and survival) we rely on new knowledge brought into application, i.e. we rely on innovation. The construction industry as the largest sector in most countries must contribute to this end. In a more confined sense than it is usual in economics, Tatum (1988: 344) describes construction technology "…*as the combination of resources, processes and conditions that produce a constructed product.*" However, the goal of technology for the construction industry remains also in this context the same, i.e. to provide more output with a fixed input; this is called the economic maximum principle.

Trott (2005) provides a useful definition of innovation as the sum of theoretical conception plus technical invention plus commercial exploitation. The conception of new ideas is the first step, transforming the ideas into something tangible means to implement a technical innovation as second step and for the third and final step many people work hard to convert the invention into products that improve company performance. While Trott focuses in his definition on a process, Freeman and Soete (1997) look at the outcome when defining as innovation the actual use of a nontrivial change and improvement in a process, product, or system that is novel to the institution developing the change. For our purposes the following nominal definition will be applied:

Innovation in construction = (def.) Processes that lead to the implementation of products, technologies, technical and management organisation that are at least new to the performing institution.

A formal process to generate innovation is through research and development (R&D), may the research be basic or applied (Trott, 2005). A less formal process is the search for a solution to an existing problem. This is similar to decision making as described by Cyert and March (1992) and they use the term "problemistic search". A very informal process is an emergent solution to an existing problem, an idea introduced by Mintzberg in the context of strategy formulation (1978).

Based on the work of Henderson and Clark (1990), Slaughter (1998) introduced five models of innovation: incremental, modular, architectural, system and radical innovations. The smallest impact is made by incremental changes which are inherent in all design and construction processes and can also stem from basic research. This could be a reduction in rebar weight relative to concrete volume (kg/m^3) due to more appropriate computational assumptions. Modular changes exert a broader influence but are still confined in their impact. An improved formwork system to erect bridge columns may serve as an example. Architectural changes affect other parts of the structure, because of existing interrelations between components. Bridge bearings transfer forces from the superstructure to the columns. Any improvements in the design of the bearings will have effects on both the superstructure and the entire substructure (not only on the columns). System changes cause impacts to the overall system. All construction methods belong to this group. The design of the structure, its cost, quality and time of construction are affected. Radical changes occur seldom and change the overall approach to particular problems. The segmental bridge construction technique was such an innovation several decades ago.

The impact of an innovation can also be measured by its degree of novelty. The above definition demands that the innovation is at least new to the developing company. Of higher impact are of course innovations that are new to the industry or the world.

The ideas presented so far can be summarised to provide a framework for the case study (fig. 1)

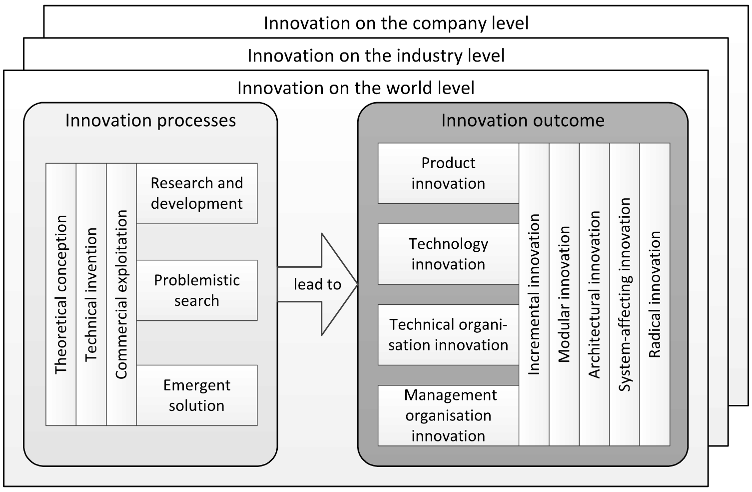

Figure 1: Framework for case study research on megaproject innovation

2. Research methodology

Laborde /Sanvido (1994) put forth that the construction industry in the U.S spends an "embarrassing" 0.4% of the annual output on R&D. It must be assumed that this is taken from the account books of contractors. Anyhow, similar data are reported for the recent years for Germany. In 2011, external and internal R&D expenditure in the German construction industry amounted officially to 012 % of all innovation expenditure of the German industry. (Stifterverband 2013). Anybody who understands the construction industry is aware of two typical facts: (1) the separation of design and construction and (2) the project-based nature of the industry. Due to the institutional separation between product (engineering firms) and process (contractors), the contractors have often no influence on the development of the product. To have a somewhat fair comparison with other industries, it is necessary to add the cost of product development to the R&D expenses of the construction industry. The project nature of the industry has also consequences: Process or technology development is not booked into an R&D account but into the project account. There seems to be a lot of confusion about innovation in construction when quantifying it from the outside.

Based on the construction investment concept, the construction sector is defined by the input of architects, engineers, contractors as well as construction material and equipment suppliers. In construction almost every building or structure is designed individually. Specific construction processes are designed each time and a new set of plant and equipment is assembled on site. A typical amount budgeted for the design of a project is approximately 7% (Barrie / Paulson, 1992), the amount spent by companies on developing technologies and site layout may be estimated to total another 3%. Finally the amount spend in laboratories might be roughly 0.4 % (Laborde /Sanvido, 1994) of the total construction output. To this we need to add R&D in construction materials and construction equipment. In addition, construction is a highly regulated industry with regard to standards. These are developed based on research sponsored by the public sector at universities and government institutions. The total amount spent on R&D in the construction sector may then be in the magnitude of 12-15% of the sum invested by the owner for any project. Describing the construction industry as non-innovative seems unjustified when comparing it with other industries: The top six spenders in the European automobile industry invested on average 12% in R&D in 2002 and the top two aerospace companies 14.4 %.

These considerations lead to the conclusion that an inside approach using case study research and participant observation is promising to better understand the phenomenon of innovation in construction. The project of choice for the case study is the BangNa Expressway in Thailand that was built from 1995 to 2001. At the time it was the longest bridge in the world (Brockmann / Rogenhofer, 2000). The observation period covers the time from 1995 to 1998. The project was procured using a turnkey design/build/finance approach. Thus, the fragmentation of the supply chain was minimised. The traditional design/bid/build method has often been criticized as being a hindrance to innovation (Walker et al., 2003). For the BangNa Expressway, the contractors were empowered to optimise the product, technology as well as the technical and management organisation. In general, case studies do not allow for hypothesis testing but for generating hypotheses. Hypotheses from this case study are summarized in the last chapter “Conclusions for innovation in megaprojects”.

3. Institutional determinants for innovation in megaprojects

Most construction projects, large or small, are unique. This is the standard case and a statement could follow that because of the uniqueness all construction is innovative. However, some of the differences are excluded by the chosen definition of innovation as it requires changes to be non-trivial. Megaprojects are defined by their complexity and not by the project size (Brockmann / Kähkönen, 2012). However, in order to simplify the matter, the project budget can serve as a proxy. This has the disadvantage that at the borderline a difference of one dollar will determine whether a project is a megaproject or not – and this does not make sense. All this thoughtfulness set aside, we will set a value of one billion US dollar as a threshold for the definition of a megaproject for our considerations here. The Gulf Cooperation Council (GCC) countries form a region where many megaprojects are under construction. Meed Projects (2014) lists projects with a project budget from 93 down to 4 billion US dollars in this area for 2011. From this list we can extract information on 97 projects for six sectors (table 1). The point is that megaprojects are not so very special cases and that conclusions based on the study of a megaproject do have importance.

Table 1: Budget for the top 97 projects in GCC countries in 2011

Sector	Number of projects	Average budget	Largest project	Smallest project
Real estate	42	14.8	93.0	4.0
Oil & gas	18	10.6	20.0	4.0
Transport	16	8.9	28.8	4.3
Power	9	7.3	20.0	4.0
Petrochemicals	8	8.1	20.0	4.0
Industry	4	11.3	40.0	5.0

The owners in real estate are most likely large investors, in oil & gas, petrochemicals and industry large multinational companies and in transport and power governments. Industrial and governmental purchasing is conducted by buying centres which show the following characteristics (Kotler/Keller, 2006): (1) few, large buyers, (2) close relationship between buying centre and contractor and numerous negotiations, (3) professional purchasing, (4) several buying influences (senior management and technical experts), (5) derived demand (no personal preferences), (6) inelastic demand (few alternatives), (7) fluctuating demand and (8) direct purchasing.

Combining these characteristics of the buying centre and the high investment cost for megaprojects, contractors are faced with a rather humourless situation where a lot of pressure is exerted on the price. Typical are sealed-bid auctions with strong competition. As a consequence, innovation is required to win the competitive bidding. For design/build procurement, the contractors need to provide a robust product with minimised quantities, a construction technology harmonised with the product design and an efficient organisation. Most likely, the financial benefits of the innovation end up in the hands of the buying centre (Brockmann, 2011): Innovation in megaprojects helps to survive, not to guarantee a large profit. Survival is a strong impetus.

When innovation is used to drive down cost, then the quantity produced must be large enough so that the investment costs can be recovered. A larger amount invested in innovation (often more specific equipment and plant) leads to lower variable production costs (fig. 2).

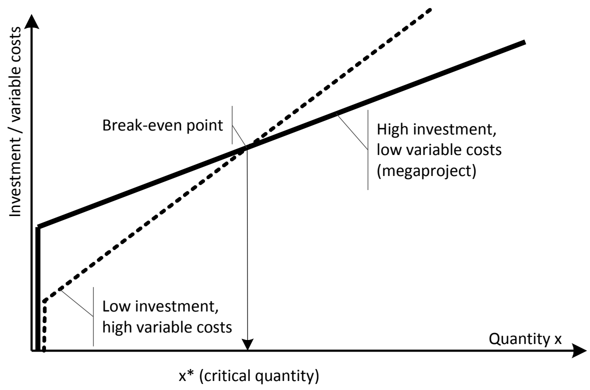

Figure 2: Investment in innovation for megaprojects

The two discussed institutional influences, buying behaviour and project size, provide for a situation where innovation is required and possible. In this regard megaprojects differ from normal projects that most often are too small to reach the critical quantity x*.

4. The innovation process

4.1 Short summary of the innovation process

The framework in fig. 1 provides for three different innovation processes: (1) R&D, (2) problemistic search and (3) emergent solutions. It has already been established that R&D is not the way of choice for the construction industry. It remains to be seen whether the two others are more prevalent. A typical innovation process observed numerous times at the BangNa Expressway and other projects is shown in fig. 3. The starting point is simple: there is a new project on the table. This will first be analysed so that it can be understood. Then step by step rules-of-thumb together with solutions from previous experience are applied. The innovation process kicks in when rules-of-thumb and previous experiences do not produce a satisfactory solution. Then, this first unsatisfactory solution is subjected to several what-if questions. The more such questions are asked, the more the solution becomes innovative. This search is carried on until the person or group working on the task feels satisficed with the solution (Simon, 1956). While the satisficing solution is developed, the possibility of implementation is continuously checked. However, at the end of the development process, the question whether the solution can be implemented is again asked: Is the solution part of the technology space of the company? Once this threshold has been passed, the solution can be presented to the decision making group which includes engineers responsible for technical aspects and managers responsible for business aspects. The whole process is iterative and repeated if the engineers are not satisficed, if the solution cannot be implemented or if the group is not convinced of the solution. This is an example of a problemistic search.

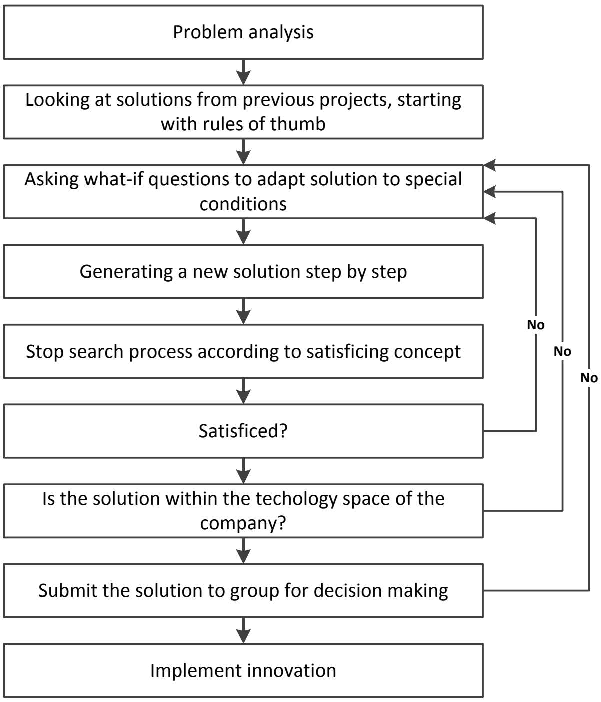

Figure 3: Innovation process

4.2 Exemplification of the general process

Problem analysis: Prior to the BangNa Expressway project, the same two construction companies (Ch. Karnchang from Thailand and Bilfinger from Germany) had contracted two similar projects with the same client in Bangkok (Expressway and Rapid Transit Authority), Sector A and Sector B of the Second Stage Expressway System. All these expressways in Bangkok were constructed in precast segmental technology. A third joint venture partner – Dywidag from Germany – had built the Don Muang Tollway in Bangkok using a different technology, prestressed AASHTO girders and decks cast in situ.

Compared with the previous projects, there were some notable differences: (1) the size of the BangNa Expressway was four times bigger than any previous project expressed in terms of deck area, (2) the bridge gradient was higher – 18 m instead of 12 m, (3) the cross-section comprised six lanes instead of two times three lanes – however the Don Muang Tollway had six lanes, (4) the time for design and construction was with 42 months comparatively much shorter than for the other projects.

Looking at solutions from previous projects: In the bidding group, the two basic alternatives (precast segmental construction versus prestressed AASHTO girders) were discussed in depth. In the end, precast segmental construction was chosen because of the predicted lower price and faster construction progress. The design at that stage showed two bridge superstructures side by side on a central pier using D3 segments developed for Sector A and B with a maximum of three lanes (fig. 4, lower part). The solution was not considered satisfactorily with regard to construction speed and price. It was assumed that the price would not be competitive enough and the search for a faster and cheaper solution started.

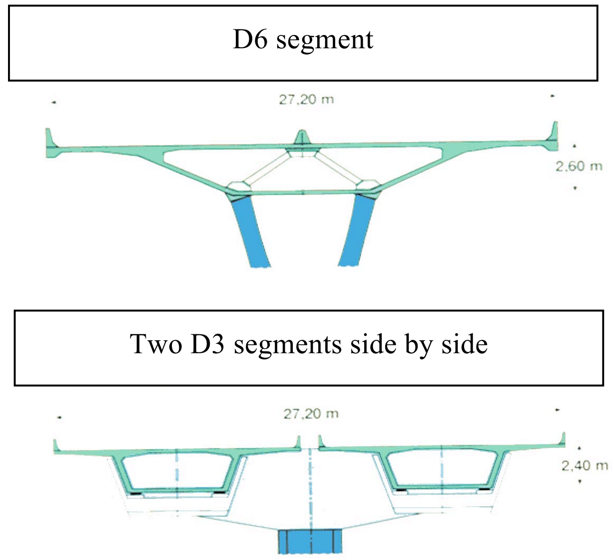

Figure 4: Comparison of superstructure designs

Asking what-if questions: The most important what-if question centred on the idea to develop a single segment for six lanes (D6 segment) with a total width of 27.20m. This would almost double the previous maximum width of the D3 segments (15.60m). Options discussed included designs with three, two or one central web in addition to the inclined outer webs. The final option is depicted in the upper part of fig. 4. It includes two internal struts and two highly inclined webs.

Generating a new solution: A comparison of the two options in fig. 4 conveys the idea that the two main objectives – increased construction speed and lower cost – can be achieved with the D6 segments. The D6 segment design was revolutionary as nothing similar had been built before (Podolny / Muller, 1982). Accordingly, this option entailed a number of unresolved problems (see also fig. 5 for illustration):

- Never before such a wide cross-section was precast and there was no experience with time-dependant behaviour, casting doubt over the internal fit of the segments.
- Knowledge at the time about the influence of the bowing effect when match-casting segments indicated that the design would lead to uncontrollable problems.
- The formulas in the codes did not allow for a safe shear transfer at the piers.
- The construction technology had to be adjusted from using tested overhead girders to untested underslung girders.
- The underslung girders influenced the design of the piers.
- The design of the piers changed the design of the bearings. The bearings were now best placed on inclined surfaces. There existed neither experience nor codes for inclined bearings.
- New moulds for precasting the segments needed to be developed.
- New means of transportation needed to be developed (shuttle lifts, trailers and swivel crane).

The savings of material for the superstructure alone are given in table 2. Further savings are in consequence to be found in the substructure (piers, pile caps and piles).

Table 2: Comparison of quantities between D6 and D3 segments

Superstructure	Concrete	Rebars	Post-tensioning
D6 segments	0.49 m^3 / m^2 bridge deck	59.2 kg / m^2 bridge deck	24.0 kg / m^2 bridge deck
2 x D3 segments	0.51 m^3 / m^2 bridge deck	70.6 kg / m^2 bridge deck	24.4 kg / m^2 bridge deck

Satisficing: The concept of satisficing was developed by Simon to replace the idea of optimising a solution. It describes a heuristic where the search is stopped once an internal aspiration level with a solution has been reached (Cyert /March, 1992). The development of a design option for the BangNa Expressway was a team process and it stopped when the team's aspiration level was surpassed. The two groups within the team, one favouring precast segmental construction and the other prestressed AASHTO girders did not find an agreement at this stage. It was only reached in the final decision making meeting.

Technology space: The answer to the question whether a solution can be implemented is a theoretical one at the time of decision making. It can only be answered through implementation. However, the decision must be taken before submitting an offer and it is a leap of confidence for contractors. Besides questions raised when generating the solution, the most important one was whether one span can be erected in two days because the whole schedule depended on this point. An additional day for each span would have increased production time by 50%. The agreement to the developed solution was based on the experiences with the production and placement of D3 segments. It clearly meant entering unchartered territory.

Final decision making: All parties involved took part in the final decision meeting, engineers and managers. After a thorough presentation, the pros and cons were discussed controversially together with the involved risks. In the end the proposed option was adopted as solution (fig. 5). Everything in this picture is innovative, the substructure, the superstructure, the erection equipment, the transportation equipment as well as the organisation.

Figure 5: Innovative features of the BangNa Expressway

The previous discussion leads to the question whether megaprojects are not per se innovative all together because of their evident uniqueness. We believe this to be a valid point of observation. However, to understand innovation in detail more easily, it might be helpful to identify some of the more innovative features of the BangNa Expressway.

A problemistic search was by far the most commonly observed innovation process. Problemistic search is easily detectable as it is a long, laborious process and it is a top-down development. It is more difficult to observe emergent solutions as they just seem to happen. They are emerging from many little steps that are added together, mostly as a bottom-up development. They can only be identified by their end result.

5. Innovative features of the BangNa Expressway

A discussion of the innovative features of a project can only be complete, if all of them are thoroughly explained. This is most often – and also in this case – not possible due to space restrictions. The BangNa Expressway is fortunately a well documented project and much information can be found in publication albeit some of them not in English.

For heavy civil engineering projects it is often practically impossible to separate the product design from the process design. Both are developed simultaneously. Despite this fact and in accordance with the framework given in fig. 1, we make firstly use of the theoretical option to differentiate four areas of innovation: product, technology, technical organisation and management organisation. Secondly, we try to indicate at what level an innovation was introduced: world, industry or company level. Attributing an innovation to one of these three levels can only be a best guess, as nobody is aware of all things going on in construction. Thirdly, we refer to the innovation models proposed by Slaughter (1998): incremental, modular, architectural, system-affecting, or radical changes. The identified changes are listed in table 4.

Table 3: List of innovations for the BangNa Expressway

No.	Description	Level	Innovation model
	Product innovation		
1	D 6 segments (Brockmann 2000)	World	System-affecting
2	Mainline columns (Brockmann/Rogenhofer, 2000)	World	System-affecting
3	Post-tensioning in D6 segment (Brockmann 2000)	World	Architectural
4	Bowing effect during match-casting (Brockmann 2001)	World	Architectural
5	Shear transfer (Brockmann 2000)	World	Architectural
6	Inclined elastomeric bearings (Krill / Eibl, 1999)	World	Architectural
7	Piers without crossbeam (Brockmann/Rogenhofer, 2000)	World	Architectural
8	Mainline portal columns (Brockmann/Rogenhofer, 2000)	World	Architectural
9	Precast portal beams (Brockmann/Rogenhofer, 2000)	Company	Architectural
10	Post-tensioned columns (Brockmann/Rogenhofer, 2000)	Company	Modular
11	Pile foundation with welded spun piles (Brockmann/Rogenh.)	Company	Modular

12	Reduction of rebars for foundation	Company	Incremental
	Technology innovation		
13	D6 underslung girder (Prade / Surbeck, 1998)	World	System-affecting
14	Production line in precast yard for D6 segments	World	System-affecting
15	Construction speed	World	System-affecting
16	Portal beam erection girder (Prade / Surbeck, 1998)	World	Architectural
17	Formwork for piers	World	Architectural
18	Lifting devices for D6 girders (Prade / Surbeck, 1998)	World	Modular
19	Shuttle lifts in precast yard	Industry	Architectural
20	Transport trailers	Industry	Architectural
21	Swivel cranes (Prade / Surbeck, 1998)	Company	Modular
	Technical organisation innovation		
22	Longest bridge in the world	World	System-affecting
23	Full-scale test-span (Fischer / Krill, 1998)	World	System-affecting
24	Production flow in precast yard	Industry	System-affecting
25	Design/build megaproject	Company	System-affecting
	Management organization innovation		
26	Voluntary coordination between ETA and DoH	Industry	System-affecting
27	Financing contract	Company	System-affecting
28	Joint management for all works	Company	System-affecting
29	Start-up company for spun pile production	Company	Modular
30	Start-up company for post-tensioning production	Company	Modular

Throughout the project incremental innovations were implemented almost on a daily basis. When 500 employees and 5,000 workers join their efforts, these incremental innovations cannot be tracked. However, sometimes they add up to a great innovative leap. An example for the BangNa Expressway is the erection speed of the superstructure. One out of five teams achieved after two years over a period of half a year an erection speed of one span per day. This is twice the speed that was planned and achieved by the other teams.

6. Conclusions for innovations in megaprojects

There are a number of important observations that can be summarised from the case study:

Firstly, the approach to innovation is through problemistic search and emergence. Specialised R&D departments are not used. Given the project nature and the uniqueness of the construction industry this seems to be a wise approach as people drive the innovation that get feedback from implementation.

Secondly, innovation on the world level is abundant. This seems to suggest a capability and willingness to innovate on the side of the contractors. There was also evidence for much entrepreneurial courage when betting on the success of innovation at the signature of the multi-billion dollar contract.

Thirdly, there are a number of barriers to innovation in construction. Separation of design and construction, project size and the necessity to reduce costs have been discussed above. More barriers can be found in the literature (Blayse / Manley, 2004).

It seems that a deeper understanding of research in construction on the practical level is required before we can make far-reaching statements on the non-innovative character of the construction industry.

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Case Study on the Impact of Information Quality in Industrial Projects

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Abstract

The diversity of the industrial projects and market requirements increasingly demand design process improvement. The rising demand for speed in construction, lower costs and quality assurance generate complexity in managing the design process. For the design phase to be performed with the desired level of quality, the information provided to designers needs to be complete and reliable. For this, client engagement from the early beginning is crucial, creating a collaborative project in which every individual can participate in order to achieve the best results. Through a case study, this paper aims to identify needs and information requirements for design detailing and the design management practices performed by the company studied. The results will be evaluated in order to propose possible management improvements. It was observed that the information available to the design firm before construction had a degree of uncertainty too large, an issue that, adding to the client's lack of commitment with regard to collaboration in the process, caused severe financial losses.

Keywords: design management, information management, collaboration

1. Introduction

Many authors and researchers associated to the construction sector have considered the design phase as extremely important, due to being directly related to the initial product design, thus bringing reflections for all subsequent stages of the production process (Fontenelle, 2002).

Although these findings indicate that it is precisely at this phase in which decisions have the greatest ability to influence the global cost of the project, considering industrial projects, we can say that the client has not properly valued and recognized the importance of the design phase, leading to the establishment of deadlines with development exiguous. According to Fontenelle (2002), the design phase is treated as a "cost", a loss to the entrepreneur, and not as an "investment" with guaranteed returns in terms of higher levels of quality and productivity of all subsequent processes.

To have success in the design phase and this is elaborated with a desired quality level according to client expectations, the requirements and information provided to the designer needs to be complete and reliable. For this, collaboration and client engagement from the beginning of the project is necessary.

The industrial projects mobilize different specialties in the conception and design development of their projects. Complex projects consist of many and varied interrelated parts and this concept is operationalized in terms of organization, different technologies and interdependencies (Baccarini, 1996). Müller (2012) defines complexity in projects as a multidimensional concept, arising from confidence in the ability to produce the result of the project, the amount of information to be processed, the dynamics and uncertainty of projects and the interaction between the persons involved. Usually design firms do not have all of the required technical expertise in-house, resorting to the hiring of technical consultants with specialized expertise related to the current project. However, this action extends the actors involved and thus both project and design management become more complex requiring more attention so that the objectives are met with quality, within cost and pre-established deadlines.

2. Objective

This paper aims to discuss, throughout a case study the needs and information requirements for the design development of an industrial project and the design management practices adopted. The flow of information between the client, the designer and management processes used will be analyzed. The results will be evaluated in order to propose possible improvements in management.

The research methods adopted were: literature review on project and design management, information management and other content that underlie the work and execution of the case study. The necessary information was obtained through contacts made by the technician responsible for design coordination, engineers and leaders of the disciplines involved, including technical interviews and analysis of documents such as contracts, proposals, and meeting minutes.

3. Literature Review

3.1 Information Management

The activities related to planning, execution, monitoring, control and closure of a project are dependent on information which must be provided at the time of demand (Fagundes et al., 2005). At the beginning of the project when the requirements are analyzed, stakeholders are considered as the main source of these requirements for project development. They are defined as a person, group or organization with a legitimate interest in the actions and performance of the project whose decisions and results may affect them. Therefore, stakeholders should participate in the project to outline their needs and allow the definition and validation of required specifications.

According to McGee and Prusak (1994), the identification of needs and information requirements is the first task of the process of information management (Figure 1).

The process of information management is a structured group of activities that includes how companies get, distribute, and use information and knowledge (Davenport, 1998).

According to Ohnuma (2003), the information serves as a communication and activities control, and supports programming, control and decision making in an organization. Therefore, it is necessary to manage the information in order to integrate the activities and thus guide and monitor the processes.

The information management in projects has the function of prospecting, selection, treatment, availability, circulation and storage of information necessary for the planning and execution of the project. The main focus of prospecting information is in the external and internal environment in order to provide quality information to designers so that they can design the project solutions with the lowest possible uncertainty (Falsarella and Monteiro, 2007).

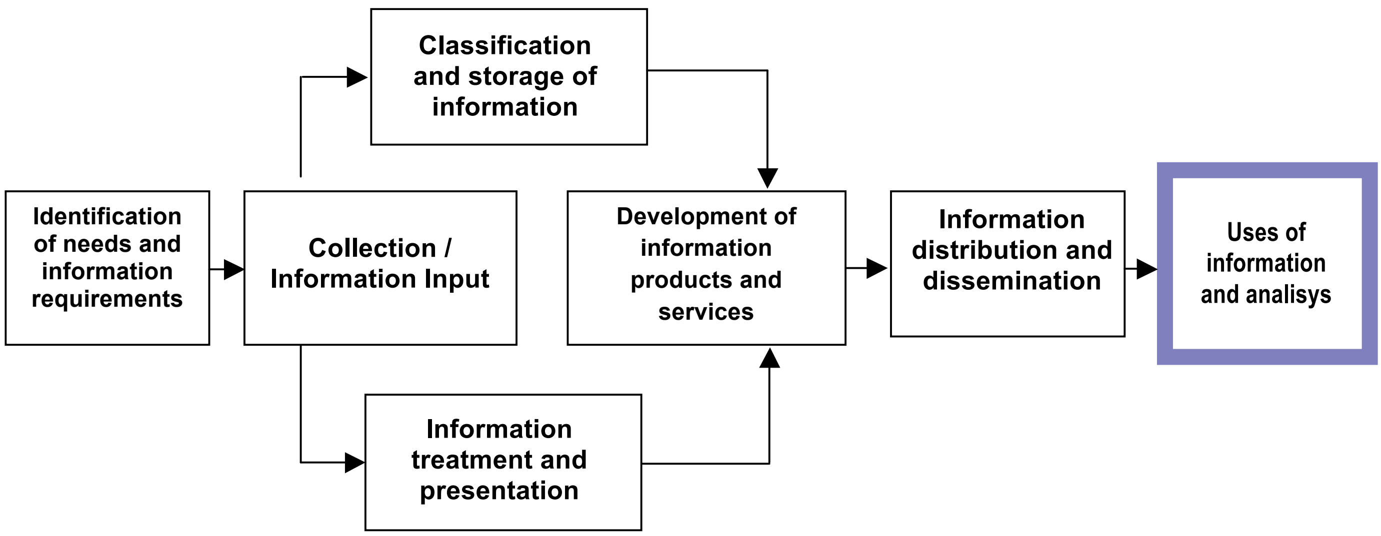

Figure 1: Tasks of the information management process (McGee and Prusak, 1994)

3.2 Design Management

Melhado et al. (2005) define design management as a set of actions involved in the planning, organization, direction and control of the design process, which involves tasks of a strategic nature, such as demand and market studies, land prospecting, obtaining of investment or sources of production funding, definition of characteristics of the product to be built, and directly linked tasks to the formation of design teams for each project like hiring designers, setting deadlines for stages of design management and client and users interface.

Pinto and Sleven (1987) define that a project is considered a success in your implementation in the case of complying with the four criteria: time, cost, efficiency and client satisfaction. The success in the design process requires, among other characteristics, skills and choice of a set of management practices that lead it. In this scenario, the arrangement of a team that favours the interaction between the stakeholders is of the utmost relevance to achieve the goals and objectives related to cost, time and design specifications.

A remarkable change has occurred in the design process in engineering. Under the influence of the social sciences, the design process, which for years has been focused only on users now have a tendency to focus more on participatory experience (Ballejos; Montagna, 2010).

In the engineering area there is a growing trend that considers the integration of technical and human elements in the design process (Gonzales, Wolf, 1996). This perspective change is based on the design FOR users' evolution to design WITH users, where new ways of thinking and working are required. Participatory design can be defined as an attitude that all players involved in the design process can collaborate (Ballejos; Montagna, 2010).

Melhado et al. (2005) said that increasing the volume of generated products (from the design disciplines), the increased flow of information and the need for greater integration and compatibility among design parts, at the same time in which deadlines are extremely reduced, implied a greater demand greater complexity in the management of the design process.

With the largest number of stakeholders and greater management complexity, it is necessary to create mechanisms of evaluation, verification and control at each stage of the design process (Figure 2). This practice should be applied to the design as a whole, even if part of it is produced by a third party.

Looking at Figure 2, considering the quality control in the stages of design, client requirements and objectives can be defined as input in the design process. During the design development, professionals will satisfy these requirements considering the best technical and economical solutions. Design review is a fundamental step in the process, aiming to identify and minimize the deviations of the design solutions in relation to the requirements initially defined. As output data from the process, finally, the design documents are delivered in accordance with the input information.

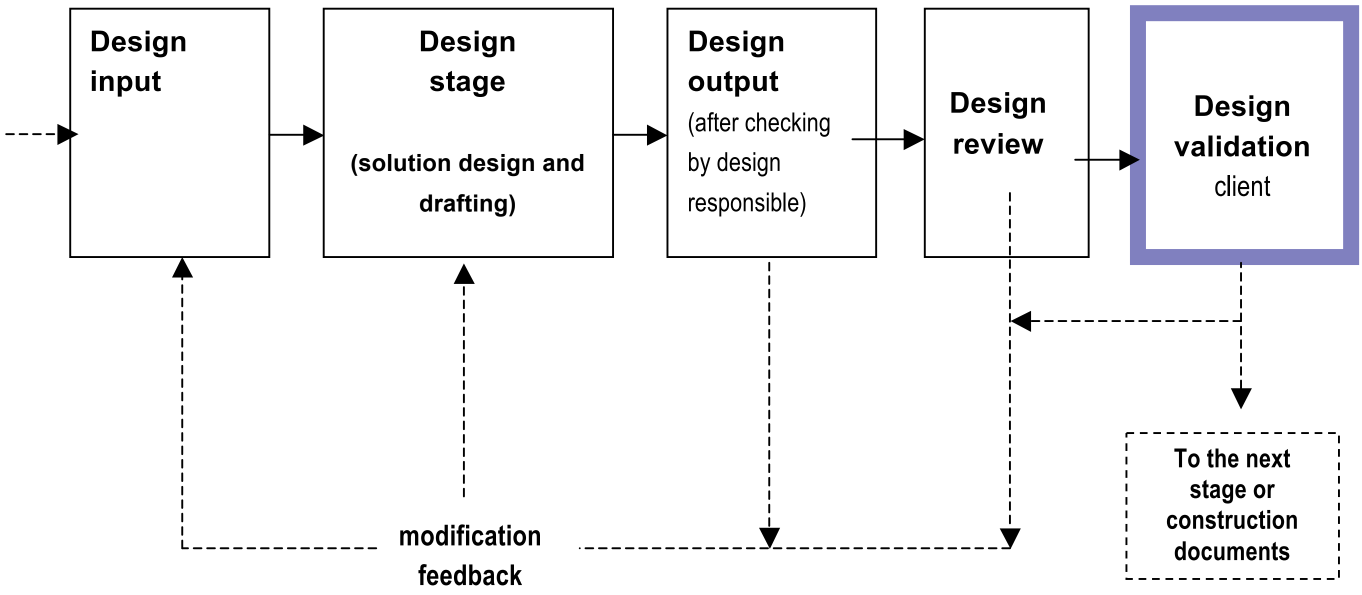

Figure 2: Design checking, review and validation (Melhado et al., 2005)

According to Carvalho and Rabechini (2005), many projects require deliveries that are impossible to be performed, because they depend on skills that are outside the boundary of the project. In these cases, designers give up developing products or services on the project and look for third parties, labour and goods to be incorporated into the design. This is done with use of subcontracting and these, in turn, need to be managed.

4. Case Study

The chosen case study is of an industrial project designed by an engineering firm that has its head office in the city of São Paulo, Brazil.

Through the case study, the authors identified some practices of design management adopted in engineering regarding the hiring of external consultants. Aiming to the development of the current research, information was collected about the adopted procedures and other relevant details.

The case study comprised the following main steps: defining the firm and project to be investigated; proposal of the research protocols for the case study; scheduling and performing the technical interviews; and compilation of all the information obtained.

4.1 About the engineering firm

The engineering firm analysed in this study is a Brazilian company of design, management, engineering and supply of EPC / EPCM services. It has 25 years experience in the Brazilian market, operating through its head office in São Paulo but also with offices in the Brazilian cities of Vitória, Belo Horizonte, Salvador, São Luís and Rio de Janeiro, in addition to some task groups settled in other sites in Brazil and abroad.

The firm has circa 2,300 professionals (of which 83% work in technical activities and 17% in administrative), having clients in different sectors such as mining, metallurgy, steel, fertilizers, Oil & Gas, petrochemicals, infrastructure, energy, docks construction, site implementation and construction management.

The engineering firm offers several services:

- Consulting and market studies (technical-economic feasibility, environmental impacts, HAZOP, project risk analysis, market potential);

- Conceptual, schematic and detailed Engineering design (specialists in the disciplines of chemical processes, metallurgical and mining processes, utilities, piping, fire systems, mechanical systems, ventilation and air conditioning, electrical, automation, data acquisition and control, architecture, steel structures, concrete structures, foundations, civil works, geology and geotechnical engineering);

- Supply (purchases of equipment and materials, manufacturing follow-up, manufacturing inspection, coordination and transportation logistics, stock management and warehouse control);

- Commissioning / Start-up Assistance and Pre-Operation;

- Implementation and Construction Management.

Design management was performed by the management team of the firm, supported by the design engineers and the planning department. Design coordinators and planners were directly supervised by the four directors of industrial sectors and management.

4.2 Overview of the project

The project will have an annual production capacity of 2.5 million tons of steel plates and rolled steel. The operation start of the plant (furnace, steelmaking and rolling) was scheduled for the end of 2013.

This industrial complex has an estimated investment of 5.8 billion and will enable the generation of 16,000 jobs during its implementation. The project comprises the construction of a rail access to receive iron ore, a boat terminal to receive coal and allow the flow of steel products to the port. Besides the production of steel, the future waterway shall serve other local economic and social activities.

Figure 3 shows the general layout of the project.

Figure 3: General Project Plan (Source: case study data)

4.3 Early phases of design

- Conceptual Design

The contractual time for this design phase was of 48 days although evidence shows that there was an actual delay of at least 15 days in design delivery. The reasons for this delay were found in the design team reports, namely inconsistent information sent by the client leading to design rework, delays in the client's replies to requests for information; infrastructure team decentralized; and communication difficulties.

- Schematic design

The initially scheduled period for schematic design was 110 days, but an amendment of cost and time was carried out adding 92 days to the deadline. The amendment was justified by overtime hours performed to complete the schematic design of foundations, in order to compensate for the delay in receiving information (load plans) from the client. After the completion and delivery of the schematic design, the client hired once again the engineering firm for the detailed design, which will be described and studied more deeply below.

4.4 Detailed Design

As described in the technical-commercial agreement and the contract, the engineering firm was responsible for:

- Detailed design of infrastructure to all the areas of the plant;

- Detailed design of the temporary water drainage system (construction phase) to all the areas of the plant;

- Detailed design of materials from landfills, industrial landfills and sanitary disposal landfills for the plant, to be used in the construction phase, as well as in the operational phase of the industrial plant;

- Detailed design of disposable materials to the plant, to be used in the construction phase, as well as in the operational phase of the industrial plant.

The contract of design development was composed by 5,000 technical hours of engineering and 1,000 technical hours of coordination and planning.

4.4.1 First Situation

Right after the initiation process, when the design team and the project charter are established, and the project becomes officially initiated, the design professionals require information provided by the client to start the design detailing. The client, however, did not define with the main equipment suppliers the specification and, therefore, reliable information about the size, weight and other characteristics of equipment. In the absence of accurate information, the design has adopted some hypothesis, for example, to courtyards sizing, based on the data available from the earlier design phases.

Near to the end of the construction phase, the client obtained information from suppliers and communicated this to the design team. However, such information contradicted the hypothesis adopted initially and, as a result, it was necessary for a 20% increase in the length of the ore yard, which led to a scope change, execution rework, increased construction time and cost, among other negative issues.

In brief, it was realised that the input data to design was unreliable. In order to meet deadlines, the design team used the available but limited information gained at design phase, but when additional information was confirmed by the client at the later date regarding actual requirements, there were major inconsistencies and this lead to significant additional costs, both in time delays and financial.

4.4.2 Second Situation

After the end of the process of project initiation, during the kick-off meeting, possible doubts and questions were discussed and a common understanding has been found between the main parts (client and design firm) concerning the scope. The design coordinator accomplished the task of detailing that scope with the team, thus defining the services each professional involved should perform. It was realised, then, that there were no available capabilities in the firm to perform the water drainage design; considering the short time until the deadline of schematic design completion, a mitigation action was needed to face up to client's criticism, and the coordinator took the decision of hiring an external consultant to develop the drainage design.

At the end, as the external consultant produced the drainage plans and only uploaded them on the closing date, the same day on which the design firm should deliver them to the client to meet the contractual deadline, the design coordinator decided to perform no clash detection and the project was delivered to the client even without his review has been made. In other words, the process of monitoring and control was not performed properly, as there was no scope control and design quality.

Some drainage plans were commented and validated by the client and the others were approved by the design firm itself, by the principle of time expiration (in the design management plan was informed that, given the expiry of the time for submitting comments by the client, the designer has the right to validate the design documents). Therefore, it was held the design closure process, considering the validation and all the design tasks as accomplished.

After the closure, the design firm was once more hired to provide technical assistance services during the construction phase. Because of this new contract, the firm's professionals spent two months making design changes.

Six months after delivery and closure of the detailed design, in the execution of earthmoving services, serious problems were detected. Cracks appeared in the soil (Photos 1 and 2) and the landfills started a process of slipping (Photos 3 and 4).


Photos 1 and 2: Soil cracks (Source: case study data)


Photos 3 and 4: Landfill slipping (Source: case study data)

The client warned the design firm leading to the engagement of an external consultant (Geotechnical Engineer) for analysis and investigations. The report drawn up and delivered to the client has appointed problem origins in the fact that the soil survey was conducted in the dry season (the design adopted this document as a reference informed by the client) and the existence of geological faults in the site. As for earthwork services, the client losses led to an additional cost of approximately USD 40 million.

Meantime, while the consultant hired by the design firm conducted the investigations, the client team has initiated a process to verify the detailed design delivered by the designer. Then, mistakes were found in drainage drawings (those that were conducted with water drainage consultants hired by the designer and not undergoing any kind of design review before delivery to the client). Considering this fact, as consequences for the designer were identified:

- Extensive rework - for a period of four months an engineer and a designer were allocated to the project, conducting review and correction of drawings;

- Economic losses relative to the design price equivalent to approximately 20%;

- Reduction of credibility under the viewpoint of the client;

- Lack of motivation of the professionals involved.

These consequences are interconnected with some of the critical success factors (FCSs) defined by Pinto and Sleven (1987), as comes in on-schedule (time criterion) and budget (monetary criterion) of the project. Rework generated due to the need of analysis and corrections delayed the final issue of the project and generated costs not initially planned. Pinto and Sleven (1987) affirm that projects are often initiated in the context of a turbulent, unpredictable, and dynamic environment. Consequently, the project manager should be well served by more information about those "specific factors critical to project success". The project manager requires the necessary tools to help him focus attention on important areas and set priorities across different project elements.

5. Conclusion

One of the main activities at the beginning of a project is the search for information. This search originates in the need to reduce uncertainty about the trend of the project. The client should define your needs and requirements and transmits them to the designer along with reliable reference information, because they will be used as input data for the project development.

It is important that an evaluation of scope and time be performed, as well as the necessary resources for project development soon in the beginning, before finalizing and signing the contract, because these analyzes make it possible to identify the need to hire technical consultants.

From the moment that the designer identifies the need for procurement of services, the development of a risk analysis, especially in relation to time and quality, it is essential for achieving success in the project. The information flow adopted in the design process, as well as verification and design review of projects should also be applied to external hires.

Both situations (first and second one) pointed in the case study, regarding the information available to the designer before the construction process; it is possible to observe that such information had a very large uncertainty, adding to the lack of commitment of client regarding the quality of information, which caused serious mischief. According to the literature studied, the initial data for the development of the project (collect and input information) define a process step of information management of great relevance; these data must be reliable so that the project can achieve the greatest degree of quality as possible, reducing risks in relation to quality, deadlines and increased costs. Greater attention is needed on the quality of information sent to the designer at this stage.

The designer, in turn, from the moment that identifies the need to hiring external services, must develop a risk analysis, mainly in relation to quality and deadlines. With the growing number of actors involved, the flow of information and the integration between disciplines become more complex, the compatibility and design review need to be assured along the design process during all its development, as proposed by Melhado et al. (2005).

The evaluation, verification and control of design process developed by third parties were not included in the design management scope. Partial delivery of projects and technical checking of the work developed by external consultants could have helped to minimize risk, reduce costs or time and attend client objectives regarding the quality of the project.

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Using Public Private Partnerships (PPPs) for the Procurement of Public Hospitals

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Abstract

Public-Private Sector Partnerships (PPPs) provide a means for developing public infrastructure without directly impacting upon Government budgets. Social infrastructure projects are generally smaller in scale than economic infrastructure projects, however, they tend to be more complex, mainly because of the on-going involvement with the community. Private sector tenderers for social infrastructure PPPs are often presented with a situation where operational complexity, including government policy towards risk allocation and the sharing of revenue, is a key difference in whether PPPs are as attractive for social infrastructure projects compared with economic ones. This paper focuses on the procurement selection process for healthcare infrastructure in Australia and the results are presented from a case study of a PPP hospital project in New South Wales.

Keywords: Australia, Healthcare, Procurement Selection, PPPs, Social Infrastructure

1. Introduction

Public Private Partnerships (PPPs) are long-term contractual arrangements between public and private sector organisations for the provision of infrastructure aiming to optimise risk allocation and maximise value for money (Akintoye et al., 2003; Commonwealth of Australia, 2002). Contemporary PPP models emerged in the UK in the 1980s as a result of the requirement for improved infrastructure and the public sector's inability to meet demand within the confines of conventional financing methods (Watson, 2003). The first PPPs were for economic infrastructure projects such as major roads, bridges and tunnels, which provide an income stream either from user charges, or shadow tolls paid by the government for each vehicle to the private sector operator (English and Guthrie, 2003; Tillman, 1997). This new method of infrastructure provision soon emerged in Australia where early PPPs included the Sydney Harbour Tunnel and Melbourne's Citylink Expressway, which are both toll roads (Grimsey and Lewis, 2002; DOTARS, 2002). PPPs in Australia are now rationalised by 'value for money' and this has led to the emergence of social infrastructure PPPs such as hospitals, schools, prisons and housing (NSW Government, 2000; Commonwealth of Australia, 2002; Jefferies and McGeorge, 2009).

In 2002, the New South Wales (NSW) Government identified over $4 billion worth of emerging PPPs for the next four years, and in excess of $13 billion of major project proposals worth over $100 million, to be implemented over the next decade, including many social infrastructure projects (NSW Government, 2002; Allen et al., 2004; Jefferies and McGeorge, 2009). This projected growth presents a range of research opportunities, particularly for social infrastructure projects. This paper focuses on the procurement selection process and risk management issues in a social infrastructure PPP project, i.e. the Newcastle Mater Hospital redevelopment, which has stimulated public debate stemming from considerable apprehension within the employee, union and community stakeholder groups, as the first health sector PPP proposal in the Hunter region. The paper presents preliminary findings of the case study project and focuses on the establishment and rationale for the PPP project.

2. Hospital Public Private Partnerships

Public Private Partnerships (PPPs) are broadly defined as partnerships, or financial arrangements, between the public and private sectors for the purposes of implementing projects that have traditionally fallen within the remit of the Government (McCann-FitzGerald, 2000; Akintoye et al, 2003; Walker and Hampson, 2003; Blake 2004; Jefferies and McGeorge, 2009). PPPs involve the sharing of responsibilities (including risk) and the Australian Procurement and Construction Council (APCC), 2002, identifies government procurement through a PPP as involving the private sector delivering certain services for government and creating, financing, operating and sometimes even owning the new asset.

In the early years of Australian health sector PPPs, the contracts were predominantly adapted from the Build-Own-Operate-Transfer (BOOT) arrangement, whereby new hospitals were constructed, owned and operated privately (Dowdeswell and Heasman, 2004). This strategy presented limited success and Australian governments have subsequently declared a commitment to provide the core services in social infrastructure, such as clinical services in hospitals, meaning that the roles filled by the private sector are generally support services such as broad ranging facilities management (English and Guthrie, 2003; NSW Treasury, 2002; Jefferies and McGeorge, 2006). Tasks commonly transferred to the private sector in PPP developed hospitals include maintenance, catering, porter services, laundry, waste and other non-core services (De Lemos et al, 2003).

The Australian health sector is relatively inexperienced in PPPs, however, the contemporary approach has been developed based on international experience such as the Private Finance Initiative (PFI) in the UK (English and Guthrie, 2003). Australian state governments that have implemented health sector PPPs have had limited success, with certain projects being declared 'failures' by some factions. Three Australian healthcare projects that have been completed in the last 10 years are:

1. Port Macquarie Base Hospital in NSW;
2. Latrobe Regional Hospital in Victoria; and
3. Berwick Community Hospital in Victoria.

Theoretical case analysis has been completed for these three healthcare projects as part of this paper. The main issues are summarised below and based upon the findings of Allen (2001); English (2004); Fitzgerald (2004); Abelson (2005); Hodge and Greve (2005); Chung (2008); NSW Treasury (2009); and Victorian Government (2010):

- Early PPP's seem to have Governments focusing heavily on transferring risk to the private consortiums and undertaking development on a basis of the lowest cost.
- Lack of due diligence by both the public and private sectors has seen Governments lose significant funds in having to buy incurred failures and debt.
- Regarding the transfer of risk, Governments seem to be paying excessive rates for services (however, the Government will bear the 'ultimate' risk if default or inadequate performance occurs and health services still need to be delivered).
- Build-Own-Operate (BOO) projects appear to have failed due to the private sector assuming to deliver services provided previously by the public sector more efficiently. Failure also seems to be an affect of government policy requiring a transfer risk in order to meet 'value for money' benchmarks (for which they have not provided).
- The issuing by the Government of 99 year leases to the private sector even though the concession agreements may be only for 20-25 years seem to not be in the publics best interest.
- The 'build' component of PPP procurement has been completed effectively on time and on budget.
- Risk transfer and assumptions needs to be better evaluated and analysed by both public and private parties.
- Accounting practices and the application of discount rates, providing consistency et al. for determining the Governments contract obligations need to be more rigorous and not be reliant on comparisons with the 'PSC'.
- Management of applying best practice, disclosure and conflicts of interest.
- PPP-type arrangements seem to be more effective in the delivery of health services (subject to risk transfer) specifically with the Government delivering clinical services.

PPPs are increasingly becoming the preferred option for Government's to deliver a range of services in social infrastructure, particularly healthcare (Jefferies and McGeorge, 2009). According to Jefferies and McGeorge (2008), current government policy limiting risk allocation and the sharing of business operation is a restricting factor for private sector stakeholders in the development of a successful revenue stream. They also indicate that Social infrastructure PPPs have relatively higher bid costs compared to economic PPPs with only a marginal increase in business opportunity. The key to a successful project is the identification and allocation of risks to the best party to manage such risks during the tender stage (Jefferies and McGeorge, 2008; 2009). Therefore, with the partnership between the public and private sectors there must be continued refinement of the allocation of risks.

3. Research Method

3.1 A single case study approach

A qualitative single case study strategy was used in order to *"investigate a contemporary phenomenon within its real-life context"* (Yin, 2003, p13). The rationale for the single-case approach lies in the unique opportunity presented by the case study project and the limited number of healthcare PPP projects in Australia, and in particular in the State of New South Wales. The method initially focused on a literature review that identified current theory regarding procurement selection and risk management of PPPs. Case study data collection then went on to firstly analyse project documentation which was used to establish project background information and establish the parameters for the interview component of the research. A semi-structured face-to-face interview format was then used and data analysed using a content analysis approach.

Yin (2003) describes two types of case studies, being exploratory and descriptive. "*An exploratory case study will be utilised to satisfy the objectives of the study"*. This was achieved through the interview process conducted with senior project personnel involved in developing the project's contractual structure and risk allocation strategy. A qualitative approach has been used as the main focus of the research to explore the 'nature of inquiry into a human process', i.e. the development of the risk management process at the tender/bid stage of a PPP project. Subsequently, the case study method adopted, supported by Yin's (2003) research design has researchers following a set of four principles. The first principle is the need to examine a 'case' within its 'real-life' context; the second principle provides a platform for an appropriate methodology within the context of the research; the third principle concentrates on data compilation and analysis; and the final principle is that the researcher must explain the findings and establish conclusions that will lead to further the analysis of the topic. Yin (2003) highlights single cases as being used to confirm or challenge a theory, or in order to represent a unique or extreme proposition. As PPPs are a relatively new and unique phenomenon the multiple case study approach is somewhat irrelevant in this instance given the limited extent of social infrastructure PPPs such as hospitals.

3.2 Case study participants

The selected project for the case study is the Mater Hospital, which is a current social infrastructure PPP project. The participating organisation, Lend Lease, was selected as they were the client's (NSW Government) representative on the case study project (Mater hospital) and were instrumental in terms of selecting the procurement method and developing the contractual arrangements. The Lend Lease staff interviewed (i.e. eight [8] middle to senior members of the project management team), as part of the case study project, had significant experience with PPPs, both on a national and global basis. These experiences range in varying capacities from representing both private and public sectors in providing procurement advice, developing expressions of interests and leading full tender preparation and evaluation of major PPP projects.

3.3 Data collection and analysis

Case study data collection involved analysing project documentation, such as contract summary documents, to establish background information and establish the parameters for the interview component of the research. A semi-structured face-to-face interview format was then used and data analysed using a content analysis approach. The intention of the interview process was to focus on risk factors identified by key senior management involved in developing both the project's risk profile and contract. To ensure this data was accurate and reliable, all participants must have played a leading role (e.g. Project Manager, Contract Manager et al) and have previous experience with PPPs and large-scale construction projects. The participant organisation then selected individuals to complete the interview process that aimed at capturing their perspectives on risk management approaches used in the project.

4. The case study project: The Mater hospital redevelopment

4.1 Project background

The NSW Government, in conjunction with the Department of Health developed an Action Plan for NSW Health by incorporating key principles to improve the state's health services and infrastructure. The implementation of these principles by Hunter Area Health via the Hunter Strategy – an area wide strategic resource plan that promotes the effective management of the area's finances, people, information technology and physical assets, as well as the effective use of the resources of the private sector. Part of the Hunter Strategy is the Newcastle Strategy (Mater Hospital re-development forms 1 of 4 projects) and involves major new upgrade works by the NSW Government. These projects were to be originally procured under conventional arrangements from the Department of Health's Capital Works budgets (Lend Lease, 2002).

Prior to the PPP proposal, the Mater was an existing functioning hospital. However, the buildings were out-dated and inappropriate for the services provided. Many of the buildings were obsolete and it was the preferred option to redevelop the Mater as an integral part of the Newcastle Strategy. There have been numerous studies over the past twenty years that clearly established that many of the Mater's buildings are beyond, or are reaching the end of, their economical life (Lend Lease 2002). Current ownership of the facility is held by the Little Company of Mary Health Care (as an affiliated health organisation) and the hospital continues to provide services to the community in the Catholic tradition. The Calvary Mater Newcastle has an agreement with the State Government, in the form of Hunter New England Health Service to provide a number and range of health services to agreed quality standards (NSW Health, 2004). These arrangements are completed under a Labour Services Agreement whereby public sector funding and public sector health employees (who remain public sector employees of the Hunter New England Area Health Service) are used for clinical purposes. Jointly, these 2 entities provide health care services at the Mater (Hunter New England Health Services, 2009).

4.2 The PPP process

From the initial concepts envisaged under the Hunter Strategy, a more detailed analysis was completed under the Newcastle Strategy and revealed that a greater scope of works was required due to substantial upgrades and demand for additional services which by far exceeded the available public funding (Lend Lease, 2002). Due to the financial constraints with the existing deficiency in the NSW Health budget, the NSW State Government considered alternatives besides delivering a staged Mater Hospital redevelopment using the conventional Capital Works budget. In June 2003, the NSW Government entered into an agreement with the then owners of the Hospital site (NSW Health, 2005, p.3) for *"an Agreement for Lease and Initial Project Agreement for the Redevelopment of the Mater Hospital."* This agreement established the parameters by which a redevelopment could be considered using private funding.

While no certainty on a procurement method had been decided, NSW Health had formulated through workshops facilitated in June 2010 by Lend Lease (the Government's procurement partner) a list of *"generic risks likely to be found in the design and construction of health facilities"* which were later defined within the Project Definition Plan. The process began in April 2002, when a preliminary risk review was conducted and focused on *"the initial processes rather than later delivery risks and the risk review focused on the elements with higher level risk profiles"* (Hunter Health, 2002, Section 8, p.2) relative to development, management and delivery of the Mater Project. This process of risk identification was continued through an intensive stakeholder engagement process, with six (6) key risk area headings identified:

4. Quality of service/Quality of hospital product
5. Timely delivery/Costs within budget
6. Disruption to hospital activities during delivery
7. Urban development
8. Equality and availability of opportunity
9. Information and consultation

(Hunter Health 2002, p.3)

Following evaluation of the significant risks by the NSW Government it was considered in August 2003 that the hospital would be procured using a PPP. NSW Health (2004, p.3) has stated that the *"Project will be undertaken within the framework of the NSW Health's 'Working with Government Policy and Guidelines for Privately Financed Projects' "*. NSW Health, in establishing a commercial framework for the project, wanted to maximise the private sector's role by transferring risks and allowing the consortiums to produce *"innovative design, engineering, operating and commercial solutions"* (NSW Health, 2004, p.3). The ideology of NSW Health appointing a procurement partner would assist in realigning its asset management objectives and still allow delivery of the aims of the Newcastle Strategy.

4.3 The proposed redevelopment

The agreement between the NSW Government and the proposed private sector consortium involves over a project term of 28 years the financing, design, construction and commissioning of: new hospital buildings; refurbishment of the old Mater Hospital; transfer of local mental health services onto the site; and maintenance of buildings, car-parks and grounds, utility supply; and management services (operational services et al). In addition, the consortium will provide a range of 'non-clinical services' (security, catering, cleaning, general services et al) while managing public sector health employees (who remain public sector employees of the Hunter New England Area Health Service) under a Labour Service Agreement.

The proposed revenue streams from the Government to the private sector are on a monthly performance based payment structure which starts on hospital operation. The payments relate to the finance (initial project capital investment); design, construction, & commissioning; and the maintenance and operation of the hospital including the management of the health sector employees. As stated by Lend Lease (2002, p.35), the *"monthly service payment (subject to abatement for non-performance) is made up of volume adjustments (catering, clinical waste), energy payments, and additional payments (groceries, security guards)"*. The Mater Hospital is the first hospital in New South Wales to be built, maintained and operated by the private sector under a PPP, and is the largest provider of radiation oncology services in NSW (Infrastructure Partnerships Australia, 2009). The redevelopment will provide a 176 bed hospital, new mental health facility, and new radiotherapy facilities.

4.4 PPP expression of interest/detailed proposals process

In October 2003, *"a Call for Expressions of Interest"* (NSW Health, 2005, p.3) by the NSW Department of Health occurred with 6 consortiums responding at the close in November 2003. An Evaluation Committee assessed the proposals on:

- design and construction experience;
- facilities management experience;
- structures, risk management and financial experience;

- financial experience and financial strategies; and
- by applying a ‘percentage weighting criteria’ to distinguish proposals.

(NSW Health, 2005, pp3-4)

Three respondents were short-listed to present ‘Detailed Proposals’ with one withdrawing prior to the ‘Request for Detailed Proposals’. The ‘Request for Detailed Proposals’ was issued in August 2004 and in December 2004 two private sector consortiums had lodged bids. Assessment of the ‘Detailed Proposals’ by the Evaluation Committee was broadly based on financial, commercial, technical and services issues, legal and costs parameters (NSW Health, 2005, p.4) which were greater defined by the following criteria:

- design;
- construction and commissioning;
- service delivery; commercial;
- financial; and
- probity compliance.

(NSW Health, 2005)

Again a percentage weighting criteria was used to distinguish the proposals. However after evaluation of payment and risks, it was concluded that neither proposal had effectively established value for money to the Government. It was considered that negotiations should continue to improve the deficiencies within the proposals that had been provided to date, and the preferred bidder needed to satisfy several criteria with a specific focus on:

- Costs below those of the public sector comparator;
- Compliance with the project’s design requirements, as ‘represented’ by the ‘reference project’ and the project’s technical specifications;
- Compliance with the project’s services requirements, in its services and technical specifications; and
- An ‘acceptable’ risk position, documented in a draft Project Deed.

(NSW Health, 2005, p.6)

NSW Health and Novacare’s (one of the private sector consortia) preferred individual position was reviewed in relation to certain risks and whether that risk was considered high, medium or low to the Government. The re-evaluation of the proposals occurred in June 2005 under the same weighting criteria and in December 2005 it was publicly announced that contracts had been executed between the Government and the Novacare Consortium. NSW Treasury calculated that the Novacare proposal would provide a ‘net present cost’ saving to the Government of approximately 2% when compared to a traditional public delivered procurement model over the contractual PPP term. Novacare’s bid price of approximately \$378.8 million was exclusive of certain risks. Through negotiations with NSW Treasury, a \$1.7 million estimate of those excluded risks was added to the price to allow a comparison with the Public Sector Comparator. As shown in Table 1, it compares Novacare’s contractual price (risk adjusted) against the ‘Public Sector Comparator’.

Table 1: Value for money comparison between public sector and private sector project delivery

Delivery method	***Public sector comparator (PSC)*** *(hypothetical, risk-adjusted estimate of the cost of the most efficient likely method of public sector delivery)*			*Private sector delivery (as Contracted)*
	PSC best case *(95% probability that PSC cost would be higher than this)*	***PSC likely case*** *(mean of PSC cost estimates)*	***PSC worst case*** *(95% probability that PSC cost would be lower than this)*	
Estimated net present value of project cost over 28 years to the NSW Health	*$384.1 m*	*$388.7 m*	*$393.7 m*	*$380.5 m*
Estimated saving through private sector delivery	*0.9%*	*2.1%*	*3.4%*	

As identified within the interview process with Lend Lease (Government's Procurement Partner) the final contractual negotiations between the Government and the private sector consortium saw *"minimal changes to the risk profile"* to what the Government had previous established. As stated "*The Governments preferred position ultimately was to allocate the risk to the party who would be best to manage that risk, and determine what proportion of cost was associated to accepting that risk by either party."*

4.5 PPP contracting parties

The Novacare Consortium is made up of the following parties:

- Westpac (Consortium Leader and Financier);
- Medirest (Soft Facilities Management);
- Honeywell (Hard Facilities Management); and
- Abigroup (Design and Construction Contractor).

The contractual rights and obligations are specified within the PPP Project Deed. Project securities are based on the negotiated acceptances of risks on the design, construction, commissioning, provision of hospital operational services and finance of the PPP Mater project. The Project Deed also stipulates requirements to manage, under the Labour Services Agreement, the clinical staff, the leases, novation, certification and other project agreements.

5. Conclusion

The objective of the Mater Hospital Case Study was to establish how 'current industry practice' is utilised by consortiums in the assessment and evaluation of procurement selection and risk management during the tender phase of procuring a PPP project. This paper presents the preliminary findings of the broader case study project and focuses on the PPP selection process. The NSW Government assessed procurement alternatives for delivering the new hospital (i.e. traditional publicly funded delivery or a PPP). Upon determining the procurement method as PPP, a scope was determined and this established a project term of 28 years for the finance, design, construction and commissioning of new hospital buildings, refurbishment of some existing buildings and transferring mental health services to the site. Clinical services were to remain the responsibility of NSW Health while non-clinical services (building maintenance, mechanical and electrical service maintenance, upkeep of grounds, security, cleaning, car parking et al) were to be provided by the private sector. Payments from the NSW Government for services were based on performance benchmarks. Significant assessment was completed for design risk, construction risks, interface risks and hospital disruption, financial risks et al in order to determine the best 'value for money' proposal against risk transfer (using the Public Sector Comparator benchmarking model). Following a rigorous tender period, the private sector consortium bids were evaluated on financial, commercial, technical and services issues, and legal and cost parameters. Final contractual negotiations between the Government and the private sector consortium saw minimal changes to the risk profile to what had previously been established. Through the PPP process, NSW Treasury calculated that the Novacare proposal would provide a 'net present cost' saving to the Government of approximately 2% when compared to a traditional public sector delivered procurement model over the contractual PPP term. The next stage of the research is to analyse the data collected during the interview process that focused on identifying the project specific risk factors and how they were successfully managed.

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Success Factors Related to Industrialized Building in Sweden

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Abstract

During the last decade there has been intense discussion in Sweden about industrialization in construction. The discussion has focused on industrialization in connection with erection of multi dwelling houses. It has been argued that industrialization is a key factor as regards obtaining affordable high-quality dwellings. During the last ten years some new industrialization concepts have been developed and tested. Even though some concepts have failed others have been more successful and are under further development. Industrialization is a reality within the Swedish construction sector and can be assumed to play an important role in the future as regards obtaining affordable high-quality dwellings. In this paper success factors related to four industrialized building concepts/methods are described and discussed. The review is based on available literature relating to each of the concepts/methods/producers, from which it was possible to ascertain success and failure factors.

Keywords: Dwellings, failure factors, industrialization, prefabrication, success factors

1. Introduction

In the early 1990s major changes were affecting the Swedish housing market. The market was de-regulated and state subsidies that had existed for a long time were abolished. In addition to this full value added tax (VAT) was applied on construction. These measures led to a sharp decrease in construction, not least when it came to housing, which fell to a historic low level (Sveriges Byggindustrier, 2013). Thus, the housing shortage was increasing, especially in big cities, while high construction costs became an increasing problem. It was clear that the building industry must seek new ways to build homes with high quality but at lower costs for the end customers, the residents. The issue became a subject of public debate and discussion and was treated in a State public inquiry publication addressing competition, quality, costs and competence within the construction sector (SOU 2002:115). Major criticism was pointed towards the construction market as a protected territory with low pressure for change. This discussion led to an interest in and proposals for a more industrialized construction process. A number of companies also began working on developing methods and concepts designed for industrial manufacturing. For some companies, it meant a deepening and further development of work started earlier, sometimes more than 10 years ago. For others, it meant investing in totally new methods and concepts.

Interest in industrial construction in Sweden peaked around 2005; at this time a dozen more or less developed concepts and methods were on the market. In the publication *Byggandets industrialisering-Nulägesbeskrivning* (*Industrialization in construction – description of the present situation*) (Apelberger et al, 2007) ten different concepts are presented and analyzed. A couple of these concepts had been introduced to the market several years earlier while others had been introduced recently. Some of the concepts meant radical rethinking and attracted much attention, both in the general press and in professional journals, see e.g. (Johansson, 2007). However, the application of the various concepts showed mixed results. Many were successful and are still available on the Swedish market today, albeit in a more developed form. Others have failed completely and were phased out relatively quickly, which led to great media attention, see e.g. (Veckans Affärer, 2007). Some of the concepts that failed represented the boldest ideas and the most radical rethinking, and this appeared to result in a decline in interest in industrialized construction within the media.

Turning to the situation in Sweden today the challenges from around 15 years ago remain. The housing shortage, especially in the big cities, is large while construction costs connected to residential buildings are regarded as too high. Industrialization of housing appears to offer a, or part of the, solution to supply and costs, but lessons need to be learned from previous efforts over the past 15-20 years. The aim of this paper is to identify, describe, analyze, and discuss factors affecting the development, introduction and implementation of a concept for industrial construction in a Swedish context. From this it was possible to identify success and failure factors.

Research is based on data gleaned from extant literature specific to the Swedish construction sector. From this four cases/concepts with a high degree of prefabrication were identified and analysed to illustrate success and failure factors. Two of the concepts studied are still in business, two have been terminated. Two of the concepts are based mainly on volumetric elements: two mainly on flat surface elements.

2. Theoretical framework

Industrialized construction (or building) can be described and defined in many different ways. A definition that is accepted in a number of contexts is that put forward by the CIB Working Group W024: ”*Industrialized building is the term given to building technology where modern systematized methods of design, production planning and control as well as mechanized and automated manufacture are applied*”.

(Lessing 2006) has suggested eight characteristics that constitute the concept of industrial construction. These eight characteristics are: (1) planning and control of the process, (2) developed technical systems, (3) off-site manufacturing of building parts, (4) long term relations between participants, (5) supply chain management integrated into the construction process, (6) customer focus, (7) use of information and communication technology and (8) systematic performance measuring and re-use of experience. Industrialized construction thus encompasses much more than the prefabrication of building elements and components. It also includes several important ‘soft parameters’ such as customer focus, long-term relationships and process thinking. Apelberger et al (2007) takes into account the conceptualization put forward by (Lessing 2006) and underlines the need for all eight characteristics to be present in a concept/method if this shall be regarded as representing industrialized building.

3. Study and analysis of concepts

3.1 Introduction – studied concepts

An initial overview of the four concepts studied is given in Table 1. In Table 2 a somewhat more detailed description of the concepts technical systems is given. Descriptions regarding development of and experiences from concepts are given later in this paper.

Table 1. Studied concepts. Brief description.

Concept/Method	*Open House*	*Lindbäcks Bygg*	*NCC Komplett*	*Peab PGS*
Prefabrication system	*Volumetric elements*	*Volumetric elements*	*Mainly planar surface elements. Volumetric elements for kitchen and bathroom*	*Mainly planar surface elements. Volumetric elements for kitchen and bathroom*
Introduction on the Swedish market	*1999*	*1994*	*2006*	*2003*
Present situation	*Phased out in 2008*	*In use*	*Phased out in 2008*	*In use*

Table 2. Studied concepts. Brief technical system description.

Part	*Open House*	*Lindbäcks Bygg*	*NCC Komplett*	*Peab PGS*
Production conditions at the building site	*Mounting of volumetric elements outdoors*	*Mounting of volumetric elements outdoors*	*Mounting of elements indoors in special production hall*	*Mounting of elements outdoors*
Framing materials	*Steel*	*Timber*	*Concrete, steel*	*Concrete, steel*
Installations	*All installations mounted on factory*	*All installations mounted on factory*	*All installations mounted on factory*	*All installations mounted on factory*
Doors and Windows	*Installed on factory*	*Installed on factory*	*Installed on factory*	*Installed on factory, except front doors*
Facades	*Various materials can be used*	*Various materials can be used*	*Various materials can be used*	*Refurbished*
Roof	*Built at site or elements de-livered to the building site*	*Elements prefabricated on site*	*Elements delivered to the building site*	*Elements delivered to the building site*
Internal surfaces	*Various options*	*Various options*	*Various options*	*Various options*
Kitchen	*Could be complete, possibly except for appliances*	*Supplied with finishes and furnishings / equipment fitted*	*Supplied with finishes and furnishings / equipment fitted*	*Supplied as assembled units, appliances at a later stage*
Bathrooms	*Can be completely finished with all fixed equipment mounted*	*Supplied with finishes and furnishings / equipment fitted. possibly except for white goods*	*Supplied with finishes and all furnishings / equipment mounted*	*Supplied with finishes and all furnishings/ equipment mounted*

In (Apelberger et al 2007) a detailed analysis and comparison of ten concepts / methods of industrialized building is presented. These concepts / methods, all available at the Swedish market around 2005, were analyzed and compared based on the characteristics areas that have been presented and proposed by (Lessing et al 2005). The comparison was based on a model presented in (Lessing et al 2005), which is an attempt to make a relevant and accurate way to describe and categorize the degree of industrialization of different concepts/methods. In order to assess the industrialization degree of a concept all eight characteristic areas were evaluated according to a five-point scale. The comparison was based on information obtained from the companies that developed the concepts as well as on literature data and data from the internet. Regarding the concepts studied in this article NCC Komplett was assessed to have the highest degree of industrialization, while Peab PGS was assessed to have the lowest.

3.2 Development and experiences

3.2.1 Open House

According to Boverket (2006) Open House (OH) was tested in three pilot projects. The first two were conducted in the early 1990s and the third in 1999, all with good results. Development of the concept was made in the third project, mainly by changing the primary frame material from concrete to steel. In the third project a change of manufacturer was made, which showed that experience in manufacturing of volume elements was not necessary for a successful outcome. Based on these pilot projects a major project started in 2003 of approximately 1,200 apartments. The project was designed to include ongoing tests and development of technical solutions. A new factory was used with partially redesigned tools. The project continued as planned. However, in 2004 the economic forecasts broke. About 300 apartments were therefore added to the project in 2005 (Larsson 2009 A). The project kept on struggling with rising costs and complaints were raised about the rent levels and the housing standard (i.e. heating costs) (Larsson 2009 A). Staff was made redundant in different rounds and in early 2008 the entire plant was closed down due to high construction costs, an uncertain market for newly built apartments and low capacity utilization in the factory. The project led to a total of 1,200 apartments in the beginning of 2008 (Larsson 2009, B). Further complaints have been raised about the houses, mostly because they are leaky with high heating costs as a result (Pedersen 2009, A). The residents have also taken legal action (Pedersen 2009, B).

In the last project, which was considerably larger than the three pilot projects, the significant difference was that it was much larger and also in most areas more complex. Among other things, the planning process was more comprehensive. These issues were probably underestimated. The systems industrially organized production was also assumed to provide a lower cost than traditional construction, according to Boverket (2006) by 25% without an elaborate and detailed cost analysis (Boverket, 2006). A conclusion is that it was *too large, complex and lacked a systematic and detailed financial analysis*. The project's development was also strongly influenced by people who lacked knowledge of, training in or experience in industrial construction (Boverket, 2006). Some of the involved persons also had no desire to take part of the system thinking that the concept was based on. There are also indications that many saw the project as synonymous with the heavy concrete systems used in the so called ‘million program’ back in the sixties. One experience is thus that there were *negative attitudes towards and lack of knowledge in industrial construction.*

Difficulties and problems associated with the industrial production system were evident through problems at the construction site that were related to the factory. Therefore, additional efforts were made to prevent problems at the construction site. Furthermore, functional measurements measures were not related to the transportation measurements and these caused (in some cases) limitations. The most serious problem on the site was the lack of weather protection of the prefabricated modules. Management did not take this seriously, which in some cases led to significant damage that almost jeopardized the project (Boverket, 2006).

The last project was a completely new concept in industrial production, with technology development during the project and application of logistical challenges. A request from the project was that the legally binding development plan would allow changed block- and house models as experiences from the project needed this, but this was not accepted by the Authorities. Instead, the level of detail was increased (Boverket, 2006). Understanding was not available for what a development project entails and its need for variation. This affected the project and its development in a negative way (Boverket, 2006). *Problems related to traditions, norms and regulations were thus another important lesson.*

3.2.2 Lindbäcks Bygg

Lindbäcks Bygg (LB) started in 1924 with production of wood in the winter and building construction in the summer. From the end of 1950 the business was concentrated on building production on the local and regional market. They had design, engineering and construction in-house, and for some work they hired subcontractors. During the 1980s, the company went into the real estate business by building and managing houses. Thereby, they got hold of end customer needs and requirements as well as the opportunity to meet and compensate for declines in demand (Nordin et al, 2010). In 1992 they started industrialized production of apartment buildings in wood via production off-site. Skills and expertise in the building construction area was rebuilt and sawmill operations restarted. A building system was developed consisting of prefabricated, standardized volume elements of wood with a high degree of completion (Nordin et al, 2010). When legislation in Sweden was changed in 1994 and wooden buildings with more than two storeys were allowed, LB built a four-story wooden house with prefabricated modules (Myhrsten 1994). The market grew to include Stockholm and Mälardalen. In 2006 - 2007 the plant was modernized and developed. Investment in a new factory hall was completed and the company focused on introducing lean concept in virtually the whole company (Åkerlund 2010). The company has won many competitions and contracts and is currently the leader in Sweden in its niche (Dahlquist, 2011, Hindersson, 2010, Gejrot, 2012).

One success factor for LB seems to be *a tradition and expertise in prefabricated construction* (Bengtsson 2001, Vallsten, 1999). LB began working with industrialization in the early 1990s and production of volume elements began in 1992. When the building regulations were changed LB had a head start since they worked with prefabrication and could apply it. They had extensive experience in construction, prefabrication and management, especially as a general contractor and they have used the material they know best, wood. They also had good knowledge of the market and its demands.

Apparently, another success factor seems to be a *sustainable and deliberate focus on the industrial processes, quality issues and coherence within the company*. LB has also in a sustainable, conscious and consistent way made efforts to develop and improve the industrial processes in their factories, mainly by introducing lean thinking and the lean philosophy. According to Åkerlund (2010), due to this, the company gained better control of their processes, the quality of their production and their products and lowered costs. LB also tried to control the earlier stages of the supply chain through close relationships with external suppliers and increase their control of raw materials, quality of the sawmill supplies and increase its cost control. By entering contracts at an early stage, often as a general contractor, they have been able to influence the design at an early stage and meet the requirements and conditions in industrialized construction.

Gradual development of construction is the last success factor. The development of the concept based on prefabricated volume elements has been an ongoing process since the mid-1990s. LB has focused on implementing the system in many small projects and has been able to develop both the product and the process gradually. They have successfully covered their development and investment costs (Olofsson et al 2011) and has throughout its development *collaborated with universities*, resulting in additional and even increased confidence in LB from both suppliers and customers, especially when it introduced its concept in the market (Nordin et al 2010).

3.2.3 NCC Komplett

With NCC Komplett, NCC wanted to take a technological leap with a new industrial process that could manage continuous improvements and productivity growth (NCC 2006A). The building system was developed to handle various projects according to the client's and the architect's wishes and the nature of the construction site. In other words, it was flexible and could cope with variations (Gerth 2008). NCC was assisted by industry experts from various companies, as well as researchers from different universities (NCC 2006 B). Internal NCC staff and architects also participated in the development work. Competencies in technology, IT support, procurement issues, logistics, and Just-in-time aspects were taken into account (NCC 2006 B). Development work continued for four years, and was surrounded by much secrecy. Many solutions also led to patent applications (NCC 2006B). The plant was inaugurated on the 25th April 2006 (NCC 2006 B) and then the concept was launched. In the factory, operators from the manufacturing industry worked. All production was order-driven and Just-In-Time was applied. After the launch, it did not take long before serious problems arose. In 2006, 400 apartments were planned, but only 50 were made (Dahlquist, 2007). The low production rate continued in 2007 and in late 2007 it was decided that the factory and the concept should be phased out gradually until May 2008 (Veckans Affärer, 2007). Until May 2008, about 300 apartments in 16 residential buildings were built with NCC Komplett. Until the end of 2007, NCC had invested and incurred costs of more than one billion Swedish Krona (approximately 150 million US dollars) in the concept (Veckans Affärer, 2007).

NCC made a bold effort but the material shows that there was *a lack of stamina at NCC*. In relation to the execution time, it was a *too big effort and leap in technology*. This has also been acknowledged within NCC (Leveranstidningen Entreprenad, 2008, Wallin 2008). The concept contained thinking that challenged and questioned the existing systems and approaches within the industry and within

NCC, which required major changes in many respects. In the debate after the concept had been closed, it has been argued that NCC gave up too early (Lind, 2011). These voices argue that if NCC had invested in the concept a few more years, they would have been able to increase quality, productivity in the factory, profitability and also continue with the concept.

NCC underestimated the problems of implementing changes in production methods (Lind 2011). NCC Komplett also quite promptly suffered from serious, *technological quality problems* (Lind 2011). These resulted in increased costs due to adjustments and additional work at site. NCC Komplett also used new and innovative technologies which further exacerbated the situation with problems and increased costs (Lind, 2011). Issues with their own processes and subcontractors that could not contain the demanded tolerances led to extra work, both in the factory and on construction sites (Dahlquist 2007). A further lesson is that *they offered too much variation* (Gerth 2008). The variation was too large for the production system and could not be used optimally (Westin 2007). Only a few modules were identical (Gerth 2008) and repetition effects on operating level in the factory became quite small and installation on the construction site took more time than anticipated. Overall, it can be said that NCC had *insufficient knowledge of industrialization*.

Besides introducing a new industrial method for the production of multi-family dwellings, NCC also initiated a process to achieve an integration of two business cultures, the culture of the Construction Company and the Industry Company (Gerth 2008). The company consisted of people with different knowledge, experience and approaches to industrial activities (Gerth, 2008). NCC Komplett used personnel with background in manufacturing both in the factory and at assembly on-site, but according to Wallin (2008), there must exist a basic competence with construction background for the assembly. Their *selection of staff and skills* are therefore a factor to consider. It is also clear that NCC had *unrealistic economic conditions*. The Swedish market is considered too small to make necessary big investments profitable (Lind, 2011). The quantities to be produced in relation to possible transport distances from the factory were over-optimistic (Lind 2011) and also material prices and purchase volumes (Wallin, 2008). The projected economies of scale turned out to be less than expected.

3.2.4 Peab PGS

PGS was first led by a project that started with defining and determining the key elements of the concept, for instance the standardization degree, standards in the system and responsibility for the design and installation of the system supplier (Unger 2006). Assembly of the system should be simple and the principle should be the same for all buildings. Drawings and final design must be finished on time. Based on customer requirements, two main systems should be used, where one was completely prefabricated and one partially prefabricated (Unger, 2006). The project continued with pilot projects, in which the concept could be evaluated and developed. Central grants from PEAB were possible for projects that were motivated to test the concept. The factory had to take a greater responsibility in the construction process than before. Lack of a strong tradition regarding the roles and responsibilities mad this possible (Unger, 2006). Methods were also added in projects on project initiatives, for instance Visible Planning that clarifies what the different goals are, how errors should be reduced and that planning and logistics should be streamlined (Apleberger et al, 2007, Nagenius & Kaldner, 2010).

The method resulted in less time spent on the project and completion on time. Based on these projects the work continued and PGS is now an established part of Peab with a shortened and simplified process and PEAB has until today built about 800 dwellings (PEAB, 2013).

To develop PGS has not been a straightforward process without barriers. In Unger (2006) it is said that barriers were identified in the implementation process. However, it is not always possible to access all the obstacles if they are not within the implementing actors' control. When you encounter obstacles, it is important to work actively to identify barriers and ways forward. One success factor is that *industrialization requires determination and stamina*. PEABs organization used decentralized decision making and managers were allowed to take autonomous decisions on their projects. The project team was due to this denied access to both data and pilot projects (Unger, 2006). Furthermore, after two years the project group was isolated from the rest of the organization and production was not organized as intended (ibid). However, the project members used personal contacts that believed in the concept and were able to bring pilot projects for testing. In order to succeed, *it is crucial with dedicated employees that understand and see possibilities.* It is also important to understand *the importance of formal power* to implement projects.

PEAB could centrally allocate money to development projects, which was crucial since project managers had financial responsibility for their projects (Unger, 2006). It is therefore important to *see development projects as such and not common projects* with normal financial responsibilities. T*o test the system in pilot projects* seems to be a good way to work, especially since *industrialization involves changes in technology, processes, organization and responsibilities*. The project also shows that *traditions and practices* need to be taken into account. The development of the concept led to changes in the activity structure between chain operators and changes of milestones. The factory wanted decisions of the structural system and its design clear at a certain point with as small changes as possible in order to allow sufficient time for the manufacturing and efficient production. PEAB established ways of working during the design and construction on the building site meant a parallel design of product and production system.

4. Summarizing discussion – conclusions

The four concepts studied differ in many ways and the identified success and failure factors are different. Based on the collected material in the study a summarizing discussion is presented with an attempt to draw some general conclusions. We do this by assigning factors of success into three main areas:

(1) **Factors related to the concept and its development**
The prospects for success in the launch of a concept is strengthened greatly if this is developed through several small projects. This is accentuated if the concept is complex and represents a major technological leap. A gradual development of the concept through several small projects is therefore a key success factor. This provides the possibility to gradually solve the problems that arise and refine the concept from project to project. It provides the opportunity to develop technical details and production processes both in the factory and at site. For this success factor to take effect, requires

stamina and determination from the concept's owner.

Industrialized construction differs in many ways and in several important respects from traditional construction. The development of a concept also means that many different problems, technical and process, need to be solved. It can be difficult for a company to address these issues on their own. Given this, a well thought-out and long-term cooperation with universities is a success factor in the development of a concept. Such cooperation also provides greater opportunities to develop a concept and apply industrial development thoughts and tools such as lean production.

(2) **Factors related to economic conditions**
A successful launch of a concept presupposes that this is based on a realistic and systematic economic analysis. In this it must be taken into account that industrial construction has completely different preconditions and a totally different economy than the traditional construction, since high investment costs need to be distributed on many fabricated units for a number of years.

Launching a new concept obviously implies a risk for the company behind the concept. Risk exposure is greatest for a concept with a great technological leap that requires significant investments in a fixed production facility. Risk exposure also increases in proportion to the size of the construction project to be built. With regard to these economic risks a gradual development of the concept through several small projects is advantageous. This gives also the company the possibility to gradually obtain better knowledge and grasp of the concept's economy.

(3) **Factors related to knowledge and knowledge transfer**
Industrialized construction involves work within two spheres, traditionally separated from each other, the manufacturing industry and the construction industry. For a concept to be successful, it means that new knowledge must be transferred between these spheres. Successful development of a concept thus requires knowledge of the construction site, its methods and its prerequisites. Conversely, a construction company that wants to engage in industrial construction has to obtain and spread knowledge about the concept industrialization and the conditions for industrialized construction among its employees.

A company that has knowledge about and experience from all the stages in the construction, from design to facility management is especially well equipped to successfully launch a concept. As a facilities management company, it has knowledge of what the end customers, the residents, want, and are able to adapt the concept and the project after that. As a construction company it can attempt to enter early in the construction process and provide governmental agencies and clients understanding of the concept's potential and advantages.

Further research
The material presented in this paper is a start for a larger study on success and failure factors for industrialized construction. Since this research is based solely on literary sources further research shall be based on interviews and other data sources to cover gaps in the information about the development of different concepts, but also to bring complementary general information. This will allow the initial findings to be tested and the three areas developed further. Combined this will help

with learning from success and failure in industrialized building, which should help to inform further developments in this area in Sweden.

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Cross Discipline Knowledge Transfer for Concurrent BIM Adoption in an Engineering Organisation

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Abstract

The use of Building Information Modelling (BIM) in the design environment has been widely discussed within the field of construction. However, its effective use requires that all contributing designers meet the technical capabilities necessary to use this environment. A reliable development process utilising BIM to its full potential requires concurrent advancement of multiple disciplines working collaboratively. An investigation into how different disciplines are advancing their BIM capabilities within a multidisciplinary engineering consultancy is carried out to identify where improvements in this process may be made. New technology and process implementation are discussed and the construction industry's silo mentality is identified as a significant factor impacting this. The consultancy's BIM capability is evaluated through semi-structured interviews with discipline representatives involved in its implementation, outlining their experiences with implementation so far, and highlighting opportunities for greater knowledge transfer. Building Services and Physics were found to require most development as a result of the complexity of modelling within these disciplines and the lack of projects involving all disciplines equally. Other disciplines were found to be more BIM capable, but these capabilities are often lowered due to reliance on external stakeholders. This study contributes to the justification of BIM implementation within building design development and identifies the need for more effective adoption across the industry as a whole, not just within discrete areas.

Keywords: BIM adoption, Knowledge transfer, Multidisciplinary organisations

1. Introduction

Building Information Modelling (BIM) is currently being implemented throughout the construction industry worldwide. In the context of this paper, BIM refers to the collaborative working environment facilitated by developments in technology to support the concurrent contribution to construction project during their design phase. UK government targets for BIM are due to be enforced in 2016 (Cabinet Office, 2011), and the construction industry requires vast changes to its practises and cross-disciplinary processes for these targets to be met. Adopting new practises is challenging, and the identification of key areas impacted by implementation is the first step towards facilitating a more effective transition to new working practices. The AEC (Architecture, Engineering and Construction) industry is slow to adopt new working practises, and though the identification of the need to do has been made clear (Egan et al., 1998), these changes have not been as forthcoming as previously hoped. This is confounded in BIM implementation where the entire industry is impacted by its adoption.

This paper investigates how a multidisciplinary engineering consultancy currently uses BIM, exploring its cross-discipline capabilities, to determine opportunities for a more effective implementation strategy. The objectives of study are defined as the identification of drivers for change bringing about implementation of BIM as standard practise, definition of the barriers to effective implementation, evaluation of the organisations current capability (establishing shortcomings of its BIM implementation) and redefinition of the organisations framework for BIM adoption as a collaborative working tool.

This forms the early stage of a larger EngD study investigating the use of BIM as a lifecycle building performance management tool, requiring the design team to input performance-impacting parameters into a BIM model for later extraction and use. Prior to this capability, the design stakeholder must first understand the impact of their actions on the holistic design process, leading to eventual building operations.

2. Research justification

2.1 Slow rates of adoption

Adoption of new technologies and processes in the AEC industry is often hindered by complex relationships between stakeholders affiliated with a project (Hosseini et al., 2013). Each has their own agenda and sometimes incompatible processes hindering cross discipline collaboration. This is confounded by the difficulties faced when operating in a collaborative working environment, where a legal framework governing the responsibilities and liabilities of all parties involved has yet to be fully defined. The industry as a whole understands its need to improve the way it works, using “lessons learned” systems to assist in the amendment of operations (Mitra and Tan, 2012). Collaborative working and interoperability have become buzz-words that show to other practitioners that an organisation has recognised its need to be more effective in the work it undertakes (Ilich et al., 2006); however, their meanings lost amongst the ease of maintaining existing practises.

2.2 Drivers for BIM adoption within the AEC industry

While market needs maybe considered the overall driver for change within a certain industry, ultimately the local government states the requirements that industry must meet. The Egan Report (1998) proposed aspirational targets to implement industry wide changes to processes in order to remain globally competitive. The government BIM agenda (BIM Task Group, 2011) informed by these reports requires '*fully collaborative 3D BIM (with all project and asset information, documentation and data being electronic) as a minimum by 2016'*.

Industry support for the implementation of BIM is widespread, with the RIBA 2013 Plan of Works, (the principle framework for project development management in the UK) recently revised to include BIM processes. However useful, industry initiatives provide guidance by which to develop BIM capabilities, but include little instruction in how to implement it in project settings or across entire organisations.

The organisations governed by industry standards and government regulation experience the benefits of BIM implementation (Liu et al., 2010), driving the organisational agenda put forward by its leadership team, and are representative of the driving factors of a typical multidisciplinary engineering organisation. The organisation assessed in this paper states its goals to be "*making BIM the default approach to building modelling and the production of construction information*" in order to increase efficiency and productivity and "*develop common standards across regions and disciplines to enable widespread adoption of the most effective techniques*". Successful adoption of a change in industry processes can be described using an iterative improvement cycle (Figure 1), showing that prior to change readiness, awareness needs to be attained. In stating its own targets, the organisation has taken the first steps towards deployment and improvement.

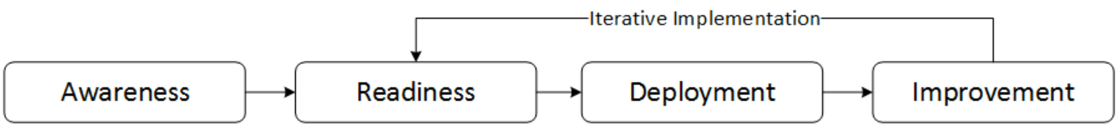

*Figure 1: Iterative improvement cycl*e

Disciplines within an organisation are subject to that organisations governance, but more reliant on its constituent individual's agenda. Within the organisation studied here, the capability each discipline performs at is unavoidably different, each developing their own capacity, specialising in distinct areas where the interoperability with other areas is an afterthought to the development of discipline specific standards. An ideal design environment would link all areas of development to bridge the silo developments to facilitate fully collaborative design and construction processes, where information is shared; however, this is still unobtainable given current industry legal and technological frameworks.

Arayici et al, (2011) suggest that careful consideration of individual experience can improve change adoption success by facilitating a bottom-up approach from within the organisation. This suggests that change adoption becomes a driver in itself, with innovation in one area spurring the implementation of new processes and techniques in another to meet the now more efficient concurrent practises.

2.3 Factors Affecting Successful Change Implementation

The successful implementation of new methods of work requiring consideration of people, processes and technology is well documented (Gu and London, 2010; Stephenson and Blaza, 2001). Some have suggested that it would be advantageous to include management in these elements to include changes to the structure governing these elements (Ruikar et al., 2005). Each of these elements are applied to the case study organisation to ascertain factors limiting its current adoption strategies.

Automation of inefficient practises will not yield a more efficient work process. Management of change is required to coordinate an entire organisation, and exists to consistently evaluate operations. Delegation of responsibility into hierarchical management systems and chains of command is necessitated by the convoluted working processes that organisations have developed (Josserand et al., 2006), and endorsement of systems and careful management of individual resistances can reduce many problems from the bottom up.

Processes define the way a certain task is completed and govern the interactions through which internal and external stakeholders contribute to a projects goal. Within the organisation assessed here, these have changed little over recent years, with the exception of partial automation. New processes need to be developed alongside technology adoption (Raineri, 2011), and existing processes must be rationalised with this reasoning supported by economic or efficiency gains. Attaran (2004) reasons that failure to identify ineffective processes almost guarantees an unsuccessful transition, potentially wasting resources improving a process with no reason to exist otherwise.

Individual resistance to change has been identified by several authors as a common hurdle to overcome when adopting changes (Gonçalves and Gonçalves, 2012; Henderson and Ruikar, 2010), and arises as a result of several factors. These could be previously negative association with change adoption or lack of perceived obligation to implementing such change

Technological capabilities define the capacity to adopt new technology, especially for integration with integration with legacy systems. Whilst easily met given the requirements for basic BIM implementation, the entire organisation needs to be able to access and use tools at an equivalent level of capability paralleled with its surrounding stakeholders. Concurrent access and contribution to a project by several stakeholders requires each contributor to work to common and agreed upon standards. Interoperability is slowed through incompatible systems, and the slowest link in the process is the one dictating the maximum output (Pala et al., 2012).

In addition to those described previously, factors such as product suppliers, specialist contractors and industry contemporaries outside the organisation have a large part to play in pushing and obstructing change. In the case study organisation, each discipline can work as separate units away from each other in order to carry out roles in different projects, but change implementation in each varies with influences from the discipline in which it occurs. External factors are especially impacting in the AEC industry, which requires collaboration between several partners in the delivery of complex projects, where the behaviour and requirements of one party affects the way that another works and contributes.

2.4 Silo Mentality

Fragmented approaches towards innovation and development within the construction sector are often attributed to its silo mentality (Froese, 2010), suggesting that concurrent development across all disciplines would lead to a more effective adoption strategy for new processes and technologies. In the context of project management, an engineering design may be considered a multi-project environment, involving different disciplines, each adhering to their own industry standards. In complex multi-project environments, the ability of a project manager to oversee development in all areas concurrently is limited (Patanakul and Milosevic, 2009), requiring delegation of oversight, and overlooking collective collaboration in favour of silo development.

Elonen & Artto (2003) go into detail, investigating the problems that multi-project environments can face and citing inadequate competencies at a project level and poor management of project-oriented business as significant problem areas, reducing overall capability. Within the AEC industry, Murphy et al., (2011) suggest that limited capability of project stakeholders plays a large part in constraining innovation and overall competency, furthering previous findings by Zou et al., (2007) in construction project environments. Sharing information between different disciplines offers the opportunity to implement new process/technology adoption (Arayici et al., 2011) as well as encourage the cross-discipline collaboration required to make BIM work.

2.5 Summary

For lifecycle BIM to be feasible, the capabilities in all BIM-based design contributing areas need to be consistent and equal. Sustainable building design is grounded in holistic design environments, where contributors to the design understand the needs and reasons behind others decisions. Synchronised project development may mean that the capability of one party to improve performance can be overlooked as a result of their incapability to contribute at the same rate as others. Using lessons from one discipline already using BIM in another at a lower level of implementation may improve the adoption rate through the pre-identification of potential pitfalls and problems that must be overcome.

3. Methodology

The organisation assessed in this paper contains disciplines operating both separately and collaboratively across a range of AEC projects. Its BIM capability is assessed following a two part investigation looking at project-based BIM implementation, and responses from semi-structured interviews with representatives of the organisations constituent disciplines describing their experiences in using BIM. The implementation structure for the organisation assessed within this paper is shown in Figure 2, enforced by a leadership team to which each discipline reports, while comprised of project teams.

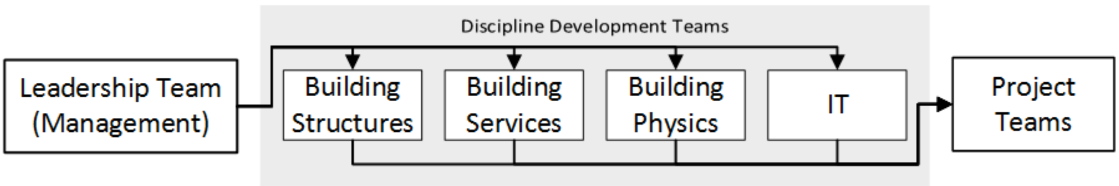

Figure 2: Organisation BIM implementation teams structure

3.1 Project-Based BIM Implementation

The first investigation scored exemplar projects according to their use of BIM concepts, technologies and processes against criteria defined in the NIBS (2007) Interactive Capability Maturity Model. Capability and maturity may seem interchangeable in the context of BIM implementation, but have different definitions (Succar et al., 2012). Capability describes the ability to perform a specific task or function, whereas maturity is the degree to which that capability is implemented.

Table 1: Project-Based BIM Implementation Results

Discipline	*Intelligence of modelled data*	*Interoperability*	*Data Exchange*	*Workflow*	*Cost data*	*Time data*	*Spatial location*	*Life Cycle*	*Customer Involvement*	*Organisation Score*	*Team Score*
Structures	*3*	*2*	*2*	*1*	*1*	*0*	*2*	*0*	*2*	*1.75*	*0.90*
	2	*2*	*1*	*0*	*1*	*0*	*2*	*0*	*1*	*1.50*	*0.60*
	2	*1*	*1*	*1*	*1*	*0*	*2*	*0*	*1*	*1.50*	*0.60*
Building Services	*2*	*1*	*1*	*1*	*1*	*0*	*1*	*0*	*1*	*1.25*	*0.60*
Average	*2.13*	*1.50*	*1.25*	*0.63*	*1.00*	*0.00*	*1.75*	*0.00*	*1.13*	*1.50*	*0.68*

Four single discipline projects were identified for evaluation from the "Structures" and "Building Services" disciplines (a skewed representation of the whole organisations capabilities, but proportional to the makeup of the implementation teams). Results of this assessment are shown in Table 1.

While limited, the conclusions that may be drawn from this preliminary investigation are that representation of "Structures" in the development teams is greater than that of other disciplines, and representative of the BIM maturity shown. Organisational maturity is greater than team maturity including external stakeholders; where lack of capability from outside the organisation holds back the team charged with delivering that project. In addition, limited project scope reduces the ability of the team to meet a level of maturity that is not required of them. These findings were used to guide the targeted questioning used in the later interviews and help identify the limitations currently encountered when using BIM during design development.

3.2 Semi-Structured Interviews

Interviews with representatives involved in BIM development and application within the "Structures", "Building Services" and "Building Physics" disciplines were conducted, in addition to representatives of the "Management" team overseeing this, and the "IT" team implementing any system changes to necessary to facilitate them (see Table 2). Interview structure was based around four areas: the role of the respondent, their perceived discipline BIM capability, how they work with other disciplines within and outside the organisation and what they perceive to be the biggest barrier to overcome to move forward.

Table 2: Interviewee roles and disciplines

Interviewee	*Job title/discipline*
A	*Structural Technician*
B	*Systems Analyst (IT)*
C	*CAD & BIM Manager (Building Services)*
D	*Building Services Technician*
E	*Building Physics*
F	*Project Principal (Management)*

Understanding the organisation as it currently operates and identifying potential areas for improvement requires an opportunity for the interviewee to explain their reasoning. Respondent familiarity with the subject area is essential for an accurate portrayal of current implementation (Creswell, 2013), and those interviewed are members of the discipline development teams (Figure 2) meaning their understanding and experiences implementing BIM are established.

4. Interview Analysis

Thematic content analysis was used to categorize commonly encountered issues based on the NIBS (2007) categories. From these, common issues causing problems in implementing BIM throughout design development and across the organisation are identified, indicating the interviewee disciplines supporting these issues.

4.1 Collaboration

Interviewees A-D used the government definition of BIM, though all stated this was limited and BIM constitutes a number of definitions, primarily a process or series of processes more than a technology, indicating that individuals are prepared to experience reduction in efficiency prior to full implementation. Several respondents mentioned that general understanding of BIM by those not directly involved in its implementation was limited. While not impeding implementation, it highlights to need for the organisation to gain a thorough understanding of BIM as a concept rather than a technology.

Interviewee B identified that knowledge sharing between disciplines should be a forefront issue in BIM implementation, noting that the discipline divide often causes collaboration problems within small, non-integrated projects. In a project based environment the silo-mentality that forms between project teams and within discipline groups needs to be overcome for fundamental change to happen, where the goal of the teams should be to further overall capability and replicate beneficial developments made in one area across the organisation. Bosch-Sijtsema and Postma (2006) reason that innovation and development centred on a single project was difficult to distribute throughout the rest of the organisation and requires the support of all members of that organisation to transfer, echoing Interviewee B's point and suggesting that whole-project based environments advance process optimisation rather than innovation.

Several respondents mentioned the limited scope of collaborative works that should be prioritised during early design stages (Interviewees A & D). Interviewee D went on to enforce the notion that collaboration with less capable stakeholders can reduce overall design development due to their lack of competency (Interviewee D).

4.2 Information Transfer

Complexity of modelling for different purposes was perceived as too great for current BIM tools to manage (Interviewees A & E), with the scope for BIM integrated performance analysis (structural, energy, operations, maintenance etc.) resulting in common formats being unlikely to be developed. (Interviewee D). However, Interviewee B noted the possibility of using BIM as an information repository rather than a design/analysis tool, instead of the conventional industry norms of project extranets. Before this can be achieved, Interviewee C suggested that supply chain segregation preventing the effective gathering and storage of information for input into BIM environment would need to be overcome.

4.3 Standards & Interoperability

The use of proprietary formats within disciplines limit interoperability, resulting in additional work translating information (Interviewee A & F), but are required for discipline specific processes. Industry bodies specifying standards produce concurrent frameworks for implementation, but supply no integrated guide between themselves for use throughout the industry (Interviewee D) In-house standards will eventually overcome such limitations, e.g. standardised objects for use in multi-discipline models, but for extensive areas such as building services considerable work is required in developing these (Interviewee B).

4.4 Future Capabilities

Interviewee F complained that resources allocated to BIM implementation and development, were not being used successfully. Smith & Tardif (2009) identified ineffective resource use as a significant way that implementation is hindered within organisations. Interviewee D highlights that technological and process advancements take time to implement due to project length, requiring significant foresight by those overseeing change. Every discipline within the organisation is subject to this constraint and as a result, familiarity with existing processes can make alternative solutions seem more uncertain in comparison (Ford and Garvin, 2009).

4.5 Knowledge Transfer

Silo mentality is also apparent within the organisation, where development is limited to the development team with that purpose, and whose work is only noticed by other members of that team (Interviewee F). Better use of in-house knowledge and resources contributing to process improvements would benefit the entire organisation, not just the team that benefits locally. Interviewee C suggested that all members of project teams need to understand what is required of them and use the capabilities of other stakeholders to develop their own skills, but that some disciplines would require more disproportionate input from others.

5. Conclusions

Individual discipline capability varies, but is underpinned by a well-established "IT" infrastructure capable of change. "Management" requires more support to buy in fully to the idea of BIM as an efficiency improving process, while "Building Services" require the majority of work to meet the government targets. "Building Physics" currently has little interaction with other disciplines using BIM tools or processes, but foresees the benefits that could come with it as an information storage repository. Figure 3 indicates each disciplines current relative performance, but this does not account for project variation such as external stakeholder capability limitations and the availability of resources and training in BIM tools and processes.

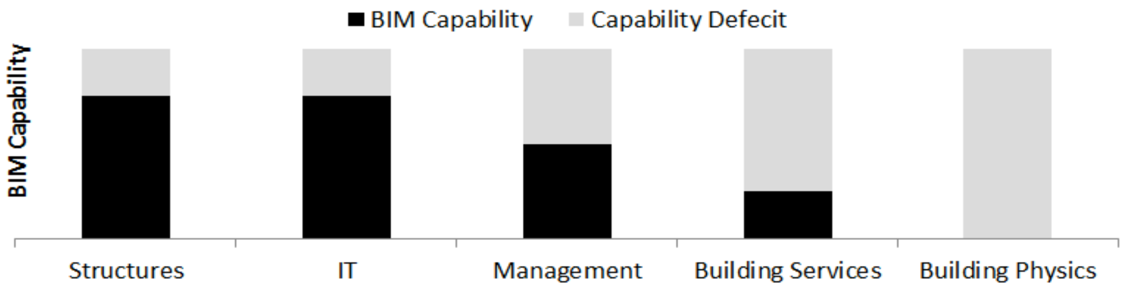

Figure 3: Relative discipline BIM capability levels

Recommendations for the improvement of BIM implementation within the organisation, also applicable to other similar industry practitioners, are that following standard processes at project onset would enable much faster progression than developing those processes in each project. Shared tools such as common object libraries and methods of exchanging files reduce unnecessary rework and improve progress effectiveness; however, these must be supported by those contributing to, and using them. This requires all project members to commit to a standard of practice at project onset. A recurring theme throughout this investigation was of the least capable stakeholder lowering the capability of entire project teams. A common standard of ability should not just be expected within the organisation, but with external collaborators, whose commitment to a common standard can reduce rework, slowdown and error. Skill sharing between disciplines outside of collaborative projects should be more prevalent within the organisation. It is evident that in organisations where each discipline has its own specific projects, opportunities for this knowledge transfer are limited; however, BIM is changing the design environment, affecting all members of the organisation. It would therefore be beneficial for all employees to understand what is expected of them once it is part of standard practises.

6. Future Work

Drawing from lessons learned during this investigation, further research will be performed on the implementation of cross disciplinary information sharing using BIM between building energy performance simulation, and the design of building systems requiring input from these simulations. Research related to performance management of buildings using this BIM embedded data will also be performed.

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Deficient Housing: Development of a New Theoretical Perspective on Poverty Traps

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Abstract

The right to adequate housing for all human beings is universally acknowledged as not only sacrosanct but an inevitable ingredient for economic, political and social development. Regardless, hundreds of millions people in developing nations are presently without adequate shelter, leading to increased vulnerability to socio-economic inequality, poverty and hazard events. This study proposes a new way of framing the debate on poverty traps, specifically adding deficient housing as a significant trap to those already discussed in literature; conflict, dependence on natural resources, and bad governance among others. The paper takes an incisive look at the causes and effects of deficient housing on occupants and demonstrates, through the development of a strategic framework, how conditions of poverty cause deficient housing to be built in the first place but also how people living in poverty are mostly likely to build deficient housing. The paper concludes by advocating for specific measures, and providing guidance for policy makers, NGOs and other stakeholders for rapid implementation so as to significantly facilitate an improvement in standards of living for those caught in such poverty traps. This study contributes to knowledge in the area by proposing a novel perspective on poverty traps, bringing built environment professional expertise and innovations into the equation and targeting shelter as a vehicle of change.

Keywords: Poverty, Traps, Deficient Housing, Developing Nations, Built Environment, Shelter

1. Introduction

It is a well-known fact that more than one billion people worldwide are living in extreme poverty. More than three billion people live on less than 2.50 dollars in a day (Chen and Ravallion, 2008). This phenomenon is the principal cause of hunger and malnourishment (FAO, 2009). Poverty claims the lives of 25,000 children each day and nearly 1 billion people entered the twenty-first century unable to read or even sign their name (UNICEF, 2000).

The major causes, consequences and solutions to poverty have been the subject of sociological and political debate for several years among philosophers. In most economics literature, forums and the media, the stated causes of poverty include the failures of both government leaders and aid agencies, as well as the adverse impacts of overreliance on aid, lack of education, overpopulation, epidemic diseases and geographical barriers (Easterly et al. 1997; Sachs, 2005; Carter et al. 2006; Paul 2007;).Most families in developing countries are stuck in a poverty cycle as a result of low levels of income, productions, development, savings and economic growth (see figure 1).

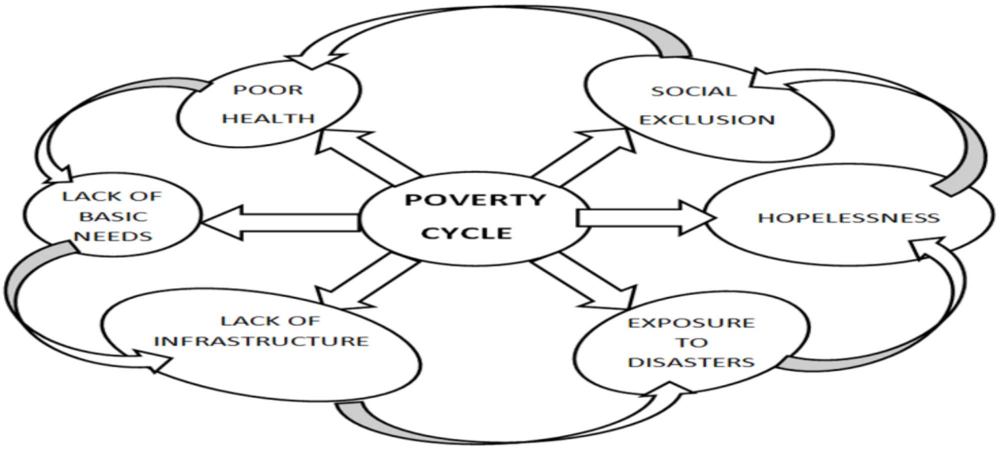

Figure 1: Poverty Cycle (Author's Expression)

Many scholars have referred to these hopeless situations as poverty traps but with different interpretations. Azariadis and Drazen, (1990) define poverty traps as "*self-reinforcing mechanisms that act as barriers to the adoption of more productive techniques and so cause poverty to persist*" (pp501-526). Meanwhile, Carter and Barrett (2006) argue that it is a critical minimum asset threshold, below which families are unable to successfully educate their children, build up their productive assets and move ahead economically over time.

The poorest countries are trapped in a downward spiral of economic and social decline based on factors ranging from conflict, dependence on the export of natural resources, landlocked with bad neighbours (Paul, 2007) to lack of infrastructure, political instability, geographic barriers (Sachs, 2005) as well as infectious diseases (Gallup and Sachs, 2001; Bloom et al., 2003; Bonds et al., 2009), and environmental degradation (Ogwumike and Ozughalu 2001).

Unfortunately, a formidable and significant factor of poverty traps that has not previously received significant attention is deficient housing, which is ultimately, a good indicator of poverty level. Olotuah, (2012) asserts that poverty does not only limit the ability to acquire life's basic amenities, it also restricts the choice of living environment, which is why the poor are compelled to live in insanitary conditions. The lack of safe and healthy housing contributes to an overall reduction in health outcomes among the poor.

Aderamo and Ayobolu, (2010) argue that a deficiency in housing can profoundly affect the health, welfare and productivity of man. Tracy, (2013) is of the opinion that until housing crisis in most developing countries is remedied, other social problems will be inadequately addressed. Families will continue to lose the battle against crime, poor education, inadequate nutrition, decaying neighbourhoods, insufficient health care and welfare dependency.

In a 2003 report, UNESCAP described the relationship between poverty and housing for slum dwellers as follows:

"Other problems of the Asian slum dwellers include their inability to grow assets under abject poverty, crime and hardships (such as collecting water, removing solid wastes, bringing children to school on foot), which take away much of poor peoples' time, making assets generation difficult, if not impossible. Unless, therefore, they are able to get out of the poverty trap it will be difficult for these 498 million slum dwellers to make significant improvement in their living conditions". (UNESCAP, 2003: 6)

2. Definitions of poverty

The definitions of poverty have been addressed in different perspectives. Nyasulu, (2010) argues that each definition has been a product of the interests championed by the defining groups. These multiple definitions can appear to be conflicting and misleading, an indication of the obscurity of poverty (Slim, 1995; Ife &Tesoriero, 2006).

Poverty can be defined on income-based approach (UN, 2011), on basic need approach (Townsend, 2006), on capabilities approach (Sen, 2001), inequality approach (UN, 2005; DFID, 2005; World Bank, 2006; UN, 2008) and Human Rights approach (UNHR, 2005) among others.

Whatever the exact definition, more than one billion poor people around the world are characterized by lack of adequate and appropriate housing-mostly in poverty clusters and squatter settlements-(SEU,1997; DSS,1999; UNESCAP, 2003; Olotuah, 2012), malnourishment and hunger (FAO, 2009), inaccessible to clean water and lack of basic sanitation (DFID, 2005), homelessness and inadequate housing; social exclusion; ill health; lack of access to education and poor sanitations (UN, 1996; Yap, 2003; WHO/EUROPE, 2006; Schmidt et al., 2008; UN, 2011).

3. Relationship between poverty and Deficient Housing

Poverty and deficient housing are strongly linked by an abundance of evidence. Torrico, (2009) argues that research has shown a link between poverty, homelessness or substandard housing. It is a daunting task for people who live in extreme poverty whether in urban neighbourhoods or rural villages to improve on their housing conditions. More than forty percent of inhabitants in the developing world are informal settlers. Most of the inhabitants suffer from multiple deprivations (UN-

Habitat, 2003a). Loewen and Lepage, (2003) argue that impoverished segments of local populations that are faced with burden of unemployment; crime, inadequate housing and poor health are trapped in cycle of poverty.

4. Causes and effects of Deficient Housing

Deficient housing is synonymous to housing conditions that are inadequate and unhealthy. It is inadequate when the necessary requirements in building codes such as legal security of tenure, functionality, and structural stability, among others are not met. It becomes unhealthy when occupants are most likely to be exposed to risk related respiratory conditions from poor air quality resulting from dust, dampness, mould, overcrowding, poor ventilation and sanitation.

4.1 Causes of Deficient Housing

i). Poverty, Unemployment/Low level of income: Globally, Over 100 million people are homeless today and over a billion people are living in deficient housing as a result of poverty, unemployment and low-level income. Calderon Cockburn, (2001) argues that inadequate housing in Latin America and Caribbean is largely attributed to state of poverty, low household income and unemployment. More than 200 million people are unemployed worldwide and expected to increase to 208 million in 2015 (ILO, 2013).

ii).Insecure of Land Tenure: Deficient housing which is mostly self-made, squatter or informal settlements with critically poor housing conditions, epitomize tenure insecurity in a very visible form. Raquel Rolink, United Nations Special Rapporteur affirms that *"Access to secure housing and land is a prerequisite for human dignity and adequate standard of living, yet many millions of people live under the daily threat of eviction"(*UN-HRC, 2013).An estimated 90 percent and 50 to 70 percent of rural and urban land in Africa are unregistered respectively (UN-Habitat, 2008).

iii).Rural–Urban Migration: The rapid urbanisation that we are witnessing is attributed to both natural population growth, and rural to urban migration. This huge increase amounts to a crisis of unprecedented magnitude in urban shelter (UN-Habitat, 2003b). This has contributed to the growth of informal settlements dominated by the poor in unsuitable deficient physical environment.

iv).Displacement based on natural and man-made disaster: Displacement can be caused by development projects, natural disasters, war and conflicts. According to the Centre on Housing Rights and Evictions, over 18 million people are displaced worldwide. This is as a result of planned forced evictions from their informal settlements between 1998 and 2008.The lack of tenure security on squatter settlements usually coincides with a risk of eviction (UN-Habitat, 2003c).The occupants of deficient housing are not only under threat of eviction, but are vulnerable to all types of disaster. They are not only psychologically weak but the situation also discourages them from maintaining or improving their terrible dwellings (Yap, 2003).

4.2 Effects of Deficient Housing

i).Incidence of Slums and Environmental degradation: The formation of slums is attributed to financial incapability of higher population of the urban dwellers to afford decent housing. Slums are manifestations of the two main challenges facing human settlements development at the beginning of the new millennium: rapid urbanization and the urbanization of poverty (UN-Habitat, 2003a). The outcomes of these developmental processes are diverse urban problems ranging from overcrowding, deplorable environment, poor living conditions, inadequate and poor infrastructural services, homelessness and other related problems (Jiboye, 2009).

ii).Poor Health: Housing quality and its environment play a major role in the health condition of the occupants. There are growing body of evidence to that effect. Deficient housing conditions may trigger poor health conditions which are multidimensional in nature (Jackson, 2003; Bonnefoy, 2007).WHO/Europe, (2006) affirm that *"Ten housing-health linkages are considered to have some evidence for quantifying burden of diseases"*. These include: Physical, chemical, biological, building and sociological factors.

iii).Vulnerability to natural hazards and disasters: Most occupiers of deficient housing and locations that lack basic services such as adequate water supply, sanitation, drainage system among others are highly vulnerable to hazards and disasters. Dayton, (2006) argues that poor people living in deficient housing, often on marginal land (like the *favelas* surrounding Rio de Janeiro) are greatly susceptible to disasters. Savings and insurance are not available to low-income households if they are hit by a shock. The poor cannot as readily escape disaster zones (as was dramatically apparent in the wake of Hurricane Katrina in New Orleans in 2005).

iv).Social Exclusion and Inequalities: Deficient housing and homelessness are good examples of poverty and social exclusion. A group of people or a geographical area is socially excluded if prevented from participating fully in economic, political and cultural activities of citizen in the society as result of combination of linked problems such as unemployment, low income, lack of basic competencies, poor housing, poor health and high crime environments among others (SEU, 1997; DSS, 1999; Burchardt et al., 2002; DFID, 2005; EUC, 2010).Another experience of socially disadvantaged people is the feeling of being neglected, isolated their areas as 'wrong part of town' or 'spatially excluded', and inaccessible to the public services (DFID, 2005; McDonald, 2011).

5. Strategic Framework Development

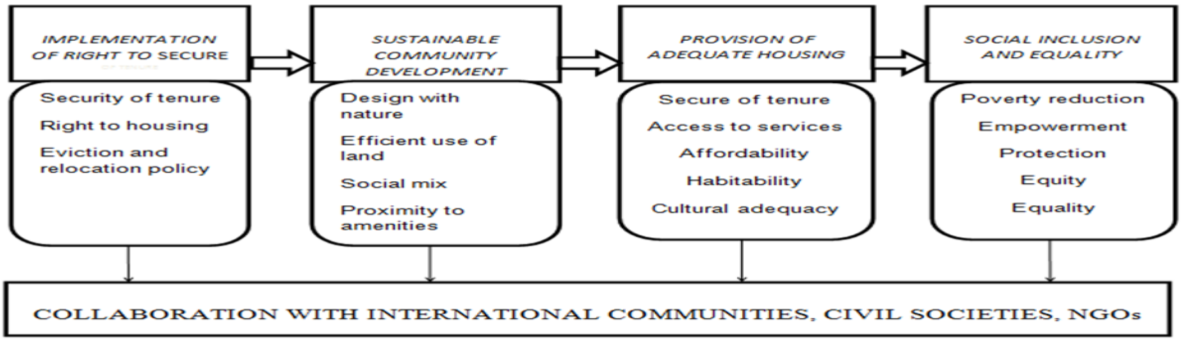

Figure 2: Strategic Framework Development

5.1 Implementation of right to secure of tenure

The access to secure land and housing is a prerequisite for reducing poverty and granting it alone does not solve the problems of poverty, deficient housing and unsafe living environment, though it is one the important steps ensuring successful shelter strategy (UN-Habitat, 2003d; Payne et al., 2012). The UN-Habitat/UNESCAP report (2008:Vol3:1) affirms, *"Without land, there can be no housing. And without looking at the issue of land, there can be no meaningful discussion about how to solve the problems of housing for the poor in our cities. The inaccessibility of decent, secure, affordable land is the major reason why there are so many slums in Asian cities and a contributing factor to urban poverty"*.

Payne et al., (2012) suggest best practices and approaches towards secure tenure: i) Prohibition of any form of discrimination in rights and access to land through amendment or formulation new laws and policy. ii) Prohibition of forced evictions by local laws, provide legal aid and simplify court procedures in case of violation. If eviction is inevitable, an option of relocation must be provided for occupants before the exercise (UN-Habitat, 2003c).iii) To recognize and treat informal settler as having a 'right to city' and include them in planning and decision- making with emphasis on social and gender equity. iv) Creation of more innovative land registration systems and appropriate instruments for best results.

5.2 Design of sustainable neighbourhood /community development

An efficient sustainable community or neighbourhood is where a variety of housing types are closer to workplaces, schools, parks, shops and other amenities, making walking and cycling more convenient (US-EPA, 2012; Welch et al., 2011).The most effective principles for sustainable neighbourhood or community planning are highlighted by US-EPA, (2012) AND UN-Habitat, (2013).These include: *i) Adequate space for streets and an efficient street networks***:** The street network should occupy at least 30 percent of the land. *ii) Use of land efficiently:* Neighbourhood that make efficient use of land limit the spread of suburban sprawl. *iii) Design with nature:* To protect local environmental quality, new development should be planned in a way that is sensitive to its natural settings. *iv) Social mix:* The availability of houses in different price ranges and tenures in any given neighbourhood to accommodate different incomes. *v) Mixed land –use:* At least 40 percent of floor spaces should be allocated for economic purpose in any neighbourhood.

5.3 Provision of adequate housing

Housing is a fundamental human right; the lack of adequate housing has a significant impact on poor people's livelihoods affecting their health, social, political and economic outcomes. It is a catalyst for poverty alleviation that cuts across almost every other indicator for human development (UN-Habitat, 2005; HFHA, 2013).

According to UN-Habitat, (2009), adequate housing is more than just a shelter or four walls and a roof. These are the features of adequate housing: *i) Secure of tenure* – Legal protection against forced evictions and harassment must be guaranteed. *ii) Availability of services and other facilities:* These include safe drinking water, good sanitation, refuse disposal, lighting and energy for cooking. iii) *Affordability:* The house costs should be compatible with the income levels of occupant or subsidises. i*v) Proper location**:*** The house should be in proximity to hospital, schools and transport. *v) Habitability:* Adequate space, protection from cold, damp, heat, rain, wind or threat to health should be provided. *vi) Cultural adequacy***:** The expression of cultural identity and way of life should be guaranteed in adequate housing.

5.4 Social inclusion

Social inclusion is a requirement for citizen participation in deliberation, decision making, execution and monitoring of government policies in a society without denying a voice directly or indirectly to be heard (Silver, 2010). Cappo, (2002) defines a socially inclusive society as a concept where all people feel valued, their differences are respected, and their basic needs are met so they can live in dignity.

OECD-DAC, (2001); DFID, (2OO5) and EUC, (2010) agree that social inclusion can be achieved by tackling social exclusion through poverty reduction. These are summarized as follow: i) *Economic development* - Creations of decent jobs, adequate housing for hall, better livelihoods and higher income. ii*) Human development* -Improvement on health status and Education advancement without discrimination. iii) *Political development* - Creation of legal, regulatory and policy framework that will enhance political participation, empowerment and rights. i*v) Social-cultural development* - Recognition of status and dignity of all citizens. *v) Protective life* - Protection of all citizens particularly the vulnerable people from risk.

6. Conclusions

Deficient housing has a significant impact on social, political and economic outcome for the global poor. There is clear evidence that poverty and deficient housing are strongly linked. While poverty causes inadequate housing, inadequate housing is also a causal factor of deepening poverty (Tracy, 2013).

Building deficiencies such as lack of protection from weather, insecurity, exposure to health disaster, poor light and ventilation, as well as lack of access to public services limits a household's ability to break out of poverty trap. These deprivations incapacitate him to generate income, secure education for his children and further take away his respect and dignity in their community.

Adequate housing is one of the effective means to reduce poverty as affirmed by Adarkwa, (2010) based on his research. He concludes that an improved housing and poverty reduction are strongly related because housing is the most expensive item in households' expenditure budget. It further puts more pressure on already insufficient income and eventually results into manifestation of spatial patterns (housing –induced poverty).

Having critically unmasked the fundamental causes and effects of deficient housing on occupants, the authors propose a viable strategic framework that can significantly facilitate an improvement in standard of living of inhabitants of poor housing. It advocates an improved investments in housing environment so as to improve their well-being especially access to basic social services such as clean water and good sanitation.

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The influence of BIM on the responsibilities and skills of a project delivery team

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Abstract

Building Information Modelling (BIM) is an emerging approach to construction that combines the use of virtual models and the principles of mutual information sharing to establish a collaborative environment in built environment projects. It is currently the subject of much discussion, among which is how it might affect the interaction between traditional construction project roles. This study focused on viewing the demand for positions that operated in a BIM setting to evaluate a set of roles that will be found in teams in the future. By analysing over 300 job adverts and comparing the findings with observational and conceptual literature, the research determined a set of management, coordinating and technical role types that interacted with BIM either directly or by proxy. The summary of this set should provide an increased understanding of the changing shape of built environment project teams.

Keywords: Building Information Modelling (BIM), Project Teams, Collaboration, Project Roles, Team Interaction

1. Introduction

The Cabinet Office (2011) states that BIM utilises "a fully collaborative 3D environment, so that all of those involved in a project are working on a shared platform with reduced transaction costs and less opportunity for error". It is being officially encouraged by the Cabinet Office (2011) as a route to improving efficiency in the industry: "Government will require fully collaborative BIM level 2 as a minimum by 2016."

BIM is a worldwide initiative that is being adopted to varying extents internationally; Figure 1 below conveys a design consultancy's assessment that the UK is not among the leaders in embracing the process. The WSP Group (2013) currently consider that Britain lacks enthusiasm relative to some other nations and attributes this to construction firms expressing "scepticism" of the government's implementation policy and doubts about the software packages currently available. Francis and Quigley (2010) agree that while there is plenty of dialogue the actual uptake by contractors is limited, asserting that "there are often misconceptions about what BIM truly means".

Figure 1: A view of international BIM uptake (Source: WSP Group, 2013)

Among the list of explanations for a muted interest and implementation such as difficulty of investment, one noted explanation is the complexity of transitioning an established firm away from its existing methods. Despite this, Aouad and Arayici (2010) claim that "networking, collaboration, information sharing and communication will become popular and critical issues in the future", which Arayici et al. (2011) build on by emphasising as a central theme the argument that "implementing BIM effectively requires significant changes in the way construction businesses work at almost every level within the building process". With this understanding, this research seeks to utilise theoretical study to investigate the extent of change required.

2. Aims and objectives

The aim of this research is to study existing BIM jobs in today's UK-based built environment to infer and examine the present and short-term future structure of BIM, with particular reference to responsibilities and skills of a delivery team during the construction phase. In order to consider how a typical BIM-handling portion of an organisation could be shaped when the principles become more universally adopted this research will explore and interpret existing studies and documented knowledge of BIM-related skills and critically analyse the functions and overall skill coverage of a projected "BIM delivery team" by utilising and amalgamating the findings of the literature review with the research findings.

3. Literature review

3.1 The uncertain maturity of BIM

When integrated into a typical project delivery team, the scope of change BIM will bring is a topic of speculation among industry members seeking to meet the Cabinet Office's implementation requirements. Cramer and Quigley (2009) refer to industry analysts expecting that its adoption "will be the most significant new technology change since the transition of paper design to two-dimensional digital data". While outlining what would become the recognised Maturity Model, Bew (2010) calls BIM adoption an evolutionary process, while Khosrowshahi and Arayici (2012) put forward a roadmap to meeting maturity needs that features people issues and organisational culture.

BIM-caused differences will affect organisational structure and the responsibilities of the roles that make it up. This is a subject of particular concern for existing team members looking to adapt and survive. Hannon (2007) hopes that Estimators will be able to transfer their skill set to perform a foreseen "Cost Engineer" role, while Osan (2012) names aspects that BIM's existence cannot replace, including planning, management, and validation/quality control. Gallello (2008) describes qualities and lists skills to justify a titular assertion that a BIM Manager role is a "must have", and prior to referencing this Mihindu and Arayici (2008) suggest that early BIM adaptation places an emphasis on experienced project managers, designers and architects, but that the new specialised courses could make graduates appealing in these areas and resolve the skill gap.

Before examining roles the working environment itself needs consideration; as an unseasoned process there is yet to be a standard method of BIM operation. Lu and Li (2011) surmise that BIM's usage has yet to reach a "tipping point", while Jung and Joo (2011) draw parallels with earlier attempts of Computer-Integrated Construction (CIC) to highlight and discuss a need for practical implementation. Horwitz-Bennett (2012) provided instances where team composition depended on which fledgling BIM software was used, highlighting that analysis of future roles should consider the probable standardisation of such systems. Day (2011) challenges the current expectation of a single comprehensive model by calling it "a dream", segregating architectural and construction BIM models and remarking that today's clients expect to see 2D plans requiring an AutoCAD user to "tart up" each drawing that is exported from a model. Devaney (2013) goes a step further by claiming drawings are faster, cheaper and "in most cases … capable of including everything necessary for the typical client's needs".

3.2 Provisional BIM team qualities

The prevailing theme is that there is yet to be a conclusive understanding of the specific roles comprising a BIM team of the future. Taking a broad outlook, Frederiks and van der Weide (2005) split the performance of an information modelling project into two areas of expertise; Domain Experts who convert information into an "informal description" and System Analysts who "abstract from this description" to provide a formal explanation. A theoretical exploration of their communication suggests that over time the competencies of each develop and begin to overlap to the benefit of discourse. In a similar vein Sebastian (2011) investigates how processes are reorganised and roles changed by the inclusion of BIM, deriving five factors including synergy and consolidation for a successful collaboration that apply to a team structure as a whole instead of individualised functions within it.

Succar (2009) reverses the examination; instead of identifying a team-based set of human qualities and then scrutinising the skills required for each, he distinguishes three types of competency set (Technology, Process and Policy) for individual development with a view to BIM maturity so in a sense they could be viewed as the three pillars of BIM development, each partitioning into subsets of multiple low-level skills against which the composition of a project team could be measured.

3.3 Roles and responsibilities

One route to an understanding the requisite functions in a BIM-based team is to recognise the existing tasks that are likely to either remain largely unchanged, or evolve into correlating roles. Kymmell (2008) surmises "the three primary BIM-related roles that emerge from (a team selection process) are the BIM Manager, the BIM Operator, and the BIM Facilitator", correlating the first two to the existing Project Manager and Project Engineer roles (respectively) and terming the third to be "a bit like a knowledgeable BIM tour guide" to exist during an estimated transition period of 10 years before BIM is sufficiently adopted.

Ahamed (cited in Meckbach, 2011) disagrees that dedicated technical guidance will be necessary, while Barison (2010) agrees with the need for a BIM Manager as a "special role in the project team", listing a number of alternative job titles it has been known as. To diverge from Kymmell's notion of Operators and Facilitators, she dubs all BIM-using roles as BIM Specialists, before breaking these down into roughly eight defined positions – such as Modeller, Analyst and Consultant – and discussing the responsibilities of each.

Another necessary consideration for a BIM team's composition is to identify needs that shall emerge from its implementation. Azhar *et al.* (2007) consider that a centralised framework introduces issues relating to ownership of both a project's design as a whole, and information contributed towards it that may be licensed or proprietary. They conclude that these would need to be resolved to avert the risk of useful information being withheld. Porwal and Hewage (2013) explore this by reflecting on the productive and legal ramifications of construction parties' reliance on information contributed by other parties, and Reddy (2012) adds that a need for qualified approval of varying information will remain. These studies suggest a need for rights management, authorisation or oversight that was not as prominent in the traditional employer-contractor-subcontractor setup.

Emergent needs will not necessarily arise from interoperability or facilitation. Shennan (2012) notes that the responsibility for selecting and procuring construction items and materials has become increasingly delegated to contractors and subcontractors over time, but that the prospective use of BIM to specify these as part of a building's design model will see the task revert to being more centrally managed once again. Robson *et al.* (2014) agrees with his assertion that this will reduce costs, stating that 80% of a contractor's costs are from the supply chain, and highlighting that existing management functions in a multi-organisational process could be redistributed and may define jobs such as a redeveloped procurement role.

4. Methodology

This study used an alternative source of primary information to remove the shortcomings of conveyance and time limitations. Firms that are looking to recruit and restructure their operations with a view to increasing adoption of BIM advertise job vacancies for roles involved in its use. These listings are directly addressed to the people they seek to recruit, so their detail and wording will be a more thought-out "honest" statement of the competencies they require for the positions and the duties that these jobs are required to perform. By collating a significant number of advertisements as a matter of precedence and interpreting those by categorising their details into a set of inferred roles, this undertaking utilised desk-based research to achieve a more comprehensive understanding of its second and third objectives. This was realised by sorting the skill requirements needed for each role so they could be analysed further both individually and as part of an overall BIM team.

The study formed a quantitative text analysis as defined by Roberts (2000) to translate written information into data for the purposes of conceptual evaluation. This is useful to help eliminate concerns over ambiguous intent or meaning as the text being assessed originates from a high volume of different sources. Performing such an analysis using job advertisements is an atypical research approach, but not pioneering; Bellis (2012) employed the method to examine the role of Quantity Surveyors, viewing a smaller sample size in greater detail to fulfil a comprehensive appraisal of one role whereas this study requires a significant representation of multiple positions to assess them all.

An important understanding with this method is that the frequency of results are not a broad indicator of role spread; should half of the findings have been for positions described or allocated as a "BIM Co-ordinator", that would not suggest that half of a BIM team would be comprised of co-ordinators. By the same reasoning, it was necessary for the research to avoid making duplicate entries for one position advertised in multiple places. For this purpose a separate set of records was created to track a selection of identifying details (job titles, employers or recruiters, reference numbers, work locations and the start of job descriptions) against which every new result was checked.

4.1 Research process

The core procedure of the study was to locate unique job advertisements for positions within or related to the UK construction industry that made specific inclusion of BIM as Building Information Modelling. This was substantially conducted in two tranches covering an overall period of approximately 3½ months in order to obtain a sufficient volume of results within the allocated time period. Once a suitable role was identified its supplied information was interpreted to determine which identified responsibilities it had and which proficiencies applicants were required to possess, which were then logged onto a table of standardised categories so all findings could be compared in a controlled manner. This allowed a set of roles to be inferred where multiple results held recurrent patterns of sharing the same categories, which in turn allowed observations to be made using others.

The scope of the research dictated that its findings should not be limited to those with BIM included within their job titles or as the principal theme of their description. By its collaborative nature BIM is hoped to be widely involved among a project's parties from a topographical surveyor whose reports would be entered into a model to a project manager with responsibility for a development that is accomplished using it. Thus the study was carried out with the main criteria for inclusion being any built environment related position that mentioned participation in the BIM process either at present or with the intent to develop this as part of the role.

4.2 Procedural clarifications

In some instances firms or their approved agencies would issue multiple advertisements for roles located on the same site. Of these the textual descriptions from which the skill and responsibility classification was made were sometimes identical throughout the set; when this was the case they were recorded as a single entry with the differing job titles included so as to not create false patterns. Conversely when the descriptions differed the positions were logged as separate records as they were not only demonstrably separate roles but interrelated and co-operative with each other by the employer's intent which is beneficial to the research purpose.

Certain regular inclusions in a job description have been omitted from the categorisation process for the purpose of maintaining research focus. The most common of these are requirements pertaining to travel such as "car owner" or "driving license holder", which have been excluded as it is unlikely they could be related consistently to particular BIM based roles, and the function or experience requirement of "participating in projects" has too broad a range of interpretations to warrant inclusion, and could be considered implicitly true for virtually any built environment role.

Other categories have been simplified: When outlining an applicant's qualities adverts expressed phrasing ambiguity, many used separate lists for essential and desirable traits but most also provided others with textual descriptions such as "should possess" or "the ideal candidate would have" so as these cannot be objectively measured in terms of sufficiency all qualities mentioned shall be considered adequate for inclusion. Similarly the category for academic progress has been truncated to degree-level or above to the exclusion of the rarely-mentioned HNC requirement, and includes membership of any of the numerous professional bodies mentioned as those cannot be quantified against each other but typically require a degree. Lastly select software packages that were often stated to be "BIM software" or "BIM authoring tools" have been considered as such universally in this study.

5. Results and discussion

Each result was recorded by whether it met each of the job responsibility and skill / competency categories chosen by the study. These were initially identified from their presence in the first tranche of positions found and later refined by assimilating categories. Merges were made when two conditions were satisfied: When the matching jobs were near-identical, and when the functions were essentially inseparable in terms of their relation to the BIM environment, such as "staff training" and "staff testing". This ultimately provided for 42 responsibility and 20 skill categories which were allocated using the conceptual maps shown in Figure 2 and Figure 3 below into groups to provide an overview.

In total 508 advertisements were logged, which yielded 304 unique positions that could be recorded as results. Of the remainder 166 were duplicate listings and 38 were discarded; the majority of these were for jobs located outside of the UK or which used an alternative unrelated BIM acronym such as Budget Impact Models or Buying In Margin, although there was one instance of an advert with no description at all whose addition would have been pointless.

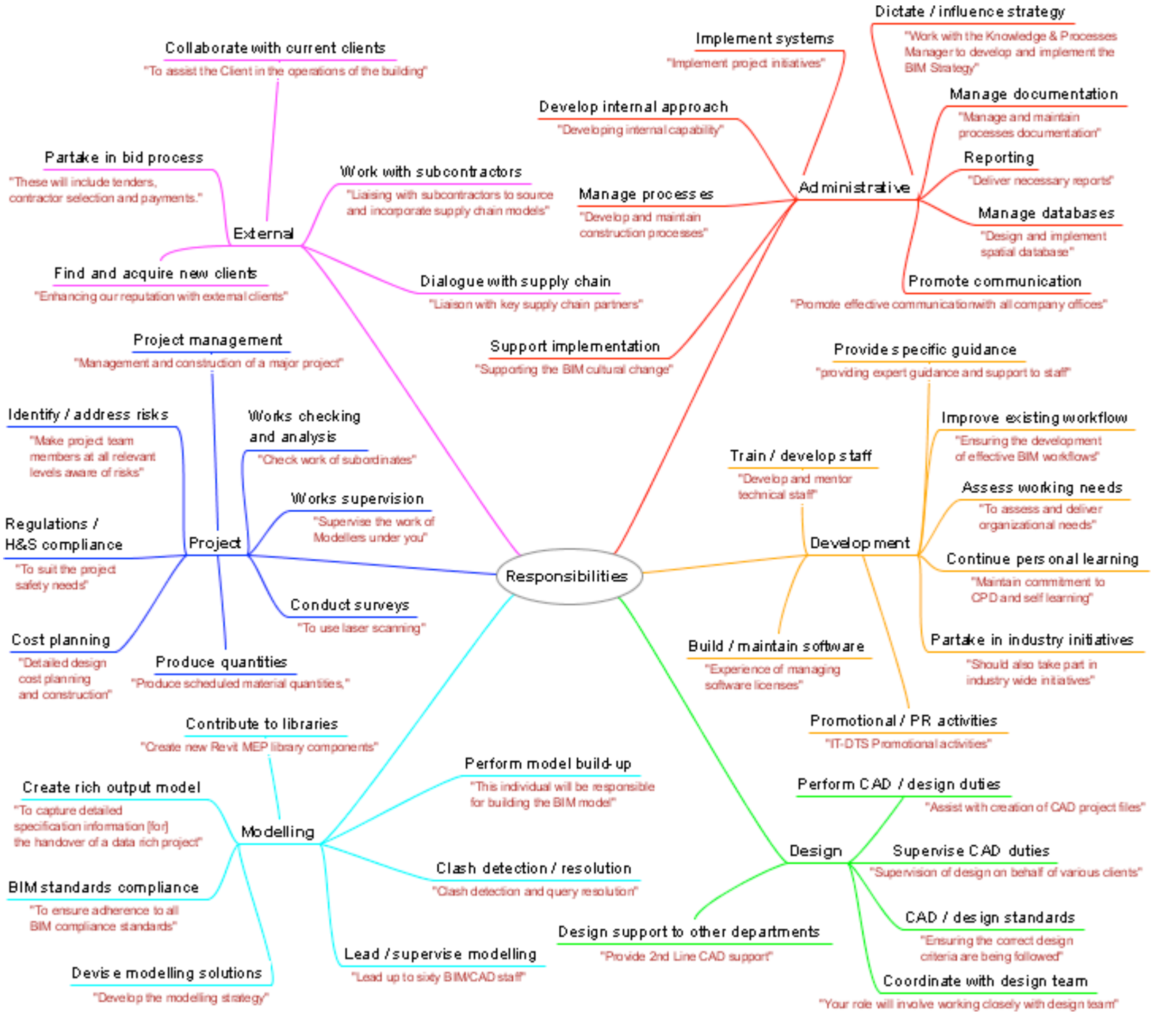

Figure 2: Responsibility concept map

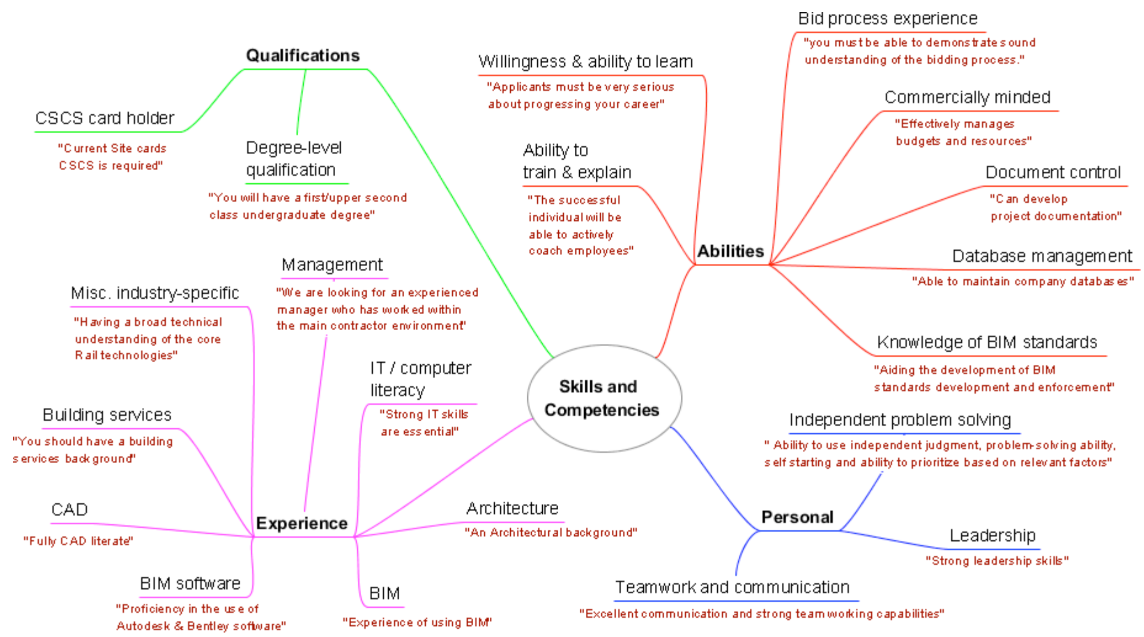

Figure 3: Skills and qualities concept map

5.1 BIM-targeted positions

79 of the unique positions recorded contained BIM in their job title, representing just over 25% of the collection. As these are the most purposefully stated to be BIM roles, they shall be used as a basis for comparison; after adjusting subtleties in their titles such as considering "BIM Revit Technician" as "BIM Technician", the initial breakdown of these jobs are shown in Table 1 below.

Table 1: BIM job title summary

Job title	Qty
BIM Manager	25
BIM Coordinator	16
BIM Technician	13
BIM Leader	5
BIM Engineer	4
BIM Architect	3
BIM Integrator	2
BIM Operator	2
BIM Consultant	1
BIM Designer	1
BIM Discipline Head	1
BIM Implementation	1
BIM Modeller	1
BIM Practitioner	1
BIM Sales Director	1
BIM Specialist	1
BIM Structural Draftsman	1

These were assessed by considering the spread of responsibilities to identify which appeared most frequently in the prospective employers' specifications. Shown graphically below for the three most prevalent titles, Figure 4 demonstrates adherence to the traditional notion that managers are primarily responsible for a range of organisational duties, and also agrees with Kymmell's (2008) assertion that a BIM Manager “can also include leading the project team through the BIM process on a personal level”. Meanwhile Figure 5 depicts technicians as largely focused on a specific performance aspect, in this case modelling, akin to Kymmell's BIM Operator.

On the other hand, Figure 6 depicts an almost even mix of administrative and modelling responsibilities for coordinators. This wide coverage suggests that a coordinator is a position with a universal set of duties required to simultaneously facilitate the transition into and aid the performance of BIM, which also matches Kymmell's (2008) impression of a BIM Facilitator as “a person who will function a little as the superintendent's assistant, someone who is at the construction site most of the time to help out with the model and other BIM-related issues”.

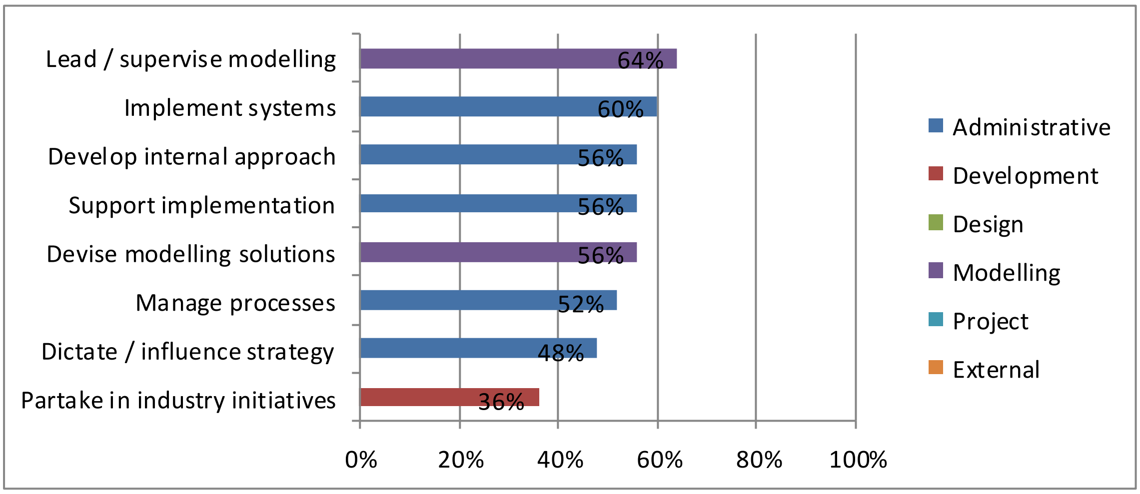

Figure 4: BIM Manager category matches (as a percentage of all BIM Manager results)

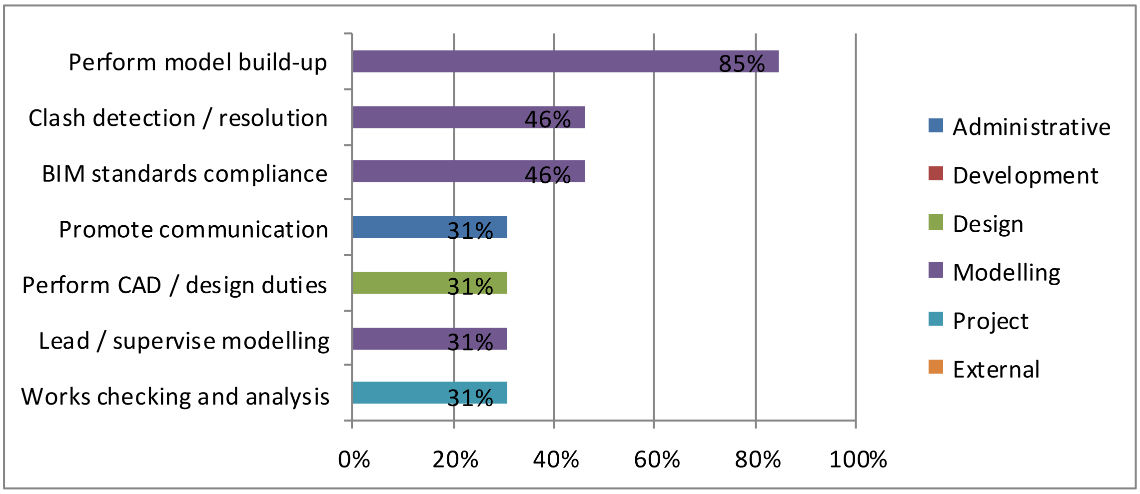

Figure 5: BIM Technician category matches (as a percentage of all BIM Technician results)

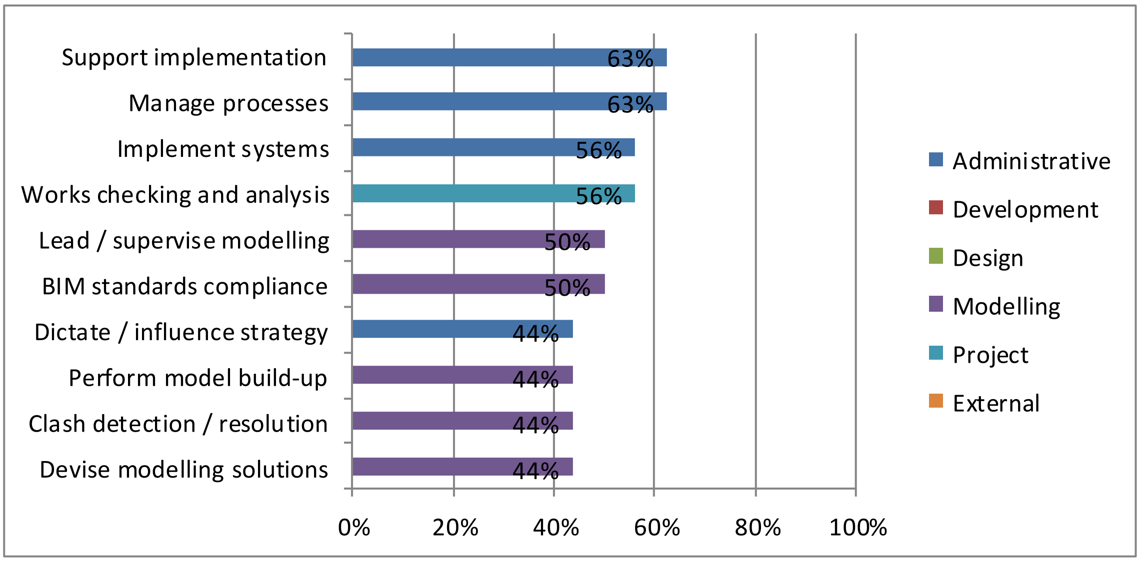

Figure 6: BIM Coordinator category matches (as a percentage of all BIM Coordinator results)

Thus far the findings of the study align with Kymmell's three "BIM Specialist" roles so this shall be adopted although with the Facilitator name replaced with that of the emergent Coordinator. The same form of greatest-responsibility analysis was extended to the remaining BIM-including titles and noted similarities were combined to form an initial profile of roles with distinct characteristics as shown in Figure 9 below. In addition to the three roles that retain the spread of responsibilities shown in Figures 6 through 8 above, this added a fourth form of role with a high use of Design responsibilities but virtually no Administrative or Development duties. Meanwhile one title was left out of this exploration as the BIM Sales Director position is exterior to a construction project team.

Table 2: Role classification of BIM job titles

Role	Kymmell Role	Job titles included
BIM Manager	BIM Manager	BIM Manager, BIM Leader, BIM Consultant, BIM Discipline Head
BIM Coordinator	BIM Facilitator	BIM Coordinator, BIM Implementer, BIM Integrator, BIM Practitioner, BIM Specialist
BIM Technician	BIM Operator	BIM Technician, BIM Modeller, BIM Operator
BIM Engineer	-	BIM Engineer, BIM Architect, BIM Designer, BIM Structural Draftsman

Besides the BIM-titled jobs are other subsets of results, most of which fit into the role classification provided by Table 2 in both name and matching responsibility. In particular there are 34 additional results that have used Revit, a proprietary software package marketed for use in BIM by Autodesk (2013), in their titles as though it were a synonym for BIM of which most translate into BIM Technicians. There are also 19 posts that focus on CAD with notable mention of hoping to evolve or facilitate to suit a greater BIM adoption strategy at a later date; some of these fit the mould for BIM Technicians and BIM Engineers, but others possess no direct BIM responsibilities either at present or in the planned future, meriting the inclusion of a CAD Technician role.

Beyond this the remaining roles are either an assortment of existing positions seeking to progress into attaining BIM operation tasks such as M&E Engineers, or project roles with no aspirations to conduct BIM directly but a recognised need to be conducted in or alongside a BIM environment either at present or in the planned future according to the company's level of development. Similar to the role allocation performed on the BIM, Revit and CAD named titles above, these can be broadly allocated into associative roles to be added to the classification.

Roles grouped into the Non-BIM Manager and Non-BIM Coordinator roles here comprise positions that have existed since prior to the emergence of BIM; these positions shared characteristics with their BIM-focused counterparts named above with their job descriptions essentially stating that BIM processes need to be adhered to without any specific involvement. 20 roles were grouped "Other" and disregarded as they either lacked project functions, for instance BIM software developers, or had them but did not appear enough in the results to warrant classification that would be significant. A further 9 had three or fewer responsibilities recorded and were similarly discarded as "Unclassifiable".

The biggest deficiencies found in BIM-led Manager/Coordinator job descriptions compared to "BIM-tolerating" Manager/Coordinator peers were found in cost planning, regulations compliance, risk management and project management. For Coordinators there was also an exceptional difference in client communication, which featured proportionally nearly four times as often for the non-BIM role. These disparities agree with Osan's (2012) reasoning detailed earlier and provide a clear distinction between the identified roles, for example to illustrate divisions between BIM Managers and Project Managers in the decision-making functions. This suggests the former are currently considered to be leaders of a necessary new tool set and not tomorrow's Project Managers; Frederiks and van der Weide (2005) may interpret the pair to behave as Domain Experts and System Analysts respectively.

This does not imply that a BIM Manager is simply an elevated technician with shifted duties, as their differences with other managers are similar to those with technicians in the Administrative and Development groups in which the latter are similarly lacking by their nature. Beyond that the descriptions for BIM Technicians themselves exemplify their independence, with one declaring "This isn't a role for a BIM manager but for a technician that can detail and model to an in-depth level" and another claiming that "Although BIM project experience is an advantage, this role would not suit a BIM Manager as this is a hands-on role which will be very focussed on Revit".

BIM Coordinators are expected to take Modelling responsibilities similar BIM Technicians, which is attributable to the former largely possessing many of them such as BIM standards compliance and developing modelling solutions, while the latter remain concentrated on simply building and administering the model. This is supported by some of the job descriptions themselves: A listed key requirement of one is "Experienced BIM modeller and potentially coordinator", while another position seeks a candidate who "Ideally previously held a post as BIM Co-ordinator … or a very experienced Technician". It is possible that when the technician role becomes more developed it shall take more of a coordinator's presently assigned responsibilities, for instance clash detection.

The broad range of duties found to be required of jobs currently titled BIM Coordinator requires its own examination. The detail for one of these highlights and attempts to justify this as it begins with the sentence "The Project BIM Coordinator is the most highly competent (BIM knowledge) member of the project team" although the size of the subsequent responsibility list seems more indicative of a “handyman” role. When viewed alongside the other BIM Coordinator descriptions, the lack of any one responsibility that appears consistently among them may also demonstrate a lack of clear consensus among employers about what the role actually entails.

6. Conclusion

The research has identified the three core role types that are likely to be found in BIM project teams. This does not represent a complete BIM team build-up, as that shall be adapted to suit the needs of the project itself. As the most frequent BIM-titled finding in the research, BIM managers already have a place in some project teams, and it seems unlikely that it would naturally decline when a position of authority will always be necessary to command the impending mandated work process. As detailed in current positions, they respond to a Project Manager and are in charge of BIM Technicians; in both instances this relationship is usually direct. Their key responsibilities are to lead modelling and run BIM systems. Similarly, BIM coordinator job title that can be seen regularly at present; however, its location in the hierarchy of a team is greatly varied. The study found some BIM Coordinators that were chiefly responsible for forming models and teams, and others that served a support function and operated alongside BIM Technicians. As such there would be value in breaking this role down further but that would require a fresh and more concentrated study. Answering to BIM Managers or Coordinators, BIM technicians perform the modelling duties and little else. The duties themselves may not be simple; there is no standardised form of model and architectural, structural and services models remain separate. This may explain why this technical role type that actively ignores CAD-based tasks is demonstrably sought. Overall the two key divisions among these types are between "BIM-focused" and "BIM-tolerant" roles and between technical and management roles, with the latter loosely adhering to Frederiks and van der Weide's (2005) narrative of Domain Experts and System Analysts respectively.

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The Implications of Supply Chain Localisation for the Evolving Sustainable Energy Products Market in the UK Built Environment

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Abstract

This paper was written to explore the viability of supply chain localisation as a strategy for minimising possible adverse environmental and social impacts of large-scale economic activity surrounding the production of sustainable energy goods and services. Supply chain localisation here refers to the situation of production activities close to the geographical areas in which the sustainable energy products would eventually be installed. Sustainable energy products refer to technologies and other goods and services that minimize negative environmental effects of energy use in buildings throughout their construction and habitation. The paper dwells on the outputs of a major energy-efficiency project that focuses on preparing for the Green Deal – a UK-wide housing retrofit initiative – and the attendant increase in economic and industrial activities that it is expected to generate. As part of measures to ensure that these activities yield minimal negative environmental and social effects while optimising economic benefits, project participants recommended the localisation of the supply chain for the production, installation and maintenance of sustainable energy products. Based on the primary research conducted on the project as well as secondary research sources, the paper discusses the economic, social and environmental benefits and detriments of the supply chain localisation agenda. It also looks at the overall practicality of the implementation of supply chain localism within the context of mainstream business practices in the property, construction and energy sectors.

Keywords: Supply Chain, Localisation, Green Deal, Sustainable Energy Products, United Kingdom

1. Introduction

Environmental concerns over negative impacts of energy generation and usage on the ecology, coupled with economic/political concerns over the volatility of fossil energy prices and unstable relationships with some crude oil-producing nations, have long since been increasing the UK government's emphasis on energy conservation, carbon emissions reduction, and a shift towards renewable energy sources (Brown, 1996). Within the UK built environment, a recent reflection of this trend is the commencement of the Green Deal programme, a government initiative aimed at retrofitting the country's residential building stock with a range of sustainable energy products that includes insulation, window-glazing, low-energy lighting and heating, 'smart' and automated energy control systems, and renewable energy technologies such as solar photovoltaics, wind turbines, biomass boilers, and geothermal systems. In addition to its intended socio-environmental goals of fuel poverty reduction and energy conservation, the Green Deal is being actively promoted by the government as a major opportunity for the creation of new businesses and the stimulation of economic and industrial growth (DECC, 2010).

Due to their role in reducing adverse environmental impacts of energy use, organisations that are involved in the provision of sustainable energy products for buildings are commonly associated with the 'green economy' and its attendant focus on ecosystem preservation and social development (Placet et al, 2005; Brand, 2012). However, previous research suggests that the application of traditional business practices to green building initiatives could give rise to the following risks: one, new environmental and social problems could arise in the process of solving existing ones; and two, the sustainable energy products could fail to achieve the expected level of technical performance if not installed in the right manner (Schmidt, 2003; De Simone and Popoff, 2000). This is mainly because traditional, mainstream business practices are based largely on economic considerations, with environmental performance and social success having only secondary relevance (Isaksson et al, 2010). It is conceivable that a combination of the aforementioned risks could lead to a worsening of socio-environmental problems associated with the use of energy for the construction and operation of buildings, damaging investor and consumer confidence within the still-evolving UK market, and thus discouraging further uptake of sustainable energy solutions.

Perhaps in awareness of this situation, a number of organisational networks, research institutes and think-tank groups have planned and are planning the development of a major industry around the Green Deal which will be economically, environmentally and socially viable all at once. One such initiative is a major energy-efficiency project based in the West Midlands and made up of members of several organisations from the construction, energy, housing, local/regional authority, and education sectors. The project focuses on the challenge of developing the supply chain, skills, resources and market demand for the Green Deal, and of optimizing economic, environmental and social returns from this activity. One of the outcomes of deliberations within the project was that the supply chain for the manufacture, installation and maintenance of sustainable energy products for buildings should be localised. Based on the project case study as well as literature sources, this paper attempts to explore the supply chain localisation concept and analyse its economic and socio-environmental implications.

2. Supply chain localisation as a resurgent practice

Alaane and Saari (2006) present the concept of localisation of the manufacture and distribution of energy products as one that has come round full circle, a resurgent phenomenon that is a reasonable alternative to the practice of globalisation and its attendant environmental and social detriments. However, the existing body of literature that offers an exposition on this perspective is quite limited. Practical applications of supply chain localisation to the commercial provision of sustainable energy products appear to vary depending on the nature of the energy product, technology or service in question. Nor does there seem to be an established, quantitative definition of localisation in terms of distance or other geographical terms, e.g. how far away from its eventual point of use can a sustainable energy technology be produced before its production can no longer be described as 'localised'?

In general though, localisation refers to the improved utilisation of local resources in energy systems, and it could take the form of local fuel harvesting and storage, the promotion of local business opportunities, and the development of products and services based on local raw materials and labour (Alaane and Saari, 2006). Within the renewable energy sector and indeed other economic sectors, a prevalent trend has been western firms' location of their manufacturing – and ever increasingly, research and development – infrastructure in countries like India and China (Cusmano et al, 2010; Christopher, 2005). Lewis and Wiser (2007) report that notable wind turbine manufacturers from major western markets such as USA, Germany, Denmark and Spain first grew and developed a stable base within their home countries before eventually relocating their facilities to China, India and other developing economies. If the home countries provided a conducive business climate for these companies to grow and stabilise to begin with, then why did the firms choose to relocate their production activities?

Within the late 20th century, a tendency grew among manufacturing and service companies to achieve greater specialisation of their functions (Kim, 1995). Outsourcing of tasks that fell outside their core competencies became a way of realising this (Humphrey, 2003; Nassimbeni, 2003). According to Perrot and Filippov (2011), within the renewable energy sector there was also the issue of high operational costs that characterise markets like wind and solar, and which make the markets dependent on production incentives, local subsidies and tax benefits. Thus, sustainable energy companies became attracted to the low-cost advantages and large market size in emerging Asian economies, the relatively adequate level of existing skills and facilities there, and the previous success of destination countries like Taiwan and China in the manufacture of semiconductors and microchips; the stagnation of western markets at intervals between the 1980s and the current decade further catalysed this trend (Perrot and Filippov, 2011).

All through this period of off-shoring, however, locally manufactured products retained their reputation for offering shorter lead times and higher quality assurance, and in more recent times, there appears to be an increasing interest among governments and businesses in parts of the developed world in encouraging localised production (Melani, 2006). Straka (2002) offers a political perspective on the reason behind the re-emergence of localisation in the energy sector in particular, stating that concerns over political conflicts in some of the major crude oil-producing nations and their attendant risk to supply chain security heighten the need for other countries to focus on the development of local energy options. Another common social argument against the 'internationalisation' of companies' operations is that it results in the loss of jobs in the companies' home countries (Li, 2005; Hamilton & Summy, 2011; Alaane & Saari, 2006). However, Perrot and Filippov (2011) suggest that the transfer of functions such as research and development to overseas locations is not always a 'zero-sum game', as it does not by default lead to the closure of corresponding jobs in the home country. Other reasons that are attributed towards the support for localisation include rising labour costs in developing countries, rising energy costs, the export-import balance, currency depreciation, and the leaning of public attitudes towards environmental protection and social responsibility (Ristola & Mirata, 2007; Longo et al, 2008; Sheffi, 2001; Walker, 1995). The Economist (2012) reports that with a 5% p.a. inflation rate in shipping costs and a wage inflation rate estimated at 30% p.a., by 2015 it will be just as cheap to manufacture in North America for the domestic market as it would be to manufacture in China.

3. Case study of an energy-efficiency project

The Green Deal and ECO are UK governmental policies aimed at encouraging the widespread implementation of a diverse range of sustainable energy products across the country, from insulation to window glazing to low-energy lighting and heating systems to renewable energy technologies, and it went 'fully live' in January 2013 (Richards, 2013). In order to investigate how the production and installation of sustainable energy products for buildings can be expanded to become a significant UK industry through the Green Deal, while minimising possible adverse environmental and social impacts of such a large-scale economic action, this author became involved in a major energy-efficiency project in the West Midlands County. The project focuses on developing supply chain, skills, and finance and other resources in preparation for the Green Deal and Energy Company Obligation (ECO) programmes, and on optimizing the economic, environmental and social returns from this activity. In this regard, the project represents a situation in which the economic activities involved in the provision of sustainable energy solutions for buildings are actively considered within social and ecological contexts. The project is made up of representatives of 30 organizations from the construction, energy, and property sectors, most of which are involved in the procurement, supply, installation and/or maintenance of sustainable energy products in buildings. The project also includes the contribution of big UK utility companies such as Eon.

The study of the project for the purpose of this research began in February 2012 and concluded in August 2013. The study involved not only listening to, watching and recording the verbal and written interactions that took place among participants, but also the participation the researcher in these interactions. This was in order to gain first-hand knowledge and experience about the planning and decision-making processes involved, and also to gain the confidence of the other participants and ensure that the researcher's presence would not alter how they responded to issues. This field research technique of participating in a culture or context while at the same time recording what is being observed is identified as participant-observation in several research literatures (Iacono et al, 2009; Trochim, 1999). To ensure that the researcher's presence in the project would not compromise the reliability of the data obtained, the researcher's participation was limited to a relatively minor role. This involved carrying out instructions given by complete participants, i.e. staff from member organisations of the project, rather than contributing an independent perspective. Thus, the outputs of each session were based on the contributions of the other participants and did not reflect the researcher's own views. To establish consistency, care was taken to maintain this approach at a constant level for the project's duration, without the researcher becoming more active. Empirical qualitative data was obtained during participant observation via the recording of field notes. Also, other important documentation created by the participants during the course of the project – such as formal reports about the outcome of each project task – were obtained as additional evidence.

In addition to participant observation, interviews were also conducted to determine the effects that a company's implementation of environmentally and socially responsible practices could have on its business capacity. The interview respondents were the management-level company representatives involved in the energy-efficiency project. This ensured that the respondents had expert perceptions of business development and its relationship with environmental and social responsibility. The interviews were semi-structured, as this provides consistency while also allowing a sufficient degree of freedom and adaptability in getting information from respondents (Haigh, 2008). In all, 20 interviews were conducted, at which point 'saturation' – new data fitting into categories already devised from old ones without introducing any new category (Charmaz, 2003) – was considered to have been achieved.

4. Research findings: Supply chain localisation as part of a socio-environmental business strategy

The observation of the energy-efficiency project indicates that supply chain localisation is viewed as a useful measure that could be taken to ensure that the expansion of commercial provision of sustainable energy solutions for UK buildings does not create new environmental and social problems. Possible new environmental and social problems that could arise as a result of the expansion were identified in the programme as the following: the production of sustainable energy technologies and other products could result in new emissions releases, energy losses, and waste generation across the products' supply chain; the wholesale installation of sustainable energy solutions could have a disruptive and invasive effect on existing housing structures, fittings and occupants; and energy costs could be increased rather than reduced.

While the invasive and disruptive nature of the installation of sustainable energy products in buildings appears to be temporary in scope, lasting only for the duration of the installation process, project participants felt that it could nevertheless serve as a disincentive for building occupants to view sustainable energy solutions favourably. The prospect of an increase in energy costs was attributed by participants to the inability of the current electricity grid network to absorb additional power from solar PV and other micro-generation technologies. This presents a significant case of sustainable energy solutions creating a social effect opposite to that which was intended, i.e. the alleviation of fuel poverty. The risk of an increase in emissions, energy loss, and waste as a result of the intensification of production activity was also acknowledged by the participants, as was the underperformance of sustainable energy products in buildings due to the inadequate integration of the products with the existing building facilities and the behaviour of building users.

In order to prevent the occurrence of these environmental and social risks, participants endorsed the localisation of the supply chain for sustainable energy products. They also recognised other measures such as whole-life costing; the reorientation of skills; a ‘whole-house’ approach; and the inclusion of building users in the capacity development process. All five measures are further highlighted in the paragraph below.

The participants appeared to share the view that the adoption of supply chain localism for the implementation of the Green Deal has the potential to stimulate UK economic growth to a significant extent. The creation of new businesses and employment and poverty reduction opportunities in Local Authority Areas throughout the United Kingdom was identified as a major potential benefit of supply chain localism. For instance, participants were observed to target the Not in Education, Employment or Training (NEET) section of the populace as a source of new members of a multi-skilled workforce for the Green Deal. The NEET category’s current lack of work experience, as well as the need for sustainable energy products to be installed and maintained with minimum social disruption and optimum technical performance, led the participants to propose the reskilling and multiskilling of the workforce. They also proposed that building occupants and other building users should be engaged in the capacity development process in order for their perspectives to be obtained on how sustainable energy solutions can be installed with minimum disruption to their lives. However, the skills training and setting of up of local supply chain activities require a high level of financial investment, and so the participants recommended a ‘whole-life costing’ standard that particularly highlighted the economic benefits that might accrue to the companies in the future to offset the initial investment costs. The aim was to encourage companies to take a longer-term view of the business rather than seek quick economic wins. In addition, the participants supported the adoption of a ‘whole-house’ approach that focuses on the integration of different sustainable energy solutions within buildings (rather than on the efficiency of any single solution in itself), in order to ensure that different solutions fully complement each other.

Beyond the social and economic rationale behind the participants’ support for supply chain localism, there also appeared to be environmental reasons as well, in terms of the need to minimise the energy, emissions and waste issues associated with procuring, transporting, installing and maintaining both production materials and finished sustainable energy products. The participants were of the view that the localism approach would allow for a closer monitoring of the production and delivery of sustainable energy solutions to guarantee that only minimal or zero harmful environmental impacts are yielded.

The interview data suggests that companies acknowledge local sourcing and procurement as a major way by which they can implement socio-environmental responsibility. The interviewees acknowledged the role of localisation in reducing the embodied energy of sustainable energy solutions (the energy consumed in the process of sourcing, producing and distributing them), carbon emissions, and negative social impacts. As one interviewee put it: *"If you are sourcing locally, you've got a little bit of comfort that …the product itself is being manufactured in the right kinds of ways"*. Another questioned: *"What's the carbon emissions to bring that piece of material from China? ... That could be a substandard material and it's not got the lifespan that you think it's got and then you've got to dump it anyway"*. However, interviewees emphasized that finance is a significant barrier to the development of business capacity for the implementation of supply chain localisation and other measures recommended during the project. One interviewee mentioned that *'There's a lot of investment required for new manufacturing facilities'*, while another states that *'The costs are more upfront as well …which is what the stumbling block, I think, is'*. Environmental and social criteria were also found to increase the intensiveness of materials specification and add to the overall complexity of the procurement process. Local partners may not always offer the financial quotes, however, and this means that the company may have to forego cheaper partnership options. Apart from this, a conflict is set up between the environmental business value of localism and the mainstream business practice of globalisation. The emphasis on localisation may also require a company to forego expansion opportunities. For example, an interviewee states: '*We could have had the model of being the biggest nationwide installation company covering the whole country, but I decided …that wasn't the best model. The better model is for there to be an installation company in every town or village or wherever …it creates local employment'*.

5. Supply chain localisation and its consequences

The data obtained from the project case study indicate that the localisation of the sustainable energy products' supply chains has the social benefit of creating new jobs, and it also provides extra income for building occupants through their sale of surplus electricity, which in turn serves as an incentive for the public to use energy more efficiently. Environmentally, it allows for greater monitoring of production activities to ensure that they yield only minimum adverse ecological effects, and it reduces the distance across which products can be distributed, thus reducing the release of carbon emissions in the case of fossil fuel-based transportation. These findings are supported by literature sources (for example, Hamilton & Summy, 2011, and Ristola & Mirata, 2007). Rio and Burguillo (2009) mention that the social benefits of the localisation of renewable energy production activities extend beyond employment creation to impact on social cohesion, education, income distribution. Localisation also acts as a disincentive for emigration, and in so doing it indirectly alleviates environmental problems that are connected with the depopulation of rural areas, such as desertification and erosion (Rio & Burguillo, 2009).

Despite these benefits, there are wider concerns surrounding the feasibility of localisation. From an economic angle, the infrastructure required for the setting up of a completely local manufacturing base involves a high level of initial investment, as identified by participants in the project case study. The situation is further compounded by the ambiguity that still surrounds the funding mechanism for the Green Deal, as well as by the insufficient security of market demand which makes such a high volume of investment harder to justify (Laughlin et al, 2012; Wustenhagen & Bilharz, 2006). There are also lingering issues concerning the disruption that a wholesale transition to localisation could cause the industry, which currently operates on a more globalised, neo-liberal market system and relies significantly on the procurement of sustainable energy technologies from China and other external markets, as noted by project participants. These viewpoints on the economics of localisation are echoed in literature as well (e.g. Omer, 2008; Sawin, 2006). Even in the case of biomass energy systems, which benefit from the local availability of feedstock, Lam et al (2010) state that extensive infrastructure networks are required for harvesting, transportation, storage, and processing activities, and the relatively low energy output produced per unit volume of resource increases the cost, emissions and complexity of supply chains (Lam et al, 2010). Richard (2010) indicates that independent local suppliers may only be adequate for small-scale energy generation activity; a more practical alternative to regional or global market arrangements is the operation of single companies on large contiguous land areas in order to achieve a less fragmented but distributed approach. However, this system comes with problems associated with land access and appropriation and employee rights; and there is also the issue of setting up contingency plans for backup suppliers (Richard, 2010).

The limitations of the supply chain localisation concept aren't just confined to the social and economic fronts either. Environmentally, there is counter-evidence to the view that localisation is truly beneficial in an ecological sense. If global energy consumption remains unchanged and traditional fuels and technologies are still used, the volume of emissions reduced by decentralised renewable power plants in particular would remain constant rather than rise (Alaane & Saari, 2006). In other words, the localisation of energy generation may redistribute global emissions but not reduce it. In regard to this, the intensification of local manufacturing and other production activities within the UK could cause a setback to the country's achievement of its energy and carbon emissions reduction targets (Anderson & Fergusson, 2006; Tsoutsos et al, 2005). Furthermore, the potential benefits of localisation with regard to resource conservation are also liable to be exaggerated because assessment studies do not always fully take into account supply chain-related processes that take place outside a given location (Albino et al, 2002). Putting the whole picture together, while localisation can yield significant environmental and social benefits, there is also an active risk that the localisation agenda could well disrupt supply beyond the short-to-medium-term and have major negative economic repercussions for the industry, thus jeopardising its socio-economic potential without guaranteeing significant positive net energy and carbon impacts.

6. Conclusion

This paper has looked at the potential of supply chain localisation to minimise adverse environmental and social impacts of the provision of sustainable energy goods and services on a major scale. The paper relied on a case study of a major energy-efficiency project within the West Midlands, United Kingdom, as well as on a study of literature. While supply chain localisation was found to represent a sustainable business option in principle, the scope for its application remains limited and reliant on standard policy tools such as subsidies, tax reliefs and other regulatory measures that could significantly lower the cost of doing business in Britain. Future studies could focus on how to resolve the barriers to supply chain localisation rather than simply promoting its benefits.

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The application of Early Contractor Involvement (ECI) in different delivery systems in Australia

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Abstract

In Australia, the Commonwealth alongside the states and territory governments are committed to delivering effective and efficient infrastructure projects across the country. To date, over 340 economic infrastructure projects valued at $20 Million or more, account for almost two-fifth of the total value of capital expenditure on major projects. The majority of these projects are delivered under a relationship-based procurement (RBP) method. Amongst various types of relational contracts, Early Contractor Involvement (ECI) is seen as one of the delivery systems and contracting arrangements that owns a number of these projects. Furthermore, the South Australian's Department for Transport Energy and Infrastructure (DTEI), and the Queensland's Department of Transport and Main Roads (TMR) have published a number of documents in an attempt to standardise the ECI contract as practiced in Australia. Despite the evident documents indicating the ECI as a form of binding contract, many academic and industrial professionals use the term as a concept too. From their perspective, ECI refers to engagement of the contractor at the early stage of project development and can happen through a wide range of methods. This paper, therefore, studies different delivery systems that incorporate the concept of ECI into their implementation process through a literary analysis on the existing scholars and contractual documents.

Keywords: Early Contractor Involvement, ECI, Relationship-based procurement systems, Relational contracting

1. Introduction

In Australia, the Commonwealth alongside the states and territory governments are committed to delivering effective and efficient infrastructure projects across the country. To date, over 340 economic infrastructure projects valued at $20 Million or more including projects in the transport and storage, energy generation, gas, water and telecommunication industries account for almost two-fifth of the total value of capital expenditure on major projects (Productivity Commission 2013). The majority of these projects are delivered under a relationship-based procurement (RBP) method (NICS, 2013). Amongst various types of relational contracts, Early Contractor Involvement (ECI) is also seen as one of the delivery systems and contracting arrangements that owns a large number of these projects. Cairns Bruce Highway Upgrade; Maroochy River Bridge Duplication; North Ward Road in Townsville; Forgan Bridge replacement in Mackay and part of the Bruce Highway Upgrade are examples that have been procured under an ECI contract. Furthermore, the South Australian's Department for Transport Energy and Infrastructure (DTEI), and the Queensland's Department of Transport and Main Roads (TMR) have published a number of documents in an attempt to standardise the ECI contract as practised in Australia (Edwards 2009, Department of MainRoads 2009). Despite the evident documents indicating the ECI as a form of binding contract, many authors and professionals use the term as a concept too. From their perspective, ECI refers to engagement of the contractor at the early stage of project development and can happen through a wide range of methods such as Alliancing, Management Contracting (or Construction Management at Risk), Integrated Project Delivery (IPD), or even a conditional two stage contract in a hybrid design-build delivery method (Caltrans 2007, Van Valkenburg, Lenferink et al. 2008, Mosey 2009, Bongiorni 2011, Rahman and Alhassan 2012). With such diversity in the use of ECI, there is no surprise to face a great deal of confusion when the term is employed in different circumstances. Therefore, further studies around this subject are required in order to offset this ambiguity. This paper, hence attempts to contribute to this clarification process by focusing on different delivery systems that the concept of ECI is incorporated into them through a literary analysis on the existing scholars and contractual documents.

2. Background of ECI

The construction industry has been frequently described as being dominated by a 'culture of confrontation' in which a vicious cycle of mistrust, conflict and waste dominated and has been characterised by adversarial attitudes, with litigation often continuing long after projects have finished (Seymore and Fellows 1999). The industry has attracted a great deal of criticism for its inability to meet the needs of its clients. Australian construction industry was not an exemption either and suffering from the same difficulties as the other construction industries. National Public Works Conference and National Building and Construction Council Joint Working Party (1990) indicated that during the late 1980's, the Australian building and construction industry had substantial increases in the incidence of contractual claims and disputes. This trend continued with increasing disputation and litigation, and win-lose attitudes promoted increasingly with adversarial relationships among project team members. The report also emphasised that no party benefits from circumstances that cause claims and disputes; and that cooperation should be encouraged in the future. The Final Report of the Royal Commission into Productivity in Building Industry in New South Wales (1992) also clearly indicated the need for a change-to a more cooperative approach to build mutual trust, respect and good faith(Hampson and Kwok 1997).

During the past few decades, the construction industry has embarked on a sustained campaign to overcome its perceived performance problems through a number of initiatives and radically different approaches to the procurement and management of construction projects. Subsequently, emerging project delivery methods increasingly rely on collaboration between the principal, designer and builder, and aim to developing longer-term positive relationships. Relationship-based approaches to project contracting have arisen in response to problems that have intensified as the construction industry has grown over the last few years (Manley 2002).

The Australian construction industry also has utilised a number of innovative variations to "traditional" contract arrangements. The early contractor involvement (ECI) is one of these new approaches developed based on the premise that traditional methods create the team much too late in the project development and there is little scope for innovation and consideration of constructability (Edwards 2009). Nonetheless, the concept of early involvement of contractors is not new and can be traced back to the pre-industrial revolution times when master artisans worked with a client commissioned agent to build large-scale structures. The term, however was formally acknowledged in the industry during 1990s when the concept of builability has drawn academics and practicians interests including the Construction Industry Institute in the US (CII) and its counterpart in Australia (CIIA) (Walker and Lloyd-Walker 2014).

Since then, the term of Early Contractor Involvement (ECI) is widely used in the industry to describe the exploitation of contractor's expertise at the pre-construction stage as an effort to ensure the practicability of design, as well as price accuracy. However, 'Pre-construction' stage is a broad spectrum in a project life cycle starting from the initial phase where a project charter for the idea is developed up to the execution phase when the project is eventually delivered (PMI 2008) thus based on the project context and participants characteristics, ECI can be conceptually visualised at different phases in the project life cycle.

Walker and Lloyd-Walker (2012) mapped various forms of ECI taking place in the project life cycle by adopting the project life cycle model proposed by Williams, Klakegg et al. (2010) and argued that ECI can take place at three of the project lifecycle phases namely internal, project definition and design, and project execution phase. However, the study fails to identify the procurement forms in which elements of ECI exist. The following section aims to define and analyse different procurement models where the concept of ECI is evident.

3. Procurement forms with elements of ECI

Procurement systems broadly can be classified into four main groups namely 1) Separated procurement systems 2) Integrated procurement systems 3) Management-oriented procurement systems and 4) Relationship-based procurement systems. Figure1 illustrates broad project procurement approaches discussed in this section.

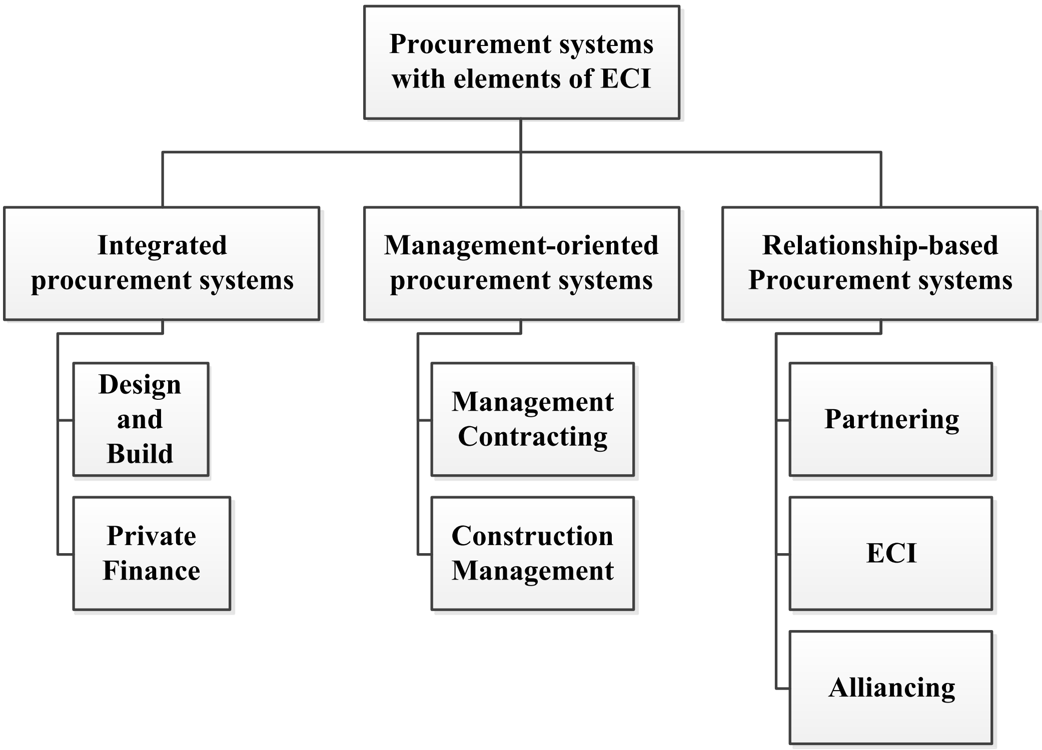

Figure 1: Project Procurement Forms with elements of ECI

Amongst a wide range of diverse forms of construction procurement being practiced in the construction industry, this paper focuses mainly on those models that the overarching theme is participation of contractor in the project before the construction activities begin. Thus, despite the predominance of the separated procurement systems in the Australian market place particularly with many State Government clients (Love, Davis et al. 2008), this study does not include such systems because they exclude the main contractor and subcontractors from the early design and project planning and the contactor comes into the play after design is completed and only during construction phase.

3.1 Integrated procurement systems

Masterman (2002) defines this category as the procurement systems which "incorporate all of those methods of managing the design and construction of a project where these two basic elements are integrated and become the responsibility of one organisation, usually a contractor." (p.40).

Numerous authors have documented a range of diverse methods and related variants that can be included in this category (McDermott 1999, Masterman 2002, Walker and Hampson 2003, Morris and Pinto 2010, Winch 2010, Walker and Lloyd-Walker 2014). The principal members of this category that are dealt here are Design and Build (sometimes referred to as Design and Construct) and Private Sector Finance Procurement Methods.

3.1.1 Design and Build

In Design and Build, a single contractor acts as the sole point of responsibility, normally on a lump sum fixed price basis, for the design and delivery of a construction project in a way that specifically meets the needs of the client (Masterman 2002, Miller, Furneaux et al. 2009).

There are several variants on a Design and Build procurement form, the chief among which are Novated Design and Build, Turnkey and Package Deals.

Novated is a form that the client appoints designer to develop the conceptual design and tender documentation and once the building contractor has been appointed, the 'existing' design team is transferred to this builder.

In *Turnkey* ,as the name implies, the responsibility of the single entity is extended to the installation and commissioning phase along with the arrangement of funding for the project (Walker and Hampson 2003). However, This approach has been largely overtaken by other procurement form under the private financed based forms of project procurement (Walker and Lloyd-Walker 2014).

The *Package Deals* system is the predecessor of Design and Build in which the client purchases a 'ready-made' standard designs for complete building and the contractor provides managing, designing and constructing service for an adopted standard product. This method can be attractive for those clients who can compromise their requirements in an effort to satisfy their building needs timely and at an economic price (Masterman 2002).

As discussed earlier, the project owner in the Design and Build has a contractual relationship for both design and construction with a single contractor. This single contractor can be either an integrated firm mechanism, which has in-house design team as well as a delivery team or a consortium of independent design and construction firms put together for a specific bid (Morris and Pinto 2010, Walker and Lloyd-Walker 2014). In either way, the construction teams provide specialised construction expertise and in-depth knowledge of construction materials, methods and local practice into design and hence their input to design will have a direct impact on the quality of the construction performance (Rahman and Alhassan 2012). Nevertheless, even though the Design and Build integrates the majority of the project supply chain in an attempt to link design and delivery, the whole integration of the design and delivery teams is not in an integrated team (Walker and Lloyd-Walker 2014).

3.1.2 Private Sector Finance Procurement Methods

The terms of Public Private Partnership (PPP), Private Finance Initiative (PFI), Design-Build-Finance-Operate (DBFO) and Build-Own-Operate-Transfer (BOOT) are interchangeably used in different literature while they are all referred to the similar, if not identical, forms of project procurement. The overarching principle of all these terms is the use of private sector finance for design, construct and long term maintenance or operate of public infrastructure projects (Duffield, Raisbeck et al. 2008). The process starts with the project initiator by inviting outline bids from selected organisations normally a consortium that made up of funder, contractors and operators. The successful bidder will enter an 'upstream' contract with the owner and 'downstream' contracts with constructors, suppliers and service providers. The deal is ultimately concluded when responsibility for the facility is transferred back to the owner after the concession period (Hughes, Hillebrandt et al. 2006). In Australia, private sector finance forms of procurement mainly known as PPPs account for around 10% of state capital spending in Victoria, around 7% in Queensland, and lesser proportions in the other States and the Commonwealth (Regan, Smith et al. 2010).

Since these forms of procurement require very high levels of expertise from all parties, the delivery team need to consist of highly skilled professionals from legal, design, operation experts and construction professionals (Walker and Hampson 2003, Love, Edwards et al. 2011).

Considering the structure of this approach, the major difference in contrast to a turnkey approach is that there is a concern over the balance between long-term operating costs and short-term capital costs (Walker and Smith 1995). Thus, the level of contribution of construction professionals to the design is likely to be similar to a turnkey approach, yet more sophisticated.

3.2 Management-oriented procurement systems

Management-oriented procurement systems are used where the client intends to contract the management of the design and construction out to a contractor who acts as a management consultant on behalf of the client (Rashid, Taib et al. 2006). The route is generally adopted where the early start and completion is of the client's requirement and project is planning and control driven (Morledge, Smith et al. 2006, Walker and Lloyd-Walker 2014). There are two main systems under this category namely Construction Management and Management Contracting.

3.2.1 Construction Management

Under a construction management route, the client employs the design team and instead of allocating risk and responsibility to a single main contractor, a construction manager is appointed to manage the design and construction activities on a professional fee reimbursement basis. The construction manager provides professional construction expertise without any contractual links with design team and contractors, and all design and construction contracts are directly agreed between the client and trade (Package) contractors (Morledge, Smith et al. 2006). Although this approach features extensive use of constructability advices by the construction management team (Walker and Lloyd-Walker 2014), it is generally accepted that the cost certainty cannot be achieved until the final trade contract is closed. Moreover, since there are no binding contracts between construction management party and design team and trade contractors, he assumes no financial risks and is only liable for negligence by failing to perform the role (Morledge, Smith et al. 2006).

3.2.2 Management Contracting

The mechanism of this form is similar to a Construction Management form but with this route, unlike the Construction Management, the management contractor has direct contractual links with all package contractors. Therefore, the liability of the management contractor extends to the construction works. The main advantage of management contracting is the contribution of the constructor to the design and project planning however, poor certainty of price at an early stage is realised as one of this method drawbacks.

3.3 Relationship-based procurement systems

Relationship-based approaches to project contracting have arisen in response to problems that have intensified as the construction industry has grown over the past decades (Manley 2002). Relationship contracting is the identification, establishment and maintenance of particular relationships with project stakeholders, commercialised and governed so that the objectives of all parties involved are met (Miller, Furneaux et al. 2009). Davis and Walker (2009) suggest that relationship-based procurement leads to mutual benefits in construction business-to-business dealing and provides benefits over traditionally forms of procurement with fragmented supply chains. A relationship-based procurement approach can take many forms. This paper focuses on three forms of it including Partnering, Early Contractor Involvement (ECI) and Alliancing.

3.3.1 Partnering

Partnering is not a procurement choice in itself but a technique for managing cultural environment of project that can be applied to other procurement forms (Masterman 2002, Walker and Lloyd-Walker 2014) . Once culture of partnering has prevailed, parties get to know each other intimately and learn to how the working relationship may be enhanced in an integrated team. Culture of openness and transparency embedded in the concept of partnering (Nyström 2005) enthuses contractors to share their construction knowledge and experience during the design and planning in an attempt to identify major problems that may be encountered during the construction phase leading to the greatest improvement in project performance (Trigunarsyah 2006). Concept of partnering was imported to Australia during 1990s as a means to overcome recognised problems within the construction industry (Walker, Hampson et al. 2000) and now is well established in road construction and maintenance (Manley 2002) . Since then, several collaborative contractual forms have been introduced to the industry, which despite the slight differences in the mechanism, partnering concept is essentially inherent in all of them. Two major forms of partnering include *Strategic* partnering where partnering occurs across a range of projects, and *Project* partnering where the partnering is applied to a range of parties within a single project.

3.3.2 Early Contractor Involvement (ECI)

ECI contract is first introduced by the engineering and construction contract published by British Institution of Civil Engineering in 1998 and adopted by the British Highways Agency for their infrastructure project. As stated previously, ECI contracting arrangement should not be confused with the concept of ECI that can be found in various forms of procurement. In this contractual model, client appoints design and construction professionals early in the project development process through a non-price based selection and those professionals assist the client in planning, assessing buildability and developing an “open book” target cost (Laursen and Myers 2009). In Australia, the ECI contract is first introduced by Queensland Mains Roads in 2005. Although the method is categorised as the Early Contractor Involvement, it is genuinely an innovative approach, which is not similar to any form of the contract practiced in other countries. The Australian's version of ECI features a two-phase strategy with separate contract for each phase. The first phase includes the design progress from a concept to a preliminary design embracing approximately 70% of the entire design process and is generally similar to an alliancing, and the second phase is completion of the detailed design and construction and employs a typical traditional design and build (construct) contract (Swainston 2006, Edwards 2009).

3.3.3 Alliancing

The concept of Alliancing was developed on North Sea in the early 1990's and imported to Australia at about the same time for development of energy projects. Since then, Alliancing were adopted for numerous projects across Australian governments. A report by Alliancing Association of Australasia (AAA) in 2008 indicates that approximately 300 infrastructure and construction projects with a total value of 90 billion dollars have been delivered through alliancing methods in Australia up to 2008.

Quite succinctly, Alliancing is "an agreement between two or more entities, which undertake to work cooperatively, on the basis of sharing of project risk and reward, for achieving agreed outcomes based on principles of good faith and trust and an open-book approach towards costs" (QGCPO, 2008).

One of the unique features of Alliancing is that a consortium of the project owner (PO), design and construction participants (referred to as Non Owner Participants (NOPs)) forms an alliance for the project and participants agree to make decision unanimously. There are three variations of alliancing. *Project* alliancing, which is the most commonly; *Design* alliancing where it occurs only at the earliest stage; and *Programme and Service* alliancing where alliancing occurs across projects, time and space (Walker and Lloyd-Walker 2014).

4. Discussion and conclusion

There is an increasing perception that alternative procurement systems with partnering principles between project participants could help improving productivity in projects by establishing working relationships amongst stakeholders through a mutually developed formal strategy of commitment and communication. The distinguishing feature of alternative project delivery methods is the ability to involve the construction contractor in the preconstruction phase of a project, providing input to the planning and design processes. This feature is known as Early Contractor Involvement (ECI) amongst academics and practitioners.

The foregoing literary analysis has attempted to demonstrate the contribution of construction contractors to the early design and planning in different procurement systems practicing in Australia. The findings indicate that contractors cannot have much contribution to the design and planning in separated forms of procurement as the level of detailed design specification is generally very high at the time of calling for bids by project delivery organisations. Integrated procurement systems are partially either contractually or physically integrated. In design and build form of procurement, the design is usually specified in functional performance and often developed from conceptual design drawings. Even though the construction knowledge and experience of contactor influence the project design, absence of contractor at the project definition and conceptual design stage impedes the client to take the full advantage of contractor's expertise when the project is defined and scoped. Management –oriented methods make a possibility for the client to receive extensive advices on buildability or constructability from management contractor in the design development. However, management construction team can be less proactive due to the lack of contractual links with design and delivery parties in the Construction Management system and inadequate management fee in Management Contracting system.

Finally, it was argued that relationship based procurement approaches tend to generate collaborative relationships between the parties involved. Two forms of relationship-based procurement system were described including Early Contractor Involvement (ECI) and Alliancing. ECI is similar to a design alliancing in terms of involvement of the contractor at the front-end phase of project but the process is shifted to a typical Design and Build for the detailed design and construction phase. This inconsistency in the contract process may raise contractor's concerns over opportunistic behaviour that other competitors may be running off with their idea and their contributions to the design, thus the degree of commitment, integration, motivation, skill, teamwork and trust that the contractor is supposed to bring to the project can be undermined.

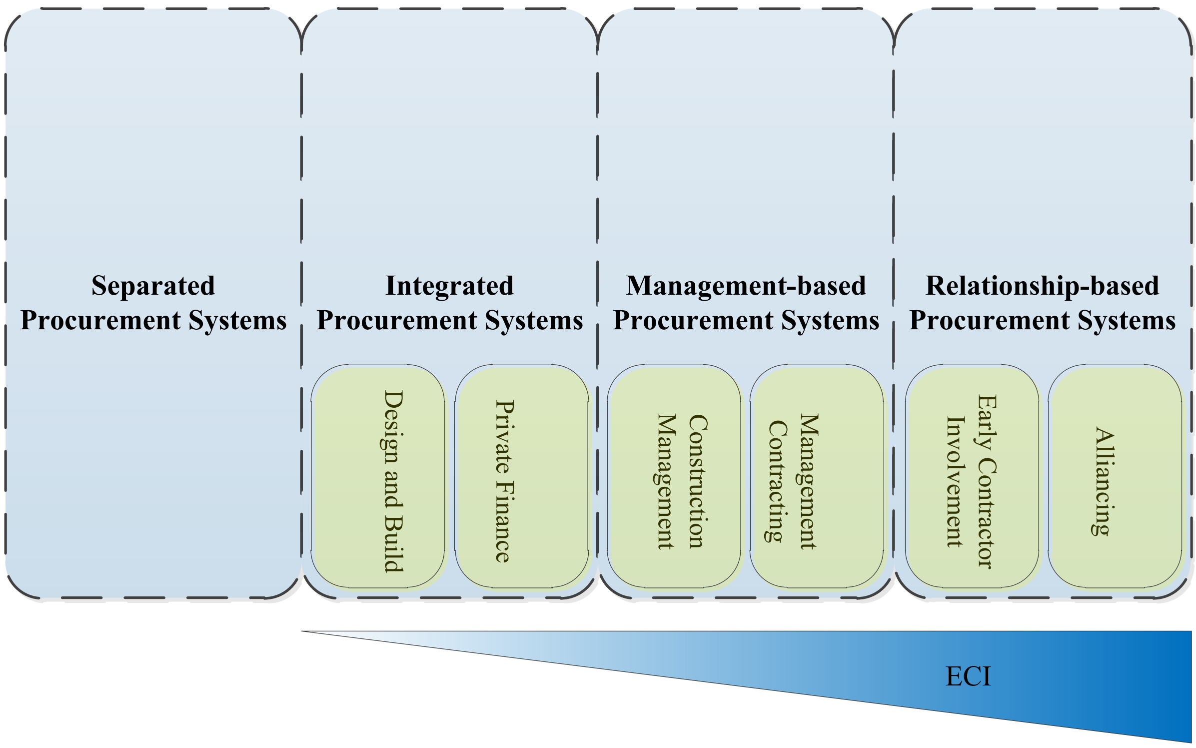

Figure 2: Extent of contractor involvement at the early stage of project in common delivery systems

Alliancing is a form of Relationship-based procurement system that requires a commitment of all parties to common objectives and outcomes. One of the fundamental characteristics of Alliancing is sharing of information, knowledge and skill in a trust-based environment where a non-adversarial culture dominates. In such environment, contractors are willing to share their knowledge and experience in an effort to deliver the project with reduced project cost or reduced overruns of time and cost which will be eventually of their own benefits. Such performances are attributed to alleviating scope definition and planning problems leading to better understanding of project objectives. Figure 2 outlines the extent of contractor involvement at the early stage of project in different delivery systems.

This paper is part of the literature review of a PhD research study under progress by the first author.

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What Do We Teach Them When We Don't Even Know What It will look like?

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Abstract

It has taken forty years for sustainability to become mainstream. Forty years ago the publication of 'Limits to Growth' forecast a collapse somewhere between 2010 and 2075. Our students are staring this in the face. The resources of the Earth are finite and the economic theories driving our economies are finite. We do not know what form business will take.

This paper looks at embedding sustainability into building trade related diploma and bachelor qualifications at Unitec. A sound base of fundamental building skills must be augmented with an understanding of ecological and technological skills. The traditional apprenticeship model, practice based and learning on the job supported with MOOCs.

Sustainability of buildings requires a building to be flexible in use and for longevity, built to a good standard. The main piece of legislation controlling this industry in New Zealand has in section 3 a purpose requiring 'sustainable building'. The traditional business model requires a profit and profit is only achieved in a growth model economy. There is only one planet and our industrial model uses one and a half, even more in some western counties. We are using our resources at an unsustainable rate and there is a case here for education to lead industry.

Sixty per cent of the buildings standing in 2050 are already in place. There is a worldwide population shift to urban environments and our students will live in these buildings. They will need the skills to determine what they want. The Built Environment uses 40% of the world's energy and there is a high possibility of being able to reduce that.

Future practitioners obtain the knowledge through their learning. The discussion will be around how this is done in the 'classroom' and some of the interesting results achieved.

Keywords: Learning, Sustainability, Industry, Finite

1 Introduction

Old ways are not adequate any more. There is the sense of an unknown threat, a danger ahead. Food prices have spiked, the world population has surged, energy prices are soaring, tornadoes rip through cities, and typhoons affected by ocean temperatures decimate coastal areas.

Governments have and are borrowing heavily to get us out of the financial crisis. The only way to pay back this debt is to have significant economic growth. Supply constraints have forced commodity prices to a new and permanently high level. Higher commodity prices limit economic growth.

The global reservoir of fossil energies, in particular oil, is approaching exhaustion with increasing speed. Peak oil has already occurred and now, all attention will be on the hard-to-access deposits. The depletion of these reserves will lead to actual or supposed shortages which will in turn result in economic upheaval or even armed conflict. It is obvious: we are living at the expense of future generations. This also applies to the greenhouse gas problem. The carbon dioxide concentration in the atmosphere has increased by 35 per cent in the last 125 years. Re-orientation is urgently required.

On reflection the MOOCs part of this strategy has been modified to be simply online tuition and support with students compiling an electronic portfolio.

This paper looks briefly at the current global predicament as a driver for education for sustainability at a vocational training institute level. There is consideration for the needs of industry and how that is met in the classroom. More importantly is the encouragement through the learning process to participate and co-operate, to be flexible enough to adapt to change.

It concludes by showing that the tools used in the learning process support their work environment and encourage ideas of a regenerating built environment.

The Oxford dictionary defines

Sustainability

Adjective

- able to be maintained at a certain rate or level: *sustainable economic growth*

- conserving an ecological balance by avoiding depletion of natural resources: *our fundamental commitment to sustainable development*

- able to be upheld or defended: *sustainable definitions of good educational practice*

Sustainable development:

Noun

- Economic development that is conducted without depletion of natural resources: *international policies should support sustainable development. Sustainable development has become the guiding theme in much environmental literature*

Sustain

Verb

- strengthen or support physically or mentally,
- bear (the weight of an object) without breaking or falling:
- undergo or suffer (something unpleasant, especially an injury:
- cause to continue for an extended period or without interruption:
- uphold, affirm, or confirm the justice or validity of:

Currently the planet's resources are being used at a rate of 1½ planet. To maintain a free market North American economic model takes 5 planets. Other western nations are somewhere in between these figures. Some large corporations and industry giants spend millions of dollars on climate denial. The issue is so complex that any understanding of the global ecosystem requires many scientific disciplines to be considered together.

When we consider these dictionary meanings in relation to how we currently use the planets resources we have gone past this phase and must look at 'Regeneration'. Sustainability is not possible if the use is greater than the supply. International policies are not working and are more often focused on making trade-offs or complying with rules and legislation.

For New Zealand Maori the theme or concept of custodial occupation (Kaitiakitanga) and a belief that the environment should be maintained in a fit state for future generations is embedded in the Treaty of Waitangi signed by the Maori (tangata whenua) and colonial British powers in 1840. Ecological messages and environmental ethics were passed down through generations of Maori by a rich tapestry of narratives. These are the guiding principles of the Resource Management Act (RMA), New Zealand's principal piece of environmental legislation. The RMA incorporated 'sustainable management' as an explicitly stated purpose at the heart of the regulatory framework. This purpose is to direct all other policies, standards, plans and decision making to be considered under the RMA. It was a unique concept worldwide in 1991 but now under review by the current National led government.

Some European counties are looking at Eco management and audit schemes for the construction sector. Environmental assessment schemes mooted in Germany are largely covered in New

Zealand by the RMA. The build process requires a resource consent administered by the local territorial authority. It will look at any aspects of the natural environment and require reports on how these will be mitigated. Often contractual documents will make requirements of the construction firm especially in regard to waste, dust from cutting material, water run-off and noise levels for example.

While academics focus on environmental assessment tools for buildings, life cycles analysis of buildings and integrating climate targets with planning strategies others are looking at the paradigm shift needed in thinking to create an ecological urban environment. At present in this world, the human species and nature are considered separate systems. "An ecological worldview holds that as humans are an integral part of nature, they are participating in and co-evolving through its processes and therefore subject to its laws. Effective action would then learn from and follow the laws of nature, and cooperate with and participate in its processes so that the outcomes of actions contribute to the well-being, nourishment and regeneration of the world." (Du Plessis 2011)

Such a shift requires co-operation and participation. It requires an ability to learn, understand and adapt. It requires a certain dynamic and flexibility. The science of ecology must have a greater importance. Ecological design and engineering for a biophysical environment will be united with processes and tools for a common language and an understanding of social-ecological systems that make our cities.

There are echoes here of the ideals that drove the hippie or counterculture movement back in the 1960s and 1970s. That was the time of 'Limits to Growth' and the 'Whole Earth Catalog'. The Whole Earth Catalog served as a guide to a new way of being an individual. It expounded an anti-technocratic reintegration with nature and offered new ways of being in community. Later in 'Out of Control' Kelly suggested networked systems, particularly computer systems that would lead humanity in a reintegration with nature. This he said would happen in the corporate world. It did and business looked at how groups learn best. The notion is one of distributed learning where individuals are elements of a system and they had the computer with which to keep the emerging networks working and communicating. Corporate business had the cyber net for the interdisciplinary work and computing for the unifying theories and collecting data. It is the environment into which students enter as apprentices although somewhat more advanced now. The construction industry works in groups or teams and for some organisations 80% of the time is spent in team work.

To survive construction businesses like any other business need a core set of beliefs and values that match clients or suppliers. Students will have to consider what their needs are and where they align with those of industry. Is the role of the tutor one of provocateur? Or is this all a progression of time? We are seeing the power of collective computing and the rise of social media as the destruction of political hierarchy like in the Arab spring. Sustainability has become a mainstream subject and at a pace similar to social media. There is a worldwide movement and demand by students for sustainable campuses. Education as a business means the institutes must compete to attract students. Academia needs to sow the seed. 'The power of collective computing has the faded images of the New Communalism of the hippies and the counterculture movement. Levelled, collaborative, linked by invisible signals and shared feelings.' (Turner 2006).

Back then in Europe and America a lot of the new ideas originated in institutes of learning so if Kellenberger et al (2010) propose a 2000watt society, 1500watts renewable energy and 500watts fossil fuel we need our students to understand what it means. We need to generate discussion with our students, ask what they will give up. Currently western society is using 6500watts per capita per annum. Greenhouse gas emissions shall be reduced from 8.7 ton today to 1 ton CO^2 equivalents in the future by 2150. By 2050 it is forecast the CO^2 emissions from the Asia Pacific region will reach the same level as North America. It will take a very concerted multidisciplinary effort to affect this type of change. CO^2 emissions today have an effect on global mean temperature lasting more than 100 years. Any resulting rise in sea level due to the thermal expansion will last at least 1000 years. Current urban design will suffer from a heat island effect where the buildings of the urban areas absorb more heat due to materials and proximity to one another. In the summer of 2003 in Paris this was 4 -5 ºC higher during the heat wave.

Ecological design could help in reducing this effect. There is a potential for business to take a lead in this as they realise the economic benefits of a green economy. Sustainable businesses currently provide as good as or better return for investors. Huang (2010) defined the green economy as 'a new economical pattern with an orientation of harmonious development of economy and environmental protection; an outcome of the requirement that industrial economy shall not hurt human health and the earth environment forming a new state of social development.' Business has the networking systems and the organisational skills are in place to develop a green economy. Academia at the behest of the business community needs flexibility to provide the required skills.

This relationship between academia and industry has not been easy with regard to sustainability. Vocational training is seen as not necessary to have these skills. It could be argued that it is absolutely necessary as these students are in the future installing the systems or the structure holding a bio-physical environment. Sharma (2011) found that industry in New Zealand plays a key role in determining what is incorporated into trade training curricula but it needs to provide support to go with this. So far the emphasis has been on universities rather than the vocational and training institutes which are seen to have less relevance. Vocational education provides important skills which are applied in industry and as such need more support due to increasing technical complexity.

Buildings are using 40% of the world's energy and many models exist to improve this. Students entering the industry now will see a quantum leap in new technology and bio-mimicry as buildings and materials replicate nature. For many in industry sustainability is seen as an extra cost and for many academics at vocational training institutes it is outside their expertise.

Faced with the global outlook does industry know what it needs? Historically in New Zealand there have been seven year cycles in the building industry. Seven year boom and bust cycles with 2007 the last boom year and starting in 2008 a prolonged recession. The construction industry is focussed on survival for much of the time but it now needs to think of sustaining its position in the light of climate change.

2 Research

2.1 Research objectives

The purpose of this qualitative research is to determine the relevance of teaching sustainability to building vocational and trade studies in New Zealand.

- Determine what the driving forces are

- Investigate the skills required by future building practitioners and current training.

2.2 Methodology

This body of work aims to gain insights into what a modern trade qualification should encompass. The building trade and related professions have for decades traversed an industrial landscape as nomad and technocrat.

Buildings could be described as technical objects attaining a meaning within social and historical contexts. In New Zealand this could range from a light timber framed holiday shack, crafted from recycled material or whatever material was gathered together to an architectural masterpiece making the cover of glossy magazines or succeeding in an international competition. The former might not even have formal building consent but still providing shelter and a small ecological footprint.

The training for a carpentry qualification starts with a one year pre-trade course. This is a certificate course encompassing the entry criteria for the diploma and bachelor courses. In the course of the first year students build a one level three bedroom house under the guidance of their tutors. Theory classes are organised to provide students with prior knowledge of each step in the construction process. On the building site a large monitor screen is set up for class tutorials. The material introduced here is reinforced around crucial points on the site by the use of Quick Response codes (QR codes). The students access information or instruction with their smart phones or tablets.

Students have to submit all assignment work as a Google document. This is shared with the tutor who can view the students' progress and provide feedback. All course content is presented using Moodle software and can be downloaded by the students. Online quizzes can also be facilitated through Moodle. At the end of the coarse students have all their work as an electronic portfolio.

The construction of a building is achieved through the organisation of a large group of people. The idea of working in groups or teams introduced in pre-trade course and continues through the diploma or bachelor course. Students enter this next phase of their learning with a basic understanding of light timber frame construction and principles of construction. The Diploma/Bachelor stage of the building education involves more complex building and an introduction to multi-storey, multi-unit developments. The majority of students are now in apprenticeships learning the practical aspects of their trade on site. The attendance at the technical institute is part–time and mostly for theory.

Throughout this course the concept of sustainability is embedded. Each paper has an outcome referring to the ‘Te Tiriti o Waitangi’ (Treaty of Waitangi) as per the institute charter. Group work is continued in the communication and problem solving paper. Here each group must develop a product or process using less resources but more sustainable than what is currently available and is specific to the building industry. This is presented to the class along with individual project for their portfolio. The focus is on an ability to think laterally and to communicate ideas. Google + enables the tutors to follow the participation of the group members. Regular feedback is possible and the role of the tutor becomes one of support and mentor.

Other technical papers use plans of existing buildings and students are required to develop or find systems or materials that will reduce the environmental footprint. Investigative research appropriate to level 6 is required. Students’ progress is monitored through the sharing of documents with their tutors and appropriate feedback given. Group exercises are monitored using circles in Google + (Plus). By adding the tutor to the circle the level of emotional maturity of working groups can be seen. This is another area of research distinct from the built environment but relevant to ecological regeneration. The new communalism and the ‘back to the landers’ of the 1960s and 1970s were social laboratories that did not work. We have to trust business and its adaption of communal networking to help provide the skills for working in teams.

For the diploma, the final year paper Technology Project requires the student to investigate a problem, material or system within the industry. This is not a chance for them to tell us what we know because we taught them so. This is to generate thoughtful lively discussion and to question the status quo and using a lateral thinking problem solving approach. It is pretty scary for a lot of students and often the initial feedback needs to sell the idea back to them so they take ownership. Environmental issues and sustainability are their main focus reflecting on discussions through the technical subjects and a perception of their working environment as an apprentice.

The bachelor course is heavily focused on sustainability. This is concurs with research done by Williams (2009), Sharma (2010) and Packard (2010). In New Zealand universities are more focused on sustainability than vocational training institutes. Architecture programs consider ideas of regenerative buildings and real time and sustainable design as essential knowledge. Their drawings are coupled to BIM modelling to enhance construction costing and management. Civil engineering students take papers in environmental science and obtain a broad understanding of eco systems. For trades, teaching sustainability is stepping outside the prescribed curriculum which is based on attaining competency.

3 Findings and discussion

A number of themes start to emerge from the feedback of students, industry and academia. Up until 2010 sustainability was contained as one of the themes of the New Zealand Government's education policy. The review of this policy by the centre-right National led government omitted this completely for the period 2010 - 2015. A review of the building trade related qualifications begun in 2013 has so far omitted to include any education for sustainability. Trade training is shaped at a national level as a vehicle for implementing New Zealand Government policies. In contrast Education for sustainability is part of the Australian curriculum and much better organised.

The advantage of an electronic portfolio is the ownership remains with the student. It will enable a student to show a prospective employer what has been covered and how well they have performed over the course of their studies. Ideally it would be linked to the institute so that grades could be seen as well.

Quick Response code originated in the Japanese automobile industry and was quickly adapted by other industry as a way of disseminating information. It has proven to be very successful in the practical classroom situation where one or two tutors oversee a large group. They offer a quick way of giving instruction for installation or health and safety requirements for a building site use. Potentially of regenerative buildings could be more complex as far as the number of systems installed. The QR code can give instruction with regard to trades following behind reducing the chances of replicating work.

Google+ monitoring supports working in groups. Students as digital natives are often supporting tutors with this technology. However it comes naturally to the Facebook generation and is a normal way of communicating with their peers. This is a social system held together by information exchange into which at any time individuals can insert themselves. The computer, smart technology etc is helping individual users to integrate more easily with "laws" of nature. Google+ is a way of communicating through an organisation. Construction firms that operate over several sites can use this for communicating with and between teams. It is more appropriate for the overall update on progress than for day to day operations but still an important communication tool.

More and more businesses are relying on groups of specialised skills to put a project together. These are precisely the skills needed for a construction project. The polytechnic/vocational training institute needs to create a work readiness aligned to the industry. That is the language of the global shift in tertiary education. Industry readiness and acceptance of people who can introduce new approaches is just as important. Such skills are considered desirable in the creative industries but need encouraging in the rest of the built environment. The 'Living Building Challenge' is a good example requiring active participation.

Students struggle with the concepts because they cannot see it happening in front of them. This issue is slowly evolving so it is sometimes difficult for students to realise the urgency. Active engagement in the classroom and peer pressure that comes from group work can be the trigger.

To quote Senator Daniel Patrick Moyniham "everyone is entitled to his own opinion, but not his own facts".

4 Conclusion

There is a very disorganised and scattered approach to sustainability in New Zealand. Vocational Students need sound core skills for their discipline and the tools to be able to participate in teams or groups. They need the ability to find information and how to use it and be able to action or build collaborative networks. Industry has shifted from a vertical hierarchy to a more horizontal model incorporating interdisciplinary teams working together. This structure was used for the development of radar and nuclear weaponry. If it could transform the outcome of a World War then interdisciplinary teams working together could have a chance to regenerate our planet.

The main focus of vocational institutes is working towards every student understanding and applying sustainable practice in their workplace and everyday activities. For building related trades it is an imperative. The world's population is becoming increasingly urbanised an in the process is turning bio-diverse and productive land into bio-absent systems of hard surfaces, retaining heat, diverting water and increasing pollution. Green buildings are often designed and built for optimal performance as a standalone and not considered within the broader social and environmental context.

As a result it is important that younger building practitioners are not disconnected to the consequences of their decisions and are able to find information and use it appropriately. Nature must be a partner in any development. Eco effectiveness, regenerative design such as living walls and roofs, modular structure, off-site construction and deconstruction are all concepts applicable to their learning.

The Natural environment will survive without mankind but humans cannot survive without a natural environment. Any advance and regeneration of our current state will require active participation and communication. Vocational training for the built environment must equip students with the awareness and skills to take this journey.

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Validating the impact of EVM on Project life cycle

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Abstract

With the inevitable increase in size and complexity of construction projects, the need for proper control is increasing. Considering the fact that each project strives for excellence, numerous studies have been conducted over the years to measure performance and investigate factors that are really critical towards project success. Earned Value Management is a project performance evaluation technique which enables industry professionals to closely monitor project performance in both time and cost .The aim of this paper is to examine the result of proper Earned Value Management (EVM) implementation on different project life cycle (PLC) and validate the impact on project success.

The study investigates different success factors in construction industry with special focus on previous researchers' work which studied the importance of cost control in project success especially in fragmented industry like construction, followed up with three different case studies to analyze the positive impact of EVM implementation on construction projects. Furthermore, for data triangulation purpose, case study analysis will be supported by interviews with specialists working in the UAE construction industry to cross check the outcomes of previous researches.

The research shows that EVM application on cost control in construction projects is not only a crucial management task which is a key to the success of the business but also its influence on project success depends on the time of implementation. It requires a number of up-to-date input data consistently throughout the construction phase. Assigning the right budgets, calculating accurate estimates and monitoring actual costs throughout different project stages are the three main drivers of an effective control through PLC staring from inception stage till completion. EVM proved to be of vital importance due to alarming escalation of construction costs which needs to be especially monitored and controlled. Senior management support and availability of professional staff to execute cost control systems are key factors towards successful implementation

Key words: Control, Performance, Earned Value Management, Implementation, Triangulation.

Introduction

The ultimate goal of project management is to drive the project to the success, while the definition of project success is still vague, since 1950s many trials to develop procedures to quantify and qualify project success factors, all of attempts considered cost management is essential to project success (Atkinson, 1999; Anderson et al.,2006 and Hwang et al., 2010).

According to (Morris, 1994)"realizing a building project successfully from a project management perspective, is generally accepted to relate to ensure that the project is delivered in accordance with its agreed objectives, typically those which concern time, cost and quality", Skitmore and Ng (2003) highlighted the importance of accurate estimate of projects duration and budget to contract administration as the predicted duration and cost form a basis for budgeting, planning, monitoring and even litigation purposes, nonetheless Westervels (2003) agreed with the traditional way of measuring project success called golden triangle which consists of budget, time and quality.

Construction industry is dynamic in nature (Chan, 2004), therefore setting projects on the road to success, providing directions and ensuring alignment are crucial to navigate efficiently with construction projects, Bayliss et al., (2004) stated that "Being a successful construction firm after projects are becoming larger and more complicated, company should be able to manage the operations efficiently and ensure that its operations are integrated in ultimate community targets.

According to (Tas and Yaman, , 2005) " in such globalizing construction sector , with the help of international partnerships and joint ventures, the number and size of projects are increasing, and the projects are getting more complicated and extensive, it is becoming more difficult to achieve the set objectives concerning the building costs". As a common practice in construction industry extra expenses and cost overruns mostly are correlated to lack of control and management, in addition previous studies by the World Bank over last twenty five years demonstrated that 90% of construction projects around the world suffered from significant cost or time slippage. Whilst most researchers claimed time, cost and quality as the predominant criteria.

When the economic crunch occur the world only efficient players were able to manage their operations in construction industry through implementing a high degree of control, alarming firms with any future losses became essential to successful organizations, absence of a proper implementation of EVM in construction companies especially in the UAE as a fast growing market, aggressively impact the potential of construction firms to compete and increase its market share and profitability, the objective of the research are:

- To investigate construction projects different success factors.
- To prove the impact of EVM implementation on project success and company strategic decisions.
- To conclude the benefits and challenges of cost control in construction projects.

2. Research methodology

2.1. Determine and define the research objectives

In order to critically examine the impact of EVM applications on construction industry, it is crucial to select different case studies which represent the influence of cost control systems on project success, hence analyzing construction projects which didn't have Earned Value Assessment (EVA) or practices in a very late stages to other projects which started with implemented EVA systems form project kick-off is essential to build a solid understanding on the influence of cost control. The selection of case studies were mainly focused to support the objectives of the research and build a strong analysis to the required aim; therefore it is required to study projects which will address following issues:

- To quantify the impact of EVM in construction projects.
- To evaluate the influence of cost control and EVM at corporate level.

2.2 Developing case study and selection basis

This part will analyze three different case studies for company (X) which is one of the biggest main contractors in the UAE market with a yearly turn over AED. 1.5 Billion, different projects were selected to analyze the impact of EVA on project success and company strategic goals.

- (P1) represents a project constructed and completed without any application of EVM system then later before closing out the account contractor applied in backward path the principle of EVM.
- (P2) represents ongoing project with45% completion without any application of EVM system then contractor started to apply in order to confirm achieving target profit margin.
- (P3) represents a project which contractor started to apply EVM system from project start

Table (2.1): Projects (P1, P2& P3) details

	P(1)	P (2)	P (3)
Project Type	Residential high rise building	five stars hotel building	mixed use development
Location	UAE- Ras Al Khimah	UAE-Dubai	UAE- Abu Dhabi
Project details	3B+5P+35F	1B+5/6 F	2B+ 1P+ 9F (2 Buildings)
Built up Area	750,000sq.ft	1,250,000 sq.ft	1,020,000 sq.ft
Contractual Duration	24 calendar months	27 calendar months	22 calendar months
Contract Value	AED. 215 M	AED. 530 M	AED. 260M
Start date	June- 2009	October 2011	January -2012
Finish date	June- 2011	January 2014	November 2013
Project status on the study date	Completed-October- 2011 with 90d excusable./	Ongoing 60%- SPI=0.72- CPI=0.76- EV= 45 %.	Ongoing 5.0%- SPI=0.92- CPI=1.06- EV=4.0 %.

3. Case study No# 01

3.1. Implementation of cost control system- EVA

It was not accepted from contractor (X) to just acknowledge the results generated from accounting files, another feedback from cost control team was required to confirm project status, cost control team started to revise the methods of calculating project expenses in term of direct and indirect costs, general expenses, overheads, payments to workshop and plant divisions, accordingly a recalculation of project value an estimate at completion along with its associated D&ID costs. The issue was the allocation of general expenses and administration costs (G&A), before applying EVA traditional accounting systems were used to allocate G&A expenses based on project certified payments while the main concern with cost control system is to reallocate G&A expenses based on actual project consumption.

3.2. Project status before/after applying cost control system

Table 3.1: Project (P1) status before/after applying cost control system

Item	Before EVA	After EVA	Remarks
Direct works	160,246,103	160,246,103	Including PS& NSC items*
Staff Salaries	9,100,080	9,100,080	
Equipment & Plant	19,317,160	9,382,741	
Labor indirect expenses	15,705,075	5,800,326	Other than salaries and
Staff indirect expenses	1,120,000	490,500	Other than salaries
Main office overheads	11,769,086	3,548,000	
Sub-total G&A costs	47,911,312	19,221,567	
Total project costs	217,257,504	188,568,350	
Profit at completion	- (2,257,504)	26,431,650	

*P.S (Provisional Sum); NSC (Nominated Subcontractors)

- Direct works reflect all expense against BOQ items, while G& A "indirect expenses" reflects general expenses and administration costs which consist of followings:
- Equipment and plants expenses: reflect costs of tower cranes and equipment which allocated to the project based on overall company costs of machinery (project machinery costs= overall company machinery expenses x (project value (P1)/ contractor (x) all current project values)
- Labor indirect expenses: reflect all costs other than labor salaries and overtime like transportation, accommodation, food, visa, health insurance, air ticket and end of service dues
- Staff indirect expenses: staff costs other than salaries like allowances, bonus, insurance…etc.
- Main office overheads: reflects head office expenses which allocated to the project = overall head office expenses x (project value (P1)/ contractor (x) all current project values)

Direct costs are the same before applying EVA, total actual profit margin after applying cost control system in backward path was revised to be 12% at the end of project (P1)

3.3. Case study# 01 Analysis

3.3.1. Before applying cost control system

Osborne and Gaebler (1992) pointed out that if companies cannot recognize failure, it will repeat old mistakes and will never get Value for Money (VFM), findings show that distribution of G&A expenses is the main issue of project losses as the vast majority of allocated ID costs were not directly related to the project and just was the outcome of unfair distribution of company ID costs which ignored the blow issues:

- Actual consumption of tower cranes and machinery by the project
- Ignored the fact that project has almost forty percent of the contract are either Provisional Sum (PS) items or Prime Cost Items (PCI) which are included in contractor invoices but will be paid back to SC with a fixed profit to the company " attendance and administration profit only"
- Calculation of ID costs on projects bi-annually, doesn't reflect the Actual Cost (AC) of indirect expenses as it was calculated based on company overall expenses not project expenses.

3.3.2. After applying cost control system

Calculations of G&A cost structured to be as follows:

- Machinery costs will be based on internal payments between site and work shop department

- Labor indirect costs: Detailed calculations of all labor general expenses were calculated and a total lump sum figure AED. 45 daily was concluded to accommodate all expenses, accordingly monthly total man days will be accumulated and multiplied by AED. 45 to calculate monthly ID labor costs.

Table (3.2): Labors indirect costs

Expenses	Yearly	Monthly	Daily	Remarks
Accommodation	7,900	658.3	21.6	4,000 per room (6 person) per month
Utilities (water, Power...)	Included	included	included	Included
Uniform & PPE	700	58.3	1.9	2 uniform + 2 PPE Set
Visa Renewal	800	66.7	2.2	1,600 each 2 years approx.
Transportation	1,444	120.0	4.6	125 AED per trip for each bus capacity 54
Paid Leave	1,700	141.7	4.6	rate of 50 AED - 26 Days - 12 Month
Air Ticket	1,300	108.3	3.6	2,600 per 2 year
Gratuity& Insurance	840	70	2.6	21 days for each year of service

Staff indirect costs: The same methodology was applied to staff considering different grades.

Table (3.3): Staff indirect costs "Grades –C& F"

	Tickets	School Buses	Car	Visa	insurance	leave salary	Gratuity	TOT. FB	Monthly FB	FB %
Grade C	12,000	20,000	32,000	2,000	7,000	-	50,000	123,000	10,250.	24.40%

Grade F	2,500	-	-	900	2,000	-	25,000	30,400	2,533	14.07%

- **Head office costs:** Total HO expenses were calculated and re-distributed to current projects based on project value not certified payment, after analyzing completed projects and reviewing accounting report acknowledged that general administration cost falls between 5-6 % of project costs.

3.4. Analysis of findings: It was company mistake to depend on the certified payment to allocate ID costs as in the late stages of the project actual consumption of machinery are minimal while most of executed works are Provisional Sum items, further benefits might be discovered on direct costs and performance if the application of EVA were applied at early stages.

Table (4.1): Project status before& after applying EVA

	G&A	Profit Value	Profit %	G&A savings
Before EVA	47,900,000	-2,250,000	-1.00%	N/A
After EVA	19,200,000	26,400,000	12.3%	28,700,000

4. Case study No# 02

4.1. Implementation of cost control system-EVA

Contractor decided to apply EVA at this stage to increase the confidence of achieving a reasonable profitability margin of the project. Analysis of (P2) status before applying EVA in term of target profit and project variables along with extracted data from EVA #01 report are listed in the below table:

Table 4.2: Project (P2) comparative findings

Item	Status before applying EVA	Status after applying EVA
Project Value	530,000,000	530,000,000
Project Budget	480,000,000	480,000,000
SPI	Not available	0.72
CPI	Not available	0.76
Estimate to Complete (ETC)	205,000,000	217,000,000
Estimate at Completion (EAC)	479,200,000	492,000,000
Expected profit	50,800,000	38,000,000

Before applying EVA, there was no available data on SPI and CPI because the direct link between time and cost performance was missed and contractor target profit was the same as planned when awarded the contract, after EVA applications contractor had a better control on the project as project SPI and CPI were clear and expected profit margin was acknowledged.

4.2. Case Study # 02 Analysis

4.2.1. Before applying cost control system

Project was in progress, payments are ongoing as planned by the client but management noticed that deployed labor to the project were exceeding gradually and some loses in productivity were noticed, cost and time performances were segregated without direct link, management decided to cast the concentration on linking cost and time performance and to deeply analyze the issue of productivity loss, reviewing project pointed out :

- Negative float was recorded due to many design variations and different IFC drawings
- Excessive machinery usage and many idle types of equipment are available at site without economical consumption as it was used in ad hoc behavior due to endless changes.
- Number of non-conformance reports (NCR) were increasing

4.2.2. After applying cost control system

Many items noticed to progress over budget which was highlighted in the EVM#01 report and project manager was advised to put more control on these items to reduce any further losses, such as:

- As the labor total budget was around 25 M, and BCWP (EV) at the cut of date was AED. 17 M While the ACWP was AED. 19 M, it is obvious that labor cost will reach at 100 % Complete AED. 29 M and the project will suffer from 4 Million extra labor costs, Project manager was advised to start discharge extra labors from the site and to reduce floating labors ASAP.
- Increase of preliminary costs due to adding more supervision staff to the project
- Some of SC packages awarded with almost the same selling price which means very low profit margin and reduction of overall profit. the new system of G&A distribution (described in case study #01) was segregated in the following categories:

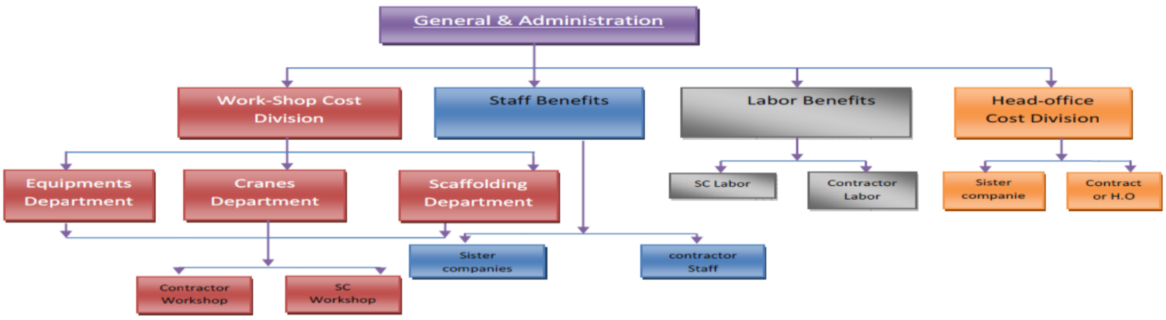

Figure 4.3: G& A costs distribution

- Category (A) which presents machinery, cranes and scaffolding expenses
- Category (B) presents staff benefits beyond direct salaries
- Category (C) presents labor benefits beyond direct salaries and overtime
- Category (D) presents general administration costs

4.3. Analysis of findings

- A drop of 25% was noticed in the target profit, from AED. 50.8M to AED. 38M with loss value of AED. 12 M.
- Around AED. 2.8 million which forms 21% of the loss are related to labor productivity at site, reasons varied between in-efficient operations in some areas and reworks in shuttering and reinforcement activities due to design changes
- AED. 3.6 M which forms 28 % of the loss are due to adding additional staff to the project, which was management decision to improve SPI.
- AED. 4.1 M forms 32 % of the loss are extra machinery consumption

- AED. 2.3 M around 18 % of the loss are related to SC awarded contracts which was higher than the budget but below the selling price meaning that loss from profit not from selling price.

4.3.1.Contractor corrective and preventive actions

Management decision to increase the supervision staff to overcome the issue of slow progress which was the outcome of issuance of many design changes and variations by the client will impact project CPI as a direct increase of preliminaries cost but contractor behavior to respond promptly to any design changes reflects a cooperative behavior to balance the issue of time and cost performance with an acceptance to reduce CPI up to reasonable limits to improve project SPI, meanwhile more concentration of supervision staff will increase project quality and reduce number of NCR.

5. Case study No # 03

5.1. Implementation of cost control system-EVA

Contractor started the application of EVM from project kick-off, based on the estimate issued from tendering department to prepare project budget then started to monitor the progress of works against the assigned budget using EVA technique. Contractor applied cost control system using EVA technique from project Kick-off, based on project selling BOQ, cost control department prepared project budget and started to monitor the progress against the assigned budget, findings as follows:

Table (5.1): Project (P3) – EVA reports summery

Item	EVA # 01	EVA # 02	EVA # 03	EVA # 04	EVA # 05
Data date	March-12	May-12	Aug-12	Nov-12	Jan-13
SPI	1.44	1.27	1.07	0.84	0.92
CPI	1.32	1.29	1.14	1.05	1.06
G&A to date	540,000	3,266,768	5,460,000	9,360,117	12,295,614
Direct costs	4,500,000	23,956,301	40,038,713	68,640,814	90,167,270
ETC	228,360,000	206,576,930	191,700,000	160,999,022	136,456,550
EAC	233,400,000	233,800,000	237,200,000	239,000,000	238,920,000
Expected Profit	26,600,000	26,200,000	22,800,000	21,000,000	21,080,000
Elapsed time %	4.55	18.18	31.82	40.91	50.00

5.2. Case study # 03 analysis

EVA describes how cost issues will be handled and how cost variances will be managed (e.g., different responses to major problems than to minor ones).

5.2.1. Before applying cost control system

Cost control system using EVA was applied on the project from Kick-off as contractor prepared project baseline budget based on selling BOQ and estimation department analysis which covers all project scope and segregated in term of D&ID costs, direct works reflected in four categories (Labor, Equipment, Materials and SC) and ID costs cover staff, fuel, head office expenses, safety, insurances,…etc.

5.2.2. After applying cost control system-EVA

As illustrated in the below figure and compared to cost baseline, BCWS, BCWP (= EV) and ACWP will be calculated as on the review date (data date), will be graphically represented compared to budget baseline.

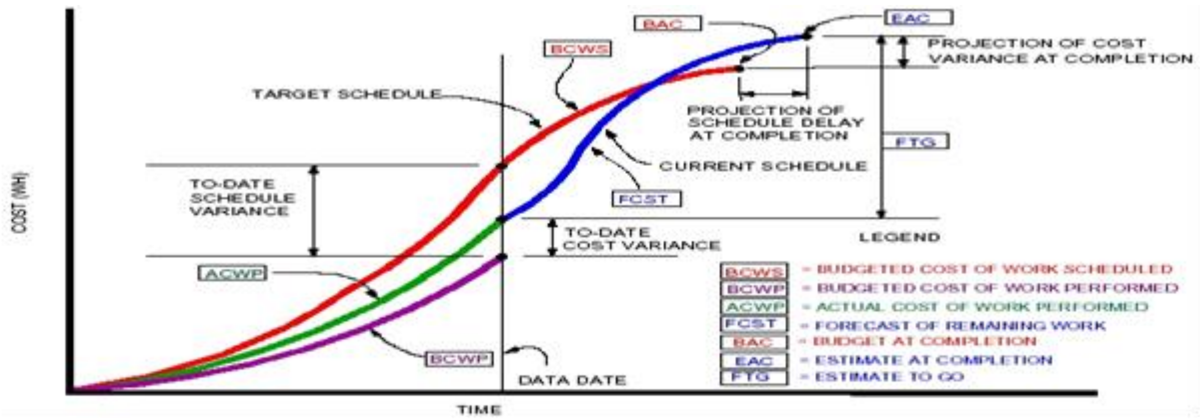

Figure (5.2): Earned value management curve

BAC (Total Budget)	CPI (EV/AC)	SPI (EV/PV)	ETC = EAC-AC (Estimate to Complete)	EAC =((BAC-EV)/CPI)+AC (Estimate at Complete)	This Period Variance	Estimate Forecast Total Variance
AED 94,599,022	1.02	1.45	AED 73,876,555	AED 93,546,310	AED 405,987	AED 1,052,712
AED 770,579	0.61	1.04	AED 159,473	AED 1,250,132	AED (424,500)	AED (479,553)
AED 75,667	0.26	1.08	AED 32,898	AED 286,570	AED (186,692)	AED (210,904)
AED 154,928	0.30	1.08	AED 58,752	AED 511,775	AED (315,881)	AED (356,847)
AED 186,925	1.89	1.08	AED 11,334	AED 98,727	AED 78,073	AED 88,198
AED 353,060	1.00	1.00	AED 56,490	AED 353,060	AED -	AED -
AED 35,811,041	1.04	1.47	AED 15,699,680	AED 34,278,777	AED 830,487	AED 1,532,265
AED 6,266,430	1.55	1.47	AED 1,845,683	AED 4,029,876	AED 1,212,212	AED 2,236,554
AED 3,977,656	1.00	1.47	AED 1,821,766	AED 3,977,656	AED -	AED -
AED 24,918,361	0.97	1.47	AED 11,792,391	AED 25,747,579	AED (449,436)	AED (829,218)
AED 648,594	1.24	1.47	AED 239,839	AED 523,665	AED 67,711	AED 124,929
AED 6,107,004	0.00	0.00	AED 6,107,004	AED 6,107,004	AED -	AED -
AED 4,357,964	0.00	0.00	AED 4,357,964	AED 4,357,964	AED -	AED -
AED 7,371,805	0.00	0.00	AED 7,371,805	AED 7,371,805	AED -	AED -

Table (5.3): EVA report- snaps shot

5.2.2.1. SPI

Project has a favorable SPI at the beginning (SPI> 1) started to decrease up to SPI= .92 which shows a delay, after analyzing project updated programs, discussions with site team and review of project correspondences it was clear that contractor has the site possession from the client 1.5 months before the contractual starting date which enabled the contractor to finish mobilization early and start some construction activities which were reflected in SPI= 1.44 at EVA#01, SPI started to decrease after finishing concrete works due to late nomination and delivery of some items by client. The link between SPI and project schedule is crucial to be able to analyze project status and there is a direct relation between SPI and Total float (TF) as below:

Table 5.4: Relation between SPI and Total float

Sr.	Project Total Float	SPI	Project Status Vs. Critical Path	Project diagnostics

1	**Total Float > 0 (+ve)**	**SPI > 1.0**	Ahead of schedule	Significant Ahead on non- critical activities
		SPI < 1.0	Ahead of schedule	Significant delays on non- critical activities
		SPI =1.0	Ahead of schedule	Delays on non critical activities
2	**Total Float = 0**	**SPI > 1.0**	On Schedule	Significant Ahead on non- critical activities
		SPI < 1.0	On Schedule	Delays on non- critical activities
		SPI =1.0	On Schedule	EV= PV
3	**Total Float < 0 (-ve)**	**SPI > 1.0**	Behind Schedule	Significant Ahead on non- critical activities
		SPI < 1.0	Behind Schedule	Significant delays on non- critical activities
		SPI =1.0	Behind Schedule	Ahead on non- critical activities

This link enables all project stakeholders to analyze any delay or ahead of schedule in critical or non-critical activities, accordingly right decisions will be taken.

5.2.2.2. CPI

Analysis shows favorable figures at the beginning of the project (CPI=1.32) which decreased through quarter reports, as the decrease was noted from EVA#02 contractor started to take corrective actions after analyzing inefficient areas which was mainly extra usage .

5.3. Analysis of findings

It was clear that expected profit margin is reduced compared to the original planned profit (AED. 21.08Magainst AED.26.6M), losses were recorded in concrete works due to invalid estimation quantities and staff costs due to adding addition staff to project team. Some other losses are expected due to recorded delay in the project which will increase preliminaries costs, these delays are due to late nomination of some sub-contractors by the client, related expenses will be submitted as an associated cost along with extension of time claim.

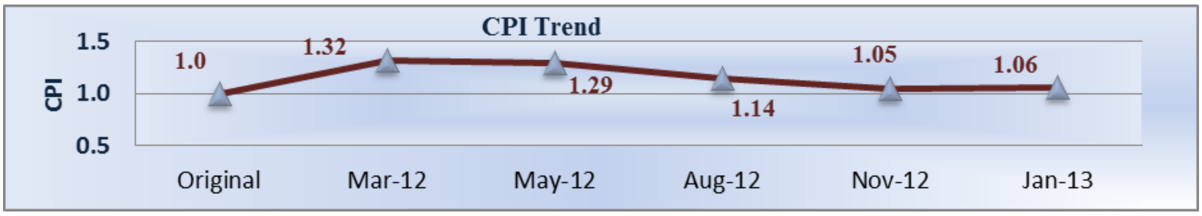

Figure (5.5): Project (P3) - CPI Trend analysis

5.4. Contractor corrective and preventive actions

Analyzing EVA reports EVA#02, EVA#03 and EVA#04 shows that contractor has some losses in safety and quality EAC, it was noticed that more nonconformance requests NCR were issued by the consultant, as a corrective action contractor allocated more resources to safety and quality in term of 2 additional safety supervisors and 2 additional quality inspectors more than manning plan, it was obvious to the contractor that some losses will be in these two items but contractor behavior to improve safety and quality was noted. EVA#04 and EVA#05 shows that technical staff BAC is suffering, reasons behind these findings was an initiation from contractor to allocate more technical staff to help client to finalize nomination process, which was reflected in improving SPI from .84 at EVA#04 to .92 at EVA#05 .

6. Case study findings

6.1. General findings

Analyzing different case studies highlights following:

- The analysis confirm the existence of strong relationship between EVM implementation and other success factors as cost performance should not be seen in isolation to other success factors.
- Applying EVA in construction at any stage of the project might add a value to both project and company, the optimum to apply cost control techniques at project kick-off while even if not happened, reviewing project status after completion will add value to the company.
- Unfair distribution of company G&A costs might change the overall project status.
- Distribution of contractor G&A costs has to be based on direct works not PS items as it is mostly has a limited profit to contractor which covers only supervision and attendance.

6.2. Added value to contractor

Applications of EVA added the following values to contractor

- Visibility of how well a particular project is doing and prompts reply to in-efficient operations.
- Improving communication level between project team members.
- Increase the level of Control on project performance and avoiding any scope creep.
- Integration of different project PI such as schedule, safety, quality and cost.

7. Interviews feedback and integrated analysis

7.1. Sample selection

Table (7.1): Information of interviewees

Sr. r	Role	Experience	Company type	Project types	Interview duration
1	VP- PM	25	Developer	Commercial/Residential/Mixed use	80 min.
2	PCS Manager	25	PMC/Consultant	Commercial/healthcare/ Industrial	50 min- phone
3	General Manager	26	Main Contractor	Commercial/Residential/Mixed use	40 min- phone
4	General Manager	24	Main Contractor	Commercial/Residential/Mixed use	75 min
5	Planning Manager	16	Main Contractor	Commercial/Residential/Mixed use	55 min

7.2. Questions feedback

7.2.1. Success factors for construction projects

Interviewees confirmed that “iron triangle” quality, time and cost is the basis of success in construction industry and quality is the most leading factor for contractors success as compromising the quality will impact time in term of reworks and costs in term of extra expenses to rectify deficiencies while most of failure are due to undefined scope of woks and continues design changes. Interviewees considered safety is a mandate delivery of projects but should not be considered as one of success factors as safety is an environment not a deliverable.

7.2.2. Is construction industry successful in the UAE

Investigations of market efficiency of the UAE confirmed that it is efficient market as it adopts high technology with high quality and fashionable architectural themes, while the market is still require further improvement in :

- Safety issues need more improvement; a kind of standardization is required.
- Developers have to avoid unrealistic estimate of construction duration and allow a reasonable time for construction so as not to compromise with quality or costs.
- Standard project management practice to standardize all processes instead of ad hoc approach.

7.2.3. Cost control environment in construction industry

Lack of availability of cost control practices in construction firms working in the UAE market is recognized, many construction firms don't apply cost control techniques although it its importance towards project success, contractors have an ad-hoc attitude when addressing cost control issues and the main reasons varies between absence senior management directions to apply control and unavailability of EVA professionals.

7.3. Balancing of success factors

Current practices in the market show that construction firms in general don't have the intention to balance different success factors, mainly concentration on issues related to profit is the main driving aspect of contractors behavior, only one of interviewees acknowledge that only grade A contractors will facilitate communication channels and change contractor attitude towards balancing other success factors, contractor attitude is the main barrier.

7.4. Data triangulation

Triangulation is defined as the mixing of data or methods so that diverse viewpoints or stand points cast light upon a topic (Olsen, 2004), it is an approach to mix different methods to integrate data and to increase the reliability of the outcome, moreover validate the claims that might arise from an initial study.

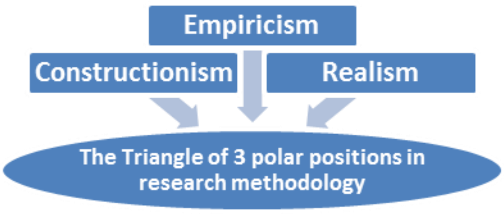

Figure (7.2): Three Traditions of triangulated research-source: Triangulation in research (Olsen, 2004)

7.4.1. Literature review and case study

Literature review confirmed the strong relationship between different success factors in construction industry, cases studies which adopted contractor prospective highlighted the importance of meeting budget to consider the project is successful while the positive impact of proper EVM helps contractor to balance other success factors.

7.4.2. Literature review and interviews feedback

As the literature review pointed out that the golden triangle of time, cost and quality is the most recognized in previous researchers works as the main sign of successful projects, interviewees showed a strong believe that the same prove to be success factors with a priority given to quality then cost and finally time, subject to project nature.

7.4.3.Case study and interview feedback

Different case studies elaborated the importance of having EVM in contractors' works and highlighted that it is critical to distinguish successful projects from failed ones, a criticism to case studies might argue that case studies are subjective in nature and its results should not be generalized beyond examined projects, testing the outcome of case studies with professional interviewees cleared the doubts on its results and confirmed the correlation.

7.4.4. Triangulation between literature review, case study and interviews

Lack of proper cost control systems in construction companies working in the UAE market was obvious from interviewee's feedback while literature review confirmed its importance to successful projects and different case studies quantified the positive impact of EVM implementation on construction projects.

8. Relationship between cost control using EVM and different success factors

8.1. Cost control and time management

Late nomination of SC, design changes and different IFC are of the main causes of delay which are not in contractor hand to reduce, but in most cases contractor can overcome the vast majority of the impact by deploying more resources, overlapping activities and changing construction method which means that CPI will suffer to improve SPI.It is contractor decision to reply positivity to delays and initiate mitigation plans.

8.2. Cost control and quality management

Increasing the quality of the final product beyond project specifications might have associated costs. Adding more skilled labors, increase supervision staff and controlling materials quality are solely contractor decision which means CPI will suffer, in the short term having such proactive attitude by contractor will cost money but in the long term will build the reliability of contractor in the market which means more projects and more profit.

8.3. Contractor behavior in balancing success factors

Good reputations are not earned in the short term; they are based on reliability and trust earned over a period of time, this statement summarizes the feedback received from different CEO's of major contractors working in the UAE market. It is the abstract of construction industry major players understanding, discussing the issue at project level contractor has to balance different success factors to reach the trust, not only to concentrate on CPI.

9. Conclusions

9.1. Research objectives

Objective (1): To investigate construction projects different success factors: Quality, time, cost and client satisfaction are the most recognized success factors for construction projects, although safety was considered in some literatures as one of project success factors but profound analysis confirms that safety is ultimately a work environment, culture and attitude of industry human resources. Quality is the main concern for construction stakeholders; contractors should not compromise quality as it builds contractor reliability in the market. Client satisfaction is important to sustain business, maintain reasonable market share and build strategic relationship with clients, balancing different success factors is the key to reach overall project success.

Objective (2): To prove the impact of EVA implementation on project success and company strategic decisions: Cost control has a dual effect actions like reducing the variable costs of materials increase the margin and reduce the working capital in the operations. The failure has a price; adopting proper cost control system which matches organizational objectives, needs and capabilities improves contractor ability to succeed in such competitive market. Cost control systems especially EVA works as a connecting bridge between cost issues in term of control not only just cutting expenses and other success factors like time, quality, safety and desired project deliverables.

Project success is an abstract concept; proper cost control is one of success routes deals with business risk factors which influence operating expenses, level of revenue. EVM implementation has a significant impact on improving contractors' performance and helps contractors to closely analyze, monitor, balance other success factors and integrate different performance indices. Proper implementation optimizes contractor use of construction resources. The outcome at organizational levels will be improving the efficiency of estimating and managing future projects more efficiently.

Objective (3): To conclude the benefits and challenges of cost control in construction projects: As the business world becomes more complex and competitive, proper control helps to improve performance at both project and organizational levels which leads to overall industry development. Proper EVM implementation enables contractors to meet new developments, become more efficient and incorporate both internal needs and capabilities, in addition to direct benefits to construction projects in term of improving operations, maximizing profit and reducing risks.

In such fast growing and competitive market only efficient contractors will be able to increase market share, professionalism comes from two main sources, proper implementation of different control systems to optimize, integrate and harmonize performance, secondly knowledgeable teams to manage the systems. Senior management support, awareness of cost control benefits and availability of knowledgeable professionals found to be main supporting factors towards proper implementation.

9.2. Cost control impact at organizational level

The core purpose of analyzing costs is guiding the managerial decisions; the effort to develop, implement and operate a cost system is justifiable only when the cost information provides effective support for decision making.UAE is a price sensitive market with high competition, before last economic crisis (2008), construction business was known for high profit margin, recently contractors should not, as a consequence expect high margin, therefore casting the concentration on proper control is much required, especially if contract is lump sum. Performance measurements are promising to improve efficiency.

9.3. Influence of proper EVM implementation on construction industry

The basic outcomes of proper EVA are better managerial control on project success and company strategic goals, therefore accurate economic decisions and overall industry improvement. For centuries, the construction industry has played an essential role in the socio-economic development of all communities. EVM implementation at project level has a positive feedback to company strategic decisions and market share; earlier decisions have the greatest impact on cost savings.

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An investigation of the performance of Saudi Arabian higher education construction projects

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Abstract

There is a building boom in the higher education industry. The demand for construction labour and materials for higher education construction projects have started to rise again according to recent statistics. Many colleges and universities in Saudi Arabia are undergoing significant capital expansion, leading to major development and growth. Although many of these organisations hired some key resources to manage their construction projects, their infrastructure has not grown as quickly. There is a need today for better systems and processes to measure the performance of construction projects in order to drive improvements. The research method consists of the philosophical position of the research, the research purpose and instrument used to investigate the performance of Saudi higher education construction projects. The constructivist approach appears to be the best ontological orientation for the research purpose of exploration. The phenomenological approach is chosen as epistemological orientation for the research. The research focuses on mixed methods; both qualitative and quantitative. Semi structured interviews were chosen as the primary research instrument, because they help better understand how individuals construct meaning and significance in their situations from a personal point of view. Currently, there is a tool to measure the performance of higher education construction projects in Saudi Arabia. The tool includes key performance indicators such as time, cost, labour and material performance. A performance report is issued by the contractor on a weekly basis and discussed during a weekly performance meeting with the owner and consultant. Saudi construction performance is influenced by different internal and external factors. Availability of qualified personnel, financial resources, lack of opportunities for real-time control and proper study of project scope, are the main influencing factors on the performance of construction projects in Saudi Arabia.

Keywords: Construction, higher education, key performance indicators, performance measurement, Saudi Arabia

1. Introduction

Saudi Arabia has the largest construction market in the Middle East, with multi-billion pound projects in both the public and private sectors. The key dynamics stimulating both public and private sector investment in construction projects are population growth and the strong increase in oil revenues (Oxford Business Group, 2010). There is a building boom in the higher education industry. The demand for construction labour and materials for higher education construction projects have started to rise again according to recent statistics. Many colleges and universities in Saudi Arabia are undergoing significant capital expansion, leading to major development and growth. Earlier in 2013, the Saudi higher education minister signed a number of contracts worth more than £0.7 billion to implement university projects including university hospitals, academic buildings and service facilities. Although many of these organisations hired some key resources to manage their construction projects, their infrastructure has not grown as quickly. There is a need today for better systems and processes to measure the performance of construction projects in order to drive improvements. Kaplan and Norton (1996) state that the first step towards achieving performance improvement is to understand current performance, by looking at structured methods of performance measurement. Thus, a credible method of performance measurement for construction is required in order to achieve that.

2. The construction industry

This section helps in establishing the base for the construction industry by capturing learning from the UK. According to Green (2011), the construction industry is not a homogeneous entity. There is a continuing debate about the boundary definition (Pearce, 2003) and that construction is not a single industry, but several separate sub-industries (Ive and Gruneberg, 2000). Emerson (1962) and Banwell (1964) use the term 'construction industries' in the plural, whereas Latham (1994) and Egan (1998) use the term 'construction industry' as if it were a single entity. Green (2011) argues that the modern practice is to refer to use the term 'construction sector'. According to Green (2011), the narrow definition of the sector “limits itself to on-site assembly together with repair and maintenance activities carried out by contractors and excludes those involved in professional services such as surveying, architecture and engineering” (pp xvii). However, professional services and construction material suppliers are included recently within the boundary of the construction sector for the purpose of improvement debate (Green, 2011).

According to Luu *et al.* (2008), construction firms have been unsuccessful over the past few years. Ezeldin and Sharara (2006) argue that the construction environment becomes riskier in developing countries, which trigger the need for construction firms to periodically measure their performance and compare with their past performance in order to identify improvement areas (Gupta, 2004). Ofori (2007) adds that the problems which face the construction industries in developing countries are well known. These problems conclude in poor performance on projects undertaken in these countries.

3. The construction industry in Saudi Arabia

The Saudi Arabian construction industry basically consists of the public and private sectors. Al-Sedairy (2001) states that "The public sector pertains to the government ministries responsible for infrastructure and national development projects, while the private sector comprises the construction firms privately owned or subsidised either by a family corporation or a conglomerate" (pp 162). In the late 1960s, Saudi Arabia had almost no infrastructure at all, apart from the traditional methods of buildings. Since then, a hundred billion pounds have been spent to promote the construction industry. The industry experienced a boom, as projects were initiated and completed across all construction types.

Uncertainty is identified as an existing element in the nature of the construction business. This may be because of different factors, such as the nature of the industry itself, competitive bidding, the workforce, changing demand and distinctive management approaches. The Saudi Arabian construction industry is no exception.

The construction industry in Saudi Arabia has enormous challenges and opportunities to face in the future, for instance, to complete the several projects announced and to create economic cities, as well as to absorb increasing demand for residential buildings. Moreover, there is hope for the construction industry in the government's enhanced commitment to the private sector and to its firm commitment to the principle of privatisation. The willingness of Saudis to invest in their own country also demonstrates the bright long-term future of the construction industry (Al-Sedairy, 2001). However, despite all the recent developments in the Saudi construction industry, there is still no system to assess the performance of construction projects (Bannan *et al.* 2012).

4. Performance measurement systems

4.1 Introduction to performance measurement

Performance measurement is the process whereby an organisation establishes the parameters within which programmes, investments, and acquisitions are reaching the desired results (Office of the Chief Information Officer (OCIO) Enterprise Architecture Program 2007). Neely *et al.* (2002) define performance measurement as the process of quantifying the efficiency and effectiveness of past actions. According to Luu *et al.* (2008), performance measurement is the heart of ceaseless improvement. A key part of a performance measurement system (PMS) is the use of results to aid the decision-making process (Beatham *et al.*, 2004). From 1998 to 2009, the reviews of performance measurement studies in construction concluded that research in this area has focused on three levels: the project level, organisational level and stakeholder level (Yang *et al.*, 2010).

4.2 Key performance indicators (KPIs)

Key performance indicators (KPIs) are quantifiable measurements that reflect the critical success factors of an organisation. KPIs can be used to evaluate performance, the results of an activity, current status or results of a process (Takim and Akintoye, 2002; Cox *et al.*, 2003). Chan and Chan (2004) posit that KPIs are general indicators of performance that allow focus on important aspects of outputs.

In the UK, following the specific targets for improvement set in the Egan report, the Movement for Innovation and the Construction Best Practice Programme (CBPP), both government-funded, were launched. The CBPP is one of the leading organisations involved in generating KPIs for the industry as well as introducing the subject of performance measurement. Other organisations include Movement for Innovation, Housing Forum, Major Contractors Group (MCG), National Contractors Federation, Design and Build Foundation, Association of Consulting Engineers (ACE), Architectural Practices benchmarking and the Construction Round Table (Beatham *et al.*, 2004).

5. Research methods

The selection of which methodology to use is one of the most vital questions and important choices in relation to research design. The researcher clearly should be looking to develop the most beneficial available method that is both practical and feasible within the scope of the study being carried out. In theory, the choice of methods depends mainly on the nature of the research problem and the research programme's philosophical orientation. However, in practice, there are certain limitations, such as time and funding, which might influence researchers' choices (Boyd et al., 1985).

The research method of this study consists of the philosophical position of the research, the research purpose and instrument used to investigate the performance of higher education construction projects in Saudi Arabia.

5.1 Ontological orientation: constructionism

The constructivist approach appears to be the best ontological orientation for the research purpose of exploration. The performance of the Saudi construction environment is believed to be socially constructed.

5.2 Epistemological orientation: phenomenology

The phenomenological approach appears to be the best epistemological orientation for the research purpose of exploration. Ideas about the performance of Saudi construction should be developed through the induction of data. The intent is to explore how respondents' attitudes are shaped by understanding the words and the meanings they allocate to them. An attempt is made to understand Saudi higher education construction phenomena in depth and not to prove or verify any theory.

5.3 Methodology: qualitative

The research focuses on qualitative methods, examining subjects' words, behaviours and actions in descriptive ways, and more closely represents the situation as experienced by participants (Maykut and Morehouse, 1994). The holistic nature of qualitative methods is thought to be useful for the purpose of understanding the performance of the Saudi construction projects. The researcher will take part in the construction of data to better understand the phenomena under study and to provide detailed description.

5.4 Research purpose: exploratory

The research aims to explore how the performance of Saudi Arabian higher education construction projects is measured and the influencing factors on its performance, with a view to obtaining new insights. Therefore, the exploratory method best suits the aims of the research.

5.5 Research strategy: case study

A case study is intensive analysis of an individual unit, which can be a person, situation, group, even organisation, or a phenomenon of interest stressing developmental factors in relation to its environment (Flyvbjerg, 2011). According to Bromley (1986), a case study is concerned with empirical investigation, relying on the collection of evidence about a real case. Case study strategy is mainly used for exploratory research purposes to explore causation in order to find underlying principles. Saudi higher education construction projects are a little known topic. The depth of investigation into particular situations that case study exploration enables, strongly indicates the suitability of this research strategy.

5.6 Research instrument: semi-structured interviews

Valentine (2005) explains that, unlike with most questionnaires, "the aim of an interview is not to be representative but to understand how individual people experience and make sense of their own lives" (pp.111). Semi structured interviews were chosen as the primary research instrument, because they help better understand how individuals construct meaning and significance in their situations from a personal point of view. They are a flexible and adaptable approach to exploring the Saudi construction industry in conversation. They allowed the researcher to focus on specific topics, while also allowing the respondents to share project information and current challenges in an open environment. Moreover, they provide the opportunity for further discussion and exploration of thoughts and ideas as they proceed.

6. Results

6.1 The case study

In order to address the questions that prompted this research, a case study was selected as the primary focus for empirical investigation. The case study, a facility called multi-storey car parks, was chosen to enable the researcher to explore the Saudi higher education construction projects in more detail and capture a range of insights from a 'real-life' project. The facility is located in King Abdulaziz University in Jeddah, Saudi Arabia. "Table 1" shows general details about the case study.

Table 1: Case study details

Consultant	*Contractor*	*Site hand over*	*Preliminary hand over*	*Extended to*	*Status*	*Contract value £*
Fluor Arabia Limited	*Al-Marshad Group*	*6/11/2010*	*20/04/2012*	*21/12/2012*	*Penalty*	*7,079,499*

6.2 Respondents

Four semi-structured interviews were conducted for the case study (project) with construction practitioners involved directly in the project. Respondents were carefully selected from among those with knowledge and experience in the field and understanding of the subject under research (Easterby-Smith, 2008). A deliberate attempt was made to secure interviews with representatives of considerable career experience (10 years or more) in order, as far as possible, to capture well-informed, 'expert' opinions as well as achieving a grounded understanding to the subject (project) under research "Table 2".

Table 2: Interviewees information

Job title	*Construction party*	*Qualification*	*Expertise*	*Experience (Years)*
Construction Engineer	*Owner*	*BSc*	*Consultancy and contracting*	*10*
Senior Construction Engineer	*Consultant*	*MSc*	*Consultancy and contracting*	*20*
Project Manager	*Contractor*	*BSc*	*Contracting*	*10*
Planning Engineer	*Contractor*	*BSc*	*Contracting*	*10*

6.3 Semi structured interview questions

The interviews were carried around the main research questions. They focused on understanding the current performance measurement in Saudi higher education construction projects, exploring the factors influencing the projects and the immediate areas of improvements. Although these themes guided the interviews, the researcher did not ask exactly the same questions each time. In so doing, each successive interview was used to expand understanding of the subject under research.

6.4 Current performance measurement for higher education construction projects in Saudi Arabia

The owner (The University Department of projects) has a standard performance measurement procedure to be used for all construction projects. It includes performance reports, meetings and site visits. A weekly performance report for the project must be issued by the consultant containing general details and performance indicators as shown in "Table 3"

Table 3: Consultant weekly performance report details

Project name	*Total built-up area*	*Variance %*	*Submittals approved #*	*Change order status*
Project number	*Total built-up level*	*Planned manpower #*	*Submittals under review #*	*Expected completion date*
Contract value	*% payment*	*Actual manpower #*	*Staff #*	*Insurance*
Contract duration	*% time elapsed*	*Submittals required #*	*Safety*	*Recommendation/actions*
Site hand over date	*Planned progress %*	*Submittals planned #*	*Concerns*	
Preliminary hand over date	*Actual progress %*	*Submittals actual #*	*Major/critical activities in progress*	

Similarly, the consultant requests specific reports from the contractor. The planning engineer of the contractor issues a daily report including the completed daily activities. More importantly, the contractor prepares a weekly report for the consultant that must be shared before the weekly meeting. The report includes the details shown in "Table 4".

Table 4: Contractor weekly performance report

Project summary	*Material submittals schedule*	*Shop drawing status*	*Long lead items*	*Electrical works*
Safety report	*Design drawing status*	*As-built drawing status*	*Mechanical works*	*Civil works*

The owner demands a weekly F2F meeting with key contributors from both the consultant and contractor to review the project performance and progress and agree the next steps needed.

Site visits are of the key elements for reviewing the physical progress of projects. There are informal visits that can take place at any time by the owner and consultant. However, there are formal visits with specific objectives and participants.

6.5 Influencing factors on the performance of higher education construction projects in Saudi Arabia

All participants were in agreement regarding the main influencing factors on project performance "Table 5".

Table 5: Influencing factors on project performance

Lack of project planning and scheduling	*Delay of shop drawing and approvals from the owner*
Capabilities of management team to complete projects within constraints	*Delay of work completion from contractor/subcontractor*
Lack of financial resources	*Payment delays from the owner*
Material delays	*Penalty system is not properly enforced*
Availability of skilled labour	*The nature of different parties involved in the project*

The consultant states that incompetent contractor is a critical influencing factor on project performance. The main factor identified by the contractor is payment delay from the owner. Site visits are of the key elements for reviewing the physical progress of projects. There are informal visits that can take place at any time by the owner and consultant. However, there are formal visits with specific objectives and participants.

6.6 Improving the performance of higher education construction projects in Saudi Arabia

The participants recommend immediate improvements in several different areas as shown in "table 6".

Table 6: Immediate improvement areas

Financial capabilities	*Change orders*	*Qualified personnel*
Government regulations	*Project planning*	*Classification of contractors*
Labour performance	*Bidding process*	*National KPIs system*
Material availability	*Decision making process*	*Penalty system*

Financial capabilities, labour performance and qualified personnel were identified by the majority of respondents. However, the level of importance differs between the owner, consultant and contractor. The owner and consultant agreed that there should be proper selection criteria to choose the contractor for a certain project (change the bidding process). Moreover, there should be a comprehensive study of project duration prior to awarding it to the contractor. The owner adds that international contractors with excellent records should be invited to Saudi Arabia in order to drive improvements. The consultant states that the resources should be clearly included in the contract with the contractor in order to be equipped with the full force. In contrast, the contractor identified change orders, on time payments to contractors and decision making process as the main areas that require immediate improvement.

7. Conclusions

The performance of higher education construction projects is currently being measured using KPIs adopted by the owner. These KPIs include time, cost, labour, material, change orders, quality and safety. The owner imposes certain reports, software and meetings to measure and review the performance of projects. The performance of Saudi higher education construction projects is influenced by different factors, such as the lack of project planning, lack of financial resources, payment delays from the owner and availability of labour. Financial capabilities, labour performance and qualified personnel were identified as the areas that require immediate improvement. The level of importance of influencing factors and immediate areas of improvement differed between the owner, consultant and contractor. In order to obtain more accurate results for measuring performance, responses from more construction parties have to be collected (i.e. client, consultant, contractor, sub-contractor, management team, end user…etc). The next step is to use several case studies to explore the similarities and differences among different construction parties in order to develop a framework for measuring the performance of Saudi construction projects.

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The influence of organisational culture on sharing knowledge in small information communication technology firms in Libya

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Abstract

Knowledge is seen as a crucial factor behind sustainable advantage and success for Information Communication Technology (ICT) business organizations. Consequently, sharing knowledge (SK) has been considered as a main element of success, which is closely interlinked with organizational culture (OC), and OC is believed to have significant influences on the processes of SK. Such interrelationships between both concepts can be reflected in the fact that both concepts focus on people who share and interact knowledge as well as those who create and build up the organizational cultural values and meanings.

Accordingly, in the literature, although there is a considerable amount of research which concerns issues related to the influence of OC on the process of SK, there is a lack of research that proposes a coherent framework which assists firms to establish good practice for SK processes.

In this study, the influence of OC on the processes of SK in ICT organizations in Libya is investigated. This aim will be accomplished by applying a multi-case study approach to examine four different cases (two public and two private) ICT Libyan firms. Both quantitative and qualitative data will be collected using different data collection methods, namely questionnaire, in depth interviews and official documents. The outcomes of this research will be to establish a framework that assists ICT firms to perform better practices in SK processes.

Keywords: Organizational culture, sharing knowledge, information communication technology, Libya.

1. Introduction

It has been argued that business organizations, since the early 1990s, tended towards conceiving existing knowledge and intellectual capital as the main assets to achieve sustainable competitive advantage in a competitive and dynamic economy. According to Grant (1996) and Spender (1996) business organizations, since the 1990s, started to maintain their knowledge and encourage staff with particular expertise to create knowledge and share it, in order to increase their possibilities to achieve better competitive advantage, stability and profitability. Ackerman et al., (2003) stated that comprehensive publications and books were published to discuss issues related to knowledge management and most of the scholars' opinions tended to consider SK as a main part of knowledge management (KM) processes. But, from another perspective, SK was seen as a core set of activities which are related to organizational practice (Mueller, 2012).

Leidner and Kayworth, (2008) saw that OC which is embedded in the firm will influence the process of SK, because the social context includes the values and beliefs which will motivate staff to create, organize and share knowledge. Following Schein (1985), OC can be defined as a set of shared values, symbols, beliefs and practices of the people who contribute to the organization life. Therefore, OC has either visible or invisible dimensions. In this part of the paper, the issues related to how the relationship between SK and KM is understood will be discussed, and then issues related to OC will be explored, before the influences of OC on the process of SK will be addressed.

2. Sharing knowledge

Browsing through Google Scholar searching for KM related literature, it is easy to see the considerable number of publications, including books, academic papers and research studies which discuss issues related to KM. According to Paulin and Suneson (2012), there is no doubt that huge effort was made since the early 1990s to examine issues related to KM, but at the same time, it has been found that most of the scholars who examine SK issues were using central terms interchangeably, and they were not able to differentiate between them. For instance, sharing knowledge and knowledge transfer were used in the literature interchangeably and most scholars were not able to provide adequate explanations of the perspectives in which the terms were used (Jonsson, 2008). Despite this confusion in the term usage, there is no doubt the success of knowledge management initiatives depends on knowledge sharing, According to Riege (2005; 2007) that lack of understanding of SK issues influences negatively on the implementation of KM.

Jackson, (2006) observed that SK is one of the knowledge based activities which requires staff to innovate new ideas and share them to gain the expected competitive advantage. According to Garud & Kumaraswamy, (2005) SK can be seen as a part of organizational practices because organizational practices are responsible for luring companies into routines that are unpredictable with the regular changing of the business' environment. Practices can involve capturing, organizing, sharing, and using knowledge. They argued that if firms did not think about allocating SK as part of the business strategy, then the business can become subject to stagnation. Hovorka & Larsen, (2006) stated that staff knowledge and skills are fundamental elements in agility. Firms adopting this strategy pay more attention to managing and leveraging knowledge. Agility is likely to be associated with an firm's ability to integrate, use and share knowledge. Jones et al., (2006) argued that organizational strategic level mechanisms are essential to facilitating knowledge sharing and usage.

In this research, this perspective is argued, more than seeing SK as part of KM processes. From this perspective, adopting such a position gives more freedom and better flexibility to examine different activities carried out in ICT firms in Libya, and greater understanding of SK practices in the Libyan context. In addition, the research findings contribute towards creating a framework that helps ICT firms perform better SK practices, and this increases the possibilities for better contribution to knowledge as the findings would not only be limited to ICT firms which apply KM, but to a wider range of firms.

3. Organizational culture and sharing knowledge

In the business literature, the terms organizational culture and knowledge have been interrelated on different occasions. For instance, Davenport and Prusak (1998) were the first to use the term knowledge friendly culture; Janz and Prasarnphanich (2003) used knowledge centred culture; and Oliver and Kandadi (2006) used knowledge culture.

Accordingly, Delong and Fahey (2000) identified four reasons why culture can be aligned with knowledge:

1. Culture is responsible for shaping staff understanding as to “what knowledge is significant”.

2. Culture allows people to understand the different types of relationships between knowledge levels, that is “What knowledge should belong to individuals and which should belong to the firm”.

3. Culture is responsible for establishing the social context to exchange and share knowledge, “What activities can be carried out to share and encourage sharing knowledge”.

4. Culture is responsible for motivating staff to create a new knowledge.

Evans, (2012) uses the term culture aligned to knowledge and conceives it as a part of organizational structure and one of the most important conditions for generating and sharing knowledge. In addition, he used such vocabulary and phrases to describe OC as flexibility, fuzzy, structures, extensive contacts, emphasis on learning, triggering creativity, smoothness of roles and job description, environment enabling working and learning in groups, clearly defined values, openness to diversity, clearly defined requirements for employees, ancillary leadership (Evans, p.59-70). McDermott and O'Dell (2001) stated that they found that on many occasions, SK practices failed because “people believed they were already sharing well enough, that senior managers did not really support it, or that, like other programs, it too would blow over” (P. 77). From their perspective, OC is all about shared morals, principles and practices of the staff who communicate in the firm. It includes visible surface elements of the firm, such as policies, mission and written values, and at the same time, it also includes more profound notions such as staff behaviour and how they interpret each other's actions. In that sense, "*culture is rooted in the organization's core values and assumptions. Often these are not only unarticulated, but so taken-for granted that they are hard to articulate, invisible to organizational members*" (P.77). So the interrelationship between the OC and SK can be seen as the culture of the firm being built up as a result of regular interactions between the staff and different types of knowledge and information existing in the firm. SK is about the provision of task information and know-how to assist others and, to collaborate and communicate with others to solve problems, create new knowledge, or develop policies or procedures (Cummings, 2004; Pulakos, Dorsey, & Borman, 2003).

4. Research methodology and data collection methods

Cohen et al. (2007) saw that there are different sets of assumptions which underlie social research. Those assumptions reflect either an interpretivist epistemological perspective, or positivist ontological understanding of the phenomenon. As the main aim of this study is to create a framework to help ICT firms establish better SK practices, this aim can be accomplished by understanding the general concepts and issues related to SK and OC which exist in the study sample, which is achieved by distributing a comprehensive survey and then examining the issues raised by the questionnaire findings, by carrying out in-depth, face-to-face interviews with decision makers, and also by examining the relevant documents to extract issues and concepts related to visible dimensions of OC.

In addition, according to Silverman (2007) research can be either inductive or deductive. A deductive approach allows a researcher to develop a theory and form a hypothesis, and then set out to test it. An inductive approach allows the researcher to build the theory based on the findings that have been gathered from the fieldwork. In this research, the researcher is likely to be more inductive than deductive because the information will be gathered from ICT firms to generate a framework that can assist ICT firms in their SK practices.

In terms of the research strategy, Punch (2005) defined a research strategy as 'a set of ideas by which the study intends to proceed in order to answer the research questions'. According to Cohen et al. (2007), research can be either qualitative or quantitative, or both at the same time, which is known as a mixed research strategy. In this research, a mixed research strategy was adopted to gain in depth understanding of the examined phenomena and to allow the researcher to gather as much information as possible about the sample.

This research follows a case study approach (Yin, 1994) to examine issues related to OC and SK that exist in ICT organisations in Libya. Case studies (two public and two private) were selected to be the core of this research. Denscombe (2003) argues that the case study approach allows the researcher to investigate the studied phenomena or the real-life situation. It also helps the researcher to gain an in-depth picture of relationships and processes within the phenomenon. Data will be collected by distributing a well–designed survey which was created after a comprehensive examination of the literature. The survey was written in the Arabic language to help respondents understand it easily. The survey will target every staff member at work in the selected ICT firms. A pilot study will be carried out in one of the selected cases and based on these findings, the survey questions will be amended as required and then full distribution of the survey among all cases will be applied. Once the data are collected, it will be analysed using SPSS software. Following this, the findings of the survey will be used to formulate the interview questions. The samples of the interviews will be purposely selected as only those who are willing to share their experiences and thoughts will be interviewed. Once the interviews are completed, the data will be transcribed and translated. The analysis process will be carried out based on thematic analysis, through steps provided by Braun and Clarke (2006):

1. Familiarize yourself with the data.
2. Generate initial codes.
3. Search for the main themes.
4. Review themes created.
5. Define and name themes.
6. Write up the report.

Official documents including website page content will also be investigated and analysed to collect information about each case to create the required background and to examine issues related to the visible dimension of the culture, including polices, strategies and procedures. A document analysis approach will be used to analysis the data. Using documents in qualitative research is discussed by many scholars (Creswell, 2009; Berg, 2007; Bryman 2004, and Prior, 2003). Prior, (2003) stated that documentary techniques are used "*to categorize, investigate, interpret and identify the limitations of physical sources, most commonly written documents, whether in the private or public domain (personal papers, commercial records, or state archives, communications or legislation*)" (Payne & Payne, 2004: 60). Scott (1990) named four main criteria for evaluating the quality of documents:

- Authenticity: Is the evidence genuine and its originality unquestionable?
- Credibility: Is the evidence accurate and without distortion?
- Representativeness: Is the evidence typical of its kind, and, if not, is the extent of its uniqueness known?
- Meaning: Is the evidence clear and written in understandable language?

The main benefits of using the documents in this research are: to examine the concepts of OC and SK as they were presented in firms' literature and, to clarify issues which might arise during the interviews. The content analysis method will be adopted to analyse the components of the documents. According to Patton, (2002, p.453) content analysis can be defined as "any *qualitative data reduction and sense-making effort that takes a volume of qualitative material and attempts to identify core consistencies and meanings*". Once the data analysis processes are completed and themes are extracted and formulated, the main elements of the framework will be built up based on the emerging findings and then the descriptions will be provided to assist the firms to establish good SK practices.

5. The contribution of this research

This research has the potential to contribute to the universal conversation in the field of SK and OC since there are a lack of studies that propose a framework that help business firms in general, and ICT firms in particular, to perform good SK practices. In addition, this topic is new to the context of Libya, which witnessed dramatic political and economic changes since the uprising of 2011. Ultimately, the findings of this research will benefit different stakeholders, namely decision makers, strategists and policy makers.

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The Water-Energy Nexus: An Overview of Recent Trends and Applications

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Abstract

Sustainability of urban communities is intricately linked with water and energy conservation. The recognition that there is a complex relationship between water and energy forms a complex nexus of urban resource flows. On one hand, water is withdrawn and consumed throughout the life cycle of an energy source (e.g. hydroelectricity); on the other hand, energy is consumed for extraction, distribution, and end-use of water resources. During the past ten years, the "Water-Energy Nexus" has emerged as an important way forward to sustainable policy development. The so-called water-energy-climate change feedback loop has significant implications for sustainable water and energy policies in general but specifically in urbanized areas. Since water and energy resource use are tightly joined with urbanization and population growth, there is a need for their integration in policy and research. This paper reviews research on water-energy nexus in the context of sustainability evaluation for urban development and related construction and infrastructure management. Moreover, this study summarizes innovation and technical changes for improved utility management under various competing water and energy demands and develops deep understanding of water, energy and urbanization nexus.

Keywords: Water-Energy Nexus, Life Cycle Assessment (LCA), Water Footprint, Carbon Footprint.

1. Introduction

Building and expanding urban infrastructure to accommodate population growth, is recognized as one of the key issues that needs an innovative approach for sustainable policy development (Kidokoro 2008; Schilling and Chiang 2011). Significant extent of research has focused on developing improved technologies for constructing increasingly complex and robust infrastructures ensuring profitability and satisfaction of the users. However, there is deficiency of sustainable policies justifying and driving the “need” for infrastructure management and construction as an outcome of urbanization (Kidokoro 2008). Conventional urbanization is accompanied by social and economic benefits up to an extent but largely at the expense of unsustainable and rapid consumption of scarce natural resources (particularly water and energy) and environmental degradation (Ness 2008).

The major natural resource inputs to develop and drive urban infrastructure systems undeniably include water and energy. Recent studies indicate that both production and consumption processes of water and energy resources are not isolated but are inextricably linked (Teschner et al. 2012). Water is not only required to generate energy for the residential, agricultural, industrial and commercial sectors but is also required for the direct consumption. The treatment, conveyance and end-use of water by these sectors also require energy. Given the projected increase in population and industrial-agricultural expansion, the water-energy consumption loop more appropriately termed “*the water-energy nexus*,” will rapidly result in the depletion of both water and energy resources (Scott et al. 2011). Consequently, a necessity arises for integrated management and optimization of production and consumption of both resources to ensure their sustainability to meet future demands (Perrone et al. 2011). As a result, the water-energy nexus is becoming an emerging area of research for many institutions. Recognizing the water and energy link (as a first part of problem identification) has offered us an opportunity for a unique approach in solving the impasse of sustainable development of urban infrastructures (Scott et al. 2011; Teschner et al. 2012). In this context, urban development needs to be guided with a broader goal of integrated and sustainable water and energy planning. This requires modelling and quantification of resource use and associated impacts as a first step towards solving the problem.

2. Modelling water-energy nexus

Built environments cannot be assessed merely on the condition of associated human dwellings As opposed to conventional instantaneous view, a complete life cycle observation provides a realistic understanding on sustainability of built environments in terms of their ability to maintain in future without compromising present and future local and global well-being (Ozcan-Deniz and Zhu 2013). Sustainability also has triple bottom line dimensions namely social, economic and environmental over the life cycle performance of built systems (Ness 2008; Reza 2013).

Figure 1 demonstrates the fallacy of conventional approach guiding the need of built environment and the lack of adequate consideration to the life cycle performance where majority of resource flows and waste generation takes place. A sustainable system does not consume significant amounts of resources and also ensures its demands are adequately met without negative social, environmental and economic impacts (Schilling and Chiang 2011). However, rapid and significant resource use due to the water-energy nexus in built environment necessitates comprehensive life cycle approach for optimization (Mo and Zhang 2013). “Water in the West" (2013), a joint program of Stanford Woods Institute for the Environment and Bill Lane Centre for the American West, presented a detailed literature review on the “water-energy nexus” from the life cycle perspective of both water for energy and energy for water systems.

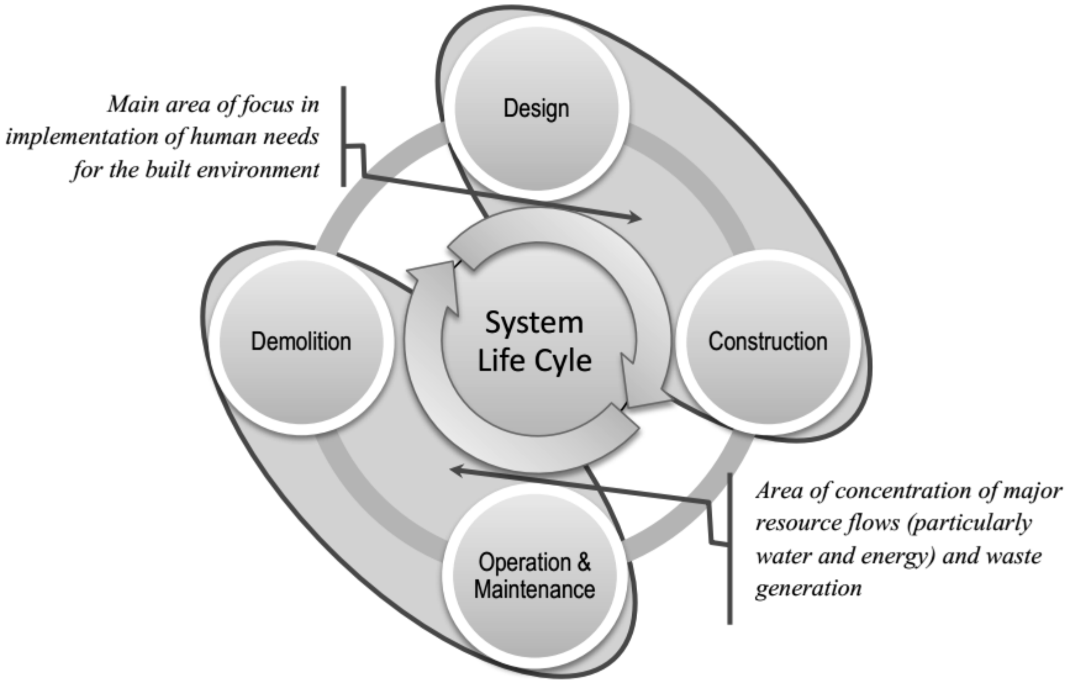

Figure 1: Life cycle of built environment

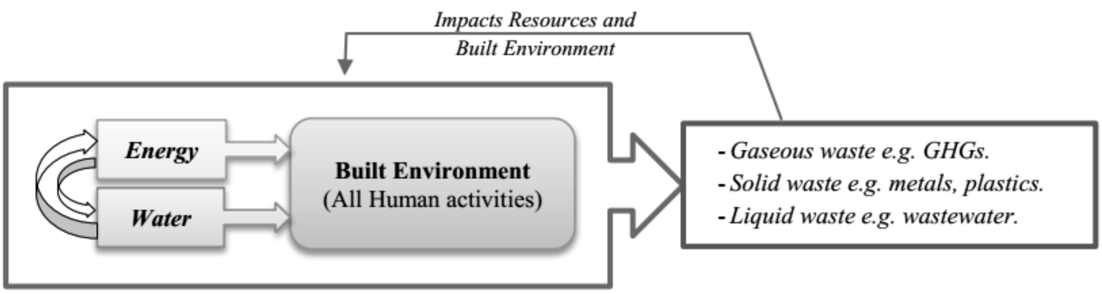

Figure 2: Conceptual view of inputs and outputs occurring due to the built environment

Figure 2 portrays a looped water and energy resource production-consumption binomial along with simultaneous waste production impacting the resources and built environments. From the life cycle perspective, aging infrastructure, population growth, water insecurity and greenhouse gas emissions can aggravate the resource efficiency of the infrastructure assets socially, economically and environmentally at an unprecedented and rapid rate (Reza 2013; Scott et al. 2011). In order to devise strategies for sustainability of urban infrastructure systems, it is first essential to measure the key indicators that ought to be controlled in the first place (Čuček et al. 2012). From **Figure 2**, those key indicators can be identified as water and energy along with outputs such as greenhouse gases, solid waste, wastewater etc. In the following sections, main assessment techniques to evaluate these inputs and outputs will be outlined.

2.1 Life cycle assessment

Life Cycle Assessment (LCA) is a wide-ranging tool for analysing variety of indicators of interest to stakeholders e.g. greenhouse gas emissions (carbon footprints), energy use, water use (water footprint) etc. including the impacts of these indicators on economic, environmental and social dimensions (Ozcan-Deniz and Zhu 2013). Primary focus here will be on two main indicators i.e. Water footprint and Carbon footprint to analyse the water-energy link and associated impacts over the life cycle of concerned system. Generally, the framework for the assessment of these footprints is similar to that provided by International Organization for Standardization standard ISO 14040 (2006) for LCA and involves the following main steps:

1. Defining the goal and scope of concerned system or item (e.g. cradle to gate or cradle to grave boundaries for a product, process, production system etc.)

2. Quantifying the direct and indirect material and energy flows limited by the defined boundaries (also called inventory analysis).

3. Analysing sustainability and impacts on environmental, social and economic dimensions based on measured indicators of water use (water footprint) or emissions (carbon footprint).

4. Developing a response strategy.

In the following sections "water footprint" and "carbon footprint" will be discussed as potential measures to guide sustainable development (Čuček et al. 2012; Radu et al. 2013).

2.2 Water footprint

Earth's freshwater resources are finite, unreliable and at risk due to ever growing and inefficient human activities (Hubacek et al. 2009). Since water and energy resources are linked, "Water Footprint" or the amount of freshwater used in providing a service or delivering a product is a figure of significant importance (Gerbens-Leenes et al. 2008). Developing decision models that take into account multiple factors such as availability of water and its use in deriving energy are possible using "*water footprint*" (Gerbens-Leenes et al. 2008). In order to manage water consuming or producing processes, first it is essential to estimate and analyse water flows in a system (Garrido 2010). Detailed analysis may also include indirect water flows (Hoekstra et al. 2011) that occur due to production of the other inputs such as energy used, thus enabling inclusion of water-energy nexus implications on resource consumption.

Figure 3 illustrates how water resource use, energy production and carbon emissions are linked in a water distribution system. All the processes can be traced to the freshwater use as the single most vital input to the system. However, there is not enough information on: (a) How much water is used in producing the energy input of this system? (b) How much water is lost during extraction, treatment, supply and distribution? (c) How much water is at risk due to carbon emissions and wasted water? (d) How much water is returned to the environment as a recharge to freshwater source?

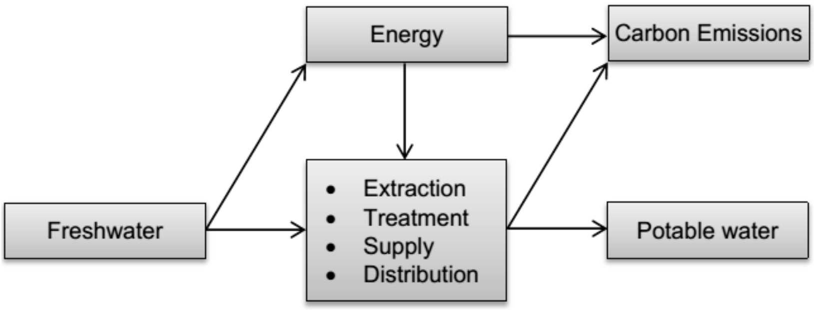

Figure 3: The water-energy link in water distribution systems

Hoekstra et al. (2011) recognized that accounting for these flows can help in understanding the impacts of consumption and trade of critical resources. The concept of "*water footprint*" was presented by Hoekstra and Hung in 2002 (Hoekstra 2003). The Water footprint indicates cumulative direct and indirect water use along supply chains (Hoekstra et al. 2011). By gaining understanding on these flows, it is possible to devise more sustainable strategies to manage freshwater resources at local as well as global level (Garrido 2010; Hoekstra et al. 2011). Hoekstra et al. (2011) classified water footprints into following main types:

1. **Blue Water Footprint**: Measure of freshwater use (surface and ground water) – It also includes loss of water that occur during evaporation, discharge to environment (e.g. sea, river, ground) and cradle to grave product life cycle.

2. **Green Water Footprint**: Measure of rainwater used. It is more related to agriculture and forest industry as it considers the moisture in soil which is used for vegetation and also includes evapotranspiration.

3. **Grey Water Footprint**: Measure of freshwater polluted. It is the volume of water required to dilute the pollutant concentrations to certain standards of water quality.

The conventional water withdrawal and consumption statistics do not consider the amount of water returned to source of freshwater i.e. blue water and also lacks information on the amounts of water polluted i.e. grey water (Ridoutt et al. 2009). 'Water footprint' carries much more meaning as it identifies the specific areas of source and also where it is used directly and indirectly (Garrido 2010).

The water footprint of a product can be expressed as the volume of water used per unit output of products, business, industries, community etc. (Garrido 2010; Jeswani and Azapagic 2011). The output can be in units of mass (for a product), money (for businesses), energy (for electricity generation plants) etc. Hoekstra et al. (2011) have presented detailed methodology for evaluating the water footprints of each medium and recognized that water footprint of specific product, processes, consumer etc. are all linked by common processes underlying them.

The accuracy of water footprint analysis depends on the accuracy of inputs and this issue is of paramount importance (Jeswani and Azapagic 2011). Accurate water use statistics throughout supply chain of processes or products can form a basis for reliable policy development after water footprint analysis. But, current and up to date statistics are not readily available and in some cases corporate or government sectors may not be willing to disclose this information (Hoekstra et al. 2011). Moreover, water footprint assessment only addresses water scarcity issues and does not take into account problems of environmental issues and aging infrastructures (Jeswani and Azapagic 2011). In order to form sound policies, LCA tools or carbon footprint measures may also be included in order to arrive at sustainable solutions (Hoekstra et al. 2011). Although LCA tools can be used for water footprint assessment but their application in this area has received little priority and are generally considered more suitable for assessing environmental performance (Koehler 2008). Therefore, addressing wide range of issues in an integrated decision making processes requires using the combination of water footprint with other environmental indicators such as Carbon footprint (Hoekstra et al. 2011; Jeswani and Azapagic 2011).

2.3 Carbon footprint

The water energy nexus, in which rising energy and water demand coupled with their inefficient use is depleting both resources rapidly, is also accompanied by significant greenhouse gas emissions (Perrone et al. 2011). Due to these emissions, more heat is trapped in earth's atmosphere resulting in global warming and a domino effect on climatic variability and water availability (United Nations Environment Program 2012). Statistical observation on global greenhouse gas emissions and water use indicates that the energy industry generally ranks among the highest in both categories (Bernstein et al. 2008; Kenny et al. 2009). In order to control these emissions, it is first essential to quantify them. Greenhouse gas emissions can be assessed in an aggregated measure called "*carbon footprint*" over the life cycle of any system (Radu et al. 2013). The carbon footprint method accounts for the overall amount of GHG emissions that are directly and indirectly produced through a process or are accumulated over the life cycle of a product (Galli et al. 2012). Wiedmann & Minx (2007) presented two main approaches for assessing carbon footprint namely the Process Analysis (bottom-up) and Environmental Input-Output analysis (top-down) approaches. The bottom-up approach is for product or process level while top-down approach is for much broad sectorial or regional level carbon-footprint accounting (Radu et al. 2013). Wiedmann & Minx (2007) suggested the simultaneous use of both approaches to get more reliable results. Despite the disadvantages of unreliable input values, non-standardized methodology and possibility of repetitive accounting (as in Water footprint methods), carbon footprint measures are anticipated to become sophisticated in future (Radu et al. 2013).

Next section will elucidate response development and policy formulation (based on key indicators discussed so far) in an integrated manner.

3. Response development and policy formulation

Key indicators of LCA such as water footprint and carbon footprint can be used for assessing sustainability of built environment (Čuček et al. 2012). Evaluation of alternative technologies and strategies based on these indicators can help formulating an informed decision. Moreover, water footprint and carbon footprint indicators can aid policy makers at institutional and governmental level to implement sustainable regulations which are conscious of water-energy nexus and associated environmental, social and economic implications (Čuček et al. 2012). **Figure 2** identifies key players in general sense and their strategic objective in upholding responsibility for maintaining the sustainable system of water-energy nexus and associated waste effluents can be worked out. Table 1 explores sustainable integration of resource efficient priorities in the consumption and production binomial within each sectors.

Table 1: Exploring sustainable integration of resource efficient priorities in various sectors from differing perspectives of consumption and production

Resource	***Perspective***	***Key Players / Sectors***	***Integrated Priorities***
Energy	*Production (EP)*	*Electricity generation (Thermal power, Nuclear power, Hydropower, Solar power etc.) Fuel extraction and production*	*- Water efficient while ensuring minimum energy loss and emissions.*
	Consumption (EC)	*Residential, Transportation, Industries, Commercial institutions, Water treatment, supply and distribution, Wastewater treatment and disposal, Bottled water companies, Electricity generation (Thermal power, Nuclear power, Hydropower etc.), Fuel extraction and production, Agriculture*	*- Energy efficient while ensuring minimum emissions.* *- Recycling waste discharge and effluents to reproduce energy and water*
Water	*Production (WP)*	*Water treatment, supply and distribution, Wastewater treatment and recycling, Bottled water companies*	*- Energy efficient while ensuring minimum water loss and emissions.*
	Consumption (WC)	*Electricity generation (Thermal power, Nuclear power, Hydropower etc.), Fuel extraction and production, Residential, Agriculture, Transportation, Industries, Commercial institutions, Fuel extraction and production, Water treatment, supply and distribution, Wastewater treatment and disposal, Bottled water companies*	*- Water efficient while ensuring minimum emissions.* *- Recycling waste discharge and effluents to reproduce water and energy*

Li et al. (2012) adopted a hybrid life cycle assessment approach and quantitatively established wind power as a sustainable option to meet criteria of reduced greenhouse gas emissions and minimized water use in China. In another study related to energy sector, Gerbens-Leenes et al. (2008) found that use of bio-fuels is not sustainable option in water stressed areas owing to their relatively large water footprints. Their study showed that the water footprint of Biofuel production is about 66 times that of crude oil and 3 times that of hydropower. Therefore, producing and consuming it may solve the problem of greenhouse gas emissions but at the expense of large water footprints. Similarly, in the U.S, statistics indicate that thermo-electricity sector is the one with the highest water withdrawals (primarily because of its extensive use in cooling processes) which is more or less a similar trend with other nations (Kenny et al. 2009). Thermoelectric facilities can adopt a energy production perspective (EP) and can enhance its efficiency and productivity by adopting water efficient technologies with minimal energy loss and waste genergation (Table 1). Similarly, they also have an energy consumption (EC) and water consumption (WC) areas and corresponding priorities can overlap with energy production (EP) along with additional focus of using waste to reproduce energy and water (Table 1). In this way, priorities in other sectors can also be oriented to adopt production-consumption binomial perspective in water-energy nexus to enhance resource sustainability in a holistic manner.

Scott et al. (2011) discussed the challenges at multiple levels of policy making sectors in adopting integrated decision making. Setting right priorities at the right places within the water-energy production and consumption sectors is the first step toward sustainable integration of water-energy resource policies (Teschner et al. 2012). The next important step is to evaluate alternative technologies and strategies that can help in achieving those priorities in terms of right deliverables. Here, the use of Life Cycle Approach to assess water and energy use along with effluents (e.g. Carbon emissions) can play an important role as indicators for performance comparisons of different technologies and strategies to be adopted in the built environment and associated systems (Čuček et al. 2012).

4. Summary and conclusion

Obsolete policies driven by the supply-demand solutions have resulted in rapid environmental degradation, depletion of scarce resources and encouraged more waste production (Teschner et al. 2012). Given the projected increase in population, water-energy demand and climate change, ensuring efficient water-energy use with the least environmental impacts has become a significant challenge for improving existing and planning new infrastructure systems (Jeswani and Azapagic 2011). Technological improvements are either highly energy intensive or water intensive as a way to reduce the environmental impacts. Without integrated approach, the situation may become difficult to handle. In order to conserve and monitor water-energy use, it is crucial to develop a comprehensive quantitative and qualitative database that accounts for important resource (direct and indirect) input and output flows that accompany any process in terms of "Water Footprint" (Hoekstra et al. 2011) and "Carbon Footprints" (Radu et al. 2013). Moreover, sustainable water-energy management integrates all sectors of the built environment and infrastructure assets by identifying extent of water-energy use and their hotspot areas through advanced techniques such as water footprint and carbon footprint assessment (Čuček et al. 2012). The evaluation of different alternatives of energy generation and consuming sectors can be based on water used, energy loss and emissions. Conversely, evaluation of different water production and consumption sectors can be based on extent of energy used, water loss and emissions. A detailed LCA can help in setting cap for resource use in our consumption-production binomial of sectors. Policymakers can gain useful insights through information from such techniques which can help in supporting informed decision making and facilitating sustainable strategies while ensuring that ecosystems are not stressed due to excessive and inefficient resource use by human activities.

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Condition-based maintenance: a case study focusing on the managerial and operational factors

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Abstract

Reliability has been consistently an essential feature in the evaluation of industrial assets (products and/or equipment), as a result maintenance is a continuous process implemented by hard facilities management (FM) providers not only with the core goal of reducing downtime caused by unexpected failures, but also to reduce the associated energy usage whilst maximizing performance and asset life.

Maintenance policies are categorised into two main strategic streams: corrective and preventive. Condition Based Maintenance (CBM) is a subdivision of preventive methodology and is based on the belief that 99 per cent of equipment will evidence some sort of indicators prior a fault develops. Through utilisation of science and technology CBM exploits the operating condition of assets to diagnose faults at early stages of occurrence thus triggering proactive maintenance based on the need. Although the field of CBM is extensively researched, the studies appear to be technical, computer and information science or mathematical modelling orientated. Consequently, contradictions remain between literature and practice concerning the consequences of CBM implementation and the impact on the managerial and operational processes. Concentrating on managerial and operational barriers and success factors, this study investigates centrifugal pumps and associated motors to ascertain the extent to which vibration provoked faults can be identified and diagnosed through the use of Vibration Analysis (for misalignment, looseness and imbalance faults) and Shock Pulse Method (SPM) (for bearing faults), albeit routine Planned Preventative Maintenance (PPM) is applied.

The study establishes that a PPM schedule based on original equipment manufacturers recommendations and best practice standards, is not sufficient at completely eliminating the investigated mechanical faults, thus CBM techniques should be utilized in conjunction to compensate. Moreover, the study recognizes key managerial and operational barriers and success factors for implementation, while drawing attention to the significant role of FM Supply Chain Management.

Keywords: Facilities Management, Condition Based Maintenance, Supply Chain Management, Reliability.

1. Introduction

Although good asset design is significantly linked to high reliability, regardless of design, over time deterioration will occur consequent of real environment operation stress or load (Jardine et al., 2006). An effective way to assure a satisfactory level of consistency during the useful life of a physical asset and reduce random failures (which has a direct effect on efficiency) is to perform maintenance (Martin, 1994; Jadine et al., 2006). There are many definitions of maintenance, they all somewhat emphasize that it is 'a set of activities or tasks used to restore an item to a state in which it can perform its designated functions' (Dhillon, 2002; Tinga, 2010; Ahmad and Kamaruddin, 2012). Due to the significant operational importance, over the years there has been rigorous effort applied to maintenance planning and management (e.g. as highlighted by Dunn (1998)), not only with the core goal to reduce downtime caused by unexpected failures, but also to minimize the associated cost of maintenance which can be as much as 40% of the operational budget in many large-scale plant-based industries (Eti et al., 2006). This is further reinforced by Alsyouf (2007) and Veldman et al., (2011a), highlighting that facilities managers within industry are increasingly accepting that maintenance is not just a cost but can actually generate a profit.

Usually, maintenance policies are categorised into two main strategic streams: corrective and preventive (also referred to as scheduled) (Martin, 1994). In contrast to corrective, preventive tackles the problem of equipment failure prior to failure occurrence. Following proactive principles, this strategy aims to reduce the failure rate or its frequency, at the same time allowing for better product quality and reduction of failure costs (Ahmad and Kamaruddin, 2012). Literature indicates that Preventive Maintenance (PM) technique can be applied through either experience, which is a conventional practice, or recommendations made by the original equipment manufacturer (OEM), which in contrast is performed on a regular prescribed basis (Nakagawa, 1984; Sheu et al., 1995). The former practice strongly relies on the technicians' and engineers' knowledge and lessons learnt acquired in the past. Based on their experience they can evaluate and predict the condition of a machine. Consequently avoiding the machine failure through applying appropriate PM actions. The disadvantage of this PM technique is considerable dependency on the human factor, i.e. the engineers or technicians who are responsible for maintenance can at any point leave the company taking away their valuable expertise on the assets, consequently increasing the operational risk (Ahmad and Kamaruddin, 2012). The other PM practice is original equipment manufacturer (OEM) recommendation, which is carried out on a pre-agreed set times (for example month, 3 months and annual). Nevertheless this technique fails to minimize operation costs and maximize machine performance. According to Labib (2004) and later supported by Tam et al. (2006) the OEM is considered to be flawed in this sense due to the fact that firstly each machine operates in different environment hence requires different PM schedules; secondly the machines designers focus more on the product delivery rather than later machine failure consequently are not as knowledgeable as the engineers or technicians who on regular basis maintain these appliances; lastly the OEM companies at times can act upon hidden agendas recommending spare parts replacements through frequent PMs. An alternative to OEM reference is SFG20 (standard maintenance specification for building services), which is a monthly reviewed library consisting of over 400 maintenance specifications, thus considered the industry standard tool for PM (SFG20, 2013).

Condition Based Maintenance (CBM) is a subdivision of PM and similarly is widely talked about, although in contrast it is not a fully explored field in practice. This paper presents a natural study of centrifugal pumps and associated motors to ascertain the extent to which vibration provoked faults can be identified and diagnosed through the use of Vibration Analysis (for misalignment, looseness and imbalance faults) and Shock Pulse Method (SPM) (for bearing faults), albeit routine (planned) Preventative Maintenance (PPM) is applied. Additionally, it explores the managerial and operational aspect of CBM implementation.

2. Condition based maintenance

Through utilisation of science and technology CBM exploits the operating condition of equipment to predict a failure occurrence thus preventing any unexpected downtime and reducing maintenance cost by avoiding unnecessary preventive actions (Tinga, 2010; Veldman et al., 2011a; Veldman et al., 2011b; Ahmad and Kamaruddin, 2012). The underlining theory of CBM is based on the belief that 99 per cent of equipment will evidence some sort of indicators prior a fault develops. Therefore according to the thorough examination of these signs an engineer can determine how severe the problem is and how long the machine can perform as normal without any actions being taken to repair the fault (Ahamed and Kamaruddin, 2012). Consequently, according to the CBM theories, it is possible to identify the fault (detection), determine the root cause (diagnosis) and establish the severity and longevity of the equipment's optimum life (prognosis) through monitoring and evaluating of data collected through various techniques such as vibration, temperature, oil and acoustic analysis (Veldman et al., 2011a; Ahamed and Kamaruddin, 2012). Moreover, CBM is also able to verify where exactly the fault is, how quickly and to what extent the component is degrading (Veldman et al., 2011a; Veldman et al., 2011b). The focus of research in the last decades within the maintenance field appears to be CBM orientated with the general conclusion that it *"is to be preferred above PM and other policies"* (Koochaki et al, 2011, p.400) thus the literature relating to CBM is extremely widespread, (as highlighted by Jardine et al., 2006 and Ahamed and Kamaruddin, 2012), and too numerous to extensively list within this review. However, generally the studies can be categorised into three areas namely technical (engineering related without any thought of the business aspects), computer and information science (focus on protocols of data/information exchange and different design in order to establish that investment is required for subsequently improving asset management) and finally, mathematical models and decision-making (i.e. the use of algorithms and stochastic models (e.g. Markov chain concept) to explain mechanical degradation) (Koochaki et al, 2011). Seemingly, companies can invest a lot of money in CBM and although implementation is successful from a technical perspective, evidence suggests that in practice CBM is not always successful economically in practice (Koochaki et al, 2011; Veldman, 2011a; Lianghua et al, 2009). This may be due to the lack of managerial and operational impact consideration, as highlighted by Koochaki et al, (2011, p.399), the justification used to invest in CBM implementation *"do not often include the operational consequences"* and incline to "*mainly focus on a single piece of equipment*" thus lacking the overall vision required for successful delivery and benefit realisation. Furthermore, Muchiria et al., (2009) provide empirical evidence of alignment deficiency between managerial and operational KPIs and maintenance objectives from CBM implementation.

2.1 Managerial and operational aspect of CBM

Despite the fact that the literature around CBM illustrates the topic mainly in the light of technology (Koochaki et al, 2011), the barriers, drivers and success factors for the CBM implementation seem to originate from the operational and management side such as risk reduction, optimized use of resources, efficiency gains, and improved maintenance processes. It can be therefore deducted that CBM adoption cannot be employed in isolation from plant organisation but must be integrated within the entire facility operation (Koochaki et al, 2011). Maintenance accounts for one of the biggest proportion of the facility operation spending. It used to be considered as a 'necessary evil' where the costs could not be avoided or reduced. However the technological development along with the managerial and operational drive towards maximisation use of assets became biggest motivation for the organisation to implement CBM (IAEA, 2007). However such a major change from the traditional preventive maintenance to more proactive CBM significantly impacts managerial and operational processes, which are subjected to both change management as well as culture change. These require endeavour of both staff and management directly affected by the change but also the entire supply chain (IAEA, 2007). Such joint effort translates to the list of the success factors for CBM implementation. The first aspect suggested by the explored literature is full commitment of staff to the process and the use of new technology as well as management and the supply chain in procuring for the appropriate technology and training provision. Second critical success factor evidenced by the literature is participation of all the parties involved and confidence in positive outcome of the transition which must be reiterated by the lead management. Further, holistic approach must be applied throughout the entire facility. Finally, in order to ensure maximised long-term benefits of CBM, sustainable programme implementation must be put in place. This means the staff must be regularly trained, resources dedicated to the task must be made available at all times and the process must be granted with the management continuous support (IAEA, 2007). Overall in practice, since the process is not mandated, the management role, and leadership of the CBM implementation as well as involvement of the entire supply chain are vital to drive the process forward (Veldman et al., 2011a).

The literature suggests supply chain is also responsible for creating a value, which in maintenance and new process implementation is essential. Supply chain management (SCM) has multiple definitions; Lambert (2004) however identifies it as *an integration of key business processes across the supply chain for the purpose of creating value for the customers and stakeholders*. The critical components of SCM are strategic purchasing, supply management, supplier base reduction, and communication where two-way information sharing is fundamental to support Facilities Management (FM) processes (Noor and Pitt, 2009). When considering introduction of a new product or an innovation process, the supplier involvement becomes an instrumental factor in its successful implementation, which can proof to be beneficial to all partners involved from the perspective of cost efficiencies, rapid production cycle, better product quality and access to technological advancements (Noor and Pitt, 2009). Such collaborative innovation can encompass elements of process innovation management and product management within a network structure where neither partners could deliver on their own meeting same expectations for product quality delivery and overall cost. Researchers suggest that collaborative innovation brings integration of all relevant aspects of knowledge, technology, process and relationship management as a result creating value (Noor and Pitt, 2009). The conclusive driver in literature for CBM implementation is a drive toward quality and innovation which have been incorporated within strategies of all the ambitious organizations wishing to cut competitive edge not only with the cost but service delivery (IAEA, 2007). Such approach focuses not only on quality but also availability, reliability, post-delivery service as well as delivery performance (Noor and Pitt, 2009). Innovation on the other hand takes shape of more exploratory investment, where the organization learns from its past mistakes and examines the outcome of the project that can prove to be somewhat beneficial (Noor and Pitt, 2009). Finally, similarly to drivers and success factors, barriers for CBM for implementation relate not only to technological challenges but also operational and managerial ones and include economic justification, training, change management plan, use of resources as well as closely correlated culture change (IAEA, 2007).

3. Methodology

Pumps are one of the most important appliances in majority of industries, monitoring and maintenance is essential to prevent drastic failures, lengthy and costly work stoppages. Although there are several types of pumps (including turbo, propeller and positive displacement), the centrifugal pump is considered as one of the simplest and most important pieces of machinery, frequently referred to as the *'workhorse of the industry'* (Pump-zone, 2012). Therefore, this research focuses on thirty-one centrifugal pumps and corresponding motors (referred to as 'assets'). Furthermore, to allow for an unbiased results analysis, the selected assets were of the same make, belt driven, installed in 2004, subjected to the same maintenance schedules and spread out across the whole facility.

The research site was set within one of the UK major government based buildings with total area of 86000sqm. Since it is highly secure building, some site-specific information including its name and location had to be omitted in order to follow the research ethics. The existing asset maintenance protocol is part of the regular time based servicing and monitoring processes which include monthly checks (including visual inspections, operations and leaks), more robust three-monthly service and finally a detailed annual service. Additionally in case of breakdown, the engineer is called to repair the problem exercising reactive unplanned maintenance, also called Corrective Maintenance (CM). All activities performed on the appliances are recorded on the Computer Aided Facilities Management (CAFM) system, stipulating the time, date, detail of the asset, location, generic technical information, detail of the faults as well as resolutions. Nevertheless, neither of the process tasks documents details such as usage period, photographic evidence, as well as comprehensive technical information relating to on-going condition of the pumps to enable possible fault or part replacement patterns.

For the purpose of this study, an industry renowned CBM solution was procured from a third-party supplier and installed on the site equipment. Due to building security restrictions this solution was remote thus requiring manual data collection using a handheld device from the equipment. The solution utilised vibration analysis and was inclusive of the most recent version of SPM technique (SPM HD), which was preferred over vibration analysis for bearing fault detection and diagnosis since its not susceptible to external factors (Sundström, 2010). The supplier undertook the installation process, which involved initial site surveys of equipment, followed by the fitting of vibration accelerometer and SPM transducers and subsequently the setup of the analysis software on a designated standalone computer.

4. Findings and discussions

Literature clearly highlights arguably the most attractive for the industry preventative maintenance as planned (time-based), undertaken through OEM recommendations or SFG20 industry standard tool with the goal of fault detection and resolution prior to failure occurrence thus reducing the risk of machine failure and saving money (as highlighted by Veldman et al., 2011a and Ahmad and Kamaruddin, 2012). Alongside the PPM, it is common practice to implement CM in the event of unexpected fault occurrence or equipment breakdown (Ahmad and Kamaruddin, 2012). This is applicable for the assets selected in study, since they were all subject to monthly, three monthly and annual PPM schedules.

The first stage of the research design reviewed the historic maintenance carried out on the assets. The CAFM system held in-depth historic records of maintenance, which included both preventive and corrective ones (in the event of unexpected failures). The records show that 65% of the assets did not have any CM undertaken suggesting that the PPM schedule was sufficient, as it prevented any unexpected breakdowns. Furthermore, 13% of the assets required corrective intervention as a result of inverter (Variable Speed Drive (VSD)) faults and/or replacements, however since the VSD are additional equipment used to control the speed of the motors and are governed by other manufactures maintenance recommendations, these unexpected breakdowns cannot be attributed to the PPM of the assets themselves. However, this clearly highlights the risks of using VSDs to control centrifugal pumps, particularly since CM on VSDs will result in loss of pump operations (Spear, 2005; Ien.com, N.D). The records that can be considered as CM in addition to the PPM schedule appear to relate to a small 21% of the investigated asset, further analysis shows 19% required unexpected strainer cleaning intervention and 3% needed CM due to a leak from mechanical seal. This analysis firstly highlights that there is a wealth of historic maintenance records available for managerial and operational reporting and secondly, the current PPM schedule is only inadequate at completely eradicating unexpected faults for a small quantity of assets thus for large majority of the assets the PPM schedules currently used are sufficient and effective at minimising downtime. This provides strong support for implementing PPM as the main maintenance policy as emphasised by literature. Further in-depth analysis suggest that the assets which had unexpected failures and required CM were more susceptible to the investigated faults. The one asset that had '*leak from mechanical seal'* also displayed *bad operating condition* on the bearings both at the pump drive end and non-drive end data collections. This clearly suggests a correlation between bearing condition and leak from mechanical seal, as suggested by numerous literature i.e. machineryLubrication.com (2013), Thomas (n.d) and Mobil (N.D).

The second stage of the study investigated the most common detectable vibration induced mechanical faults as suggested in literature namely, bearings faults, misalignment, looseness and imbalance. This quantitative research was undertaken via acquiring the vibration and SPM readings and applying analysis in comparison to ISO Standard (ISO 10816-7) and bearing manufacturer's tolerances. It must be noted only the first set of readings collected were analysed as this would provide the truest reflection of the equipment condition, particularly as the Engineers were required to immediately resolve any issues before taking second reading. The analysis of results indicates that 48% of the investigated assets exhibited one or more of the investigated faults even though PPM had been undertaken accordingly, which evidently suggests that these assets are operating in a faulty condition thus not to the maximum capability nor efficiency. More specifically, the motor appeared to show more of the investigated faults than the pump. Labib (2004) and Tam et al., (2006) suggest that PPM practices fail to not only minimise operating costs but also disappoint at maximising the machine performance, clearly this can be related to this study, particularly in reference to their justification that machines operate in different environments thus require different PPM schedules specific to that machine and that environment. Therefore, this study indicates that PPM undertaken based on OEM recommendations and SFG20 standards (SFG20, 2013) may not be the most appropriate maintenance programme in eradicating these faults, which (as discussed in literature) can have severe consequences on the efficiency and life of the assets. Perhaps PPM schedules should be applied on assets in conjunction with CBM techniques to achieve optimum maintenance of in practice.

Finally, the third stage of the study, addressed the literature gap relating to the FM Supply Chains perspective of CBM and operational and managerial aspects through unstructured interviews and observations. The literature supplements give indication that both barriers and drivers for the CBM implementation stem from the managerial and operational aspects of the business therefore it is only natural that it should be considered in the wider context of FM and include similar challenges including supply chain and managerial and operational issues. It is also imperative to point out that the FM contributes to achieving strategic objectives of the company and maintenance plays such a profound role, managing it in strategic way is critical (Noor and Pitt, 2009). Always most controversial aspect, cost in CBM implementation can be considered as both a driver as well as barrier and relates to the operational part encompassing staff training as well as possible additional resource appointment (Koochaki et al, 2011). Justification for initial investment on the technology and resources contests with the risk minimization, improved asset quality, and savings made on corrective maintenance. Moreover, operationally, multiple barriers transpired on this project including *'the time required for data collection using the handheld'*, *'practicality of duty and standby*', and *'impact of VSD'*. Furthermore, as pilot project the CBM technology did not replace the existing PPM thus engineers were still required to undertake planned maintenance with expectation of committing additional time for CBM data collection. As a result, the operational success factors identified are limited to the fact that the detectable faults can be identified through CBM thus preventing asset failure. In contrast, an online (automatic data collection) CBM solution that replaces the existing PPM schedules could demonstrate numerous operational drivers and benefits (as highlighted in literature e.g. IPE, 2009).

On the managerial front, it is evident that the overall perception on the success and validity of the project varied across the board with management and staff as well as supply chain partners. The maintenance engineers were subjected to the introduction of new processes and additional duties, which resulted in expected reservation to changes. The project sponsor on the other hand focused on the project delivery and maximizing CBM effectiveness in order to improve asset performance and life. In-depth on demand asset diagnostic reporting for management can be considered as a driver for implementation, however this can only be achieved if internal team members are provided advanced continuous training to undertake reporting, which was not the case in this project. Furthermore, as demonstrated by this study, CBM mandates collaboration of multiple supply chain partners as such effective supply chain management ensuring all partners have clear goals throughout the project with visible benefits, can influence the success or failure of CBM implementation and practical endorsement. Therefore, based on the literature reviewed and findings of this study, it is non disputable that CBM implementation and industry acceptance should not merely be analyzed in technological perspective. As CBM is part of a complex FM maintenance, it is subjected to supply chain, managerial and operational challenges which must be identified and appropriately addressed.

5. Conclusion and recommendations

Literature demonstrates the technically feasible capabilities and benefits of CBM application, calling for a transition from PPM to performing proactive maintenance upon evidence of need. However, where research has been undertaken in these areas the application and acceptance in the practical field of maintenance appears to be limited for the following reasons, firstly, nearly all CBM research is usually undertaken in controlled environments with a single quantity of asset, consequently there is a discrepancy between the effects of CMB implementation reported in literature and the actual effects experienced in practice. Secondly, majority of literature investigating bearing faults has been undertaken through the use of Vibration Analysis. However, the significant disadvantage of using this technique to identify bearing damage in industry plant room environments is the limitation of external factor influence, by the time damage is detected it is too late to rectify. Moreover, there is limited literature focus around Shock Pulse Method (SPM) as a superior alternative in bearing condition monitoring (perhaps due to its patented exclusivity and cost of implementation). Lastly, the widely researched domain of CBM can be broadly categorised into three areas namely technical, computer and information science, and finally mathematical models and decision-making. Consequently there is a significant lack of understanding in practice relating to the managerial and operational impact of CMB implementation.

The research analysis points out the importance of managerial processes when implementing the CBM within the organization. The proved effectiveness and efficiency potential in data gathering as well as improvement in asset quality and risk reduction of CBM suggests that the technology is here to stay and be utilized on a greater scale however it requires an incremental culture change of the entire supply chain as well as the staff and management involved. It is envisaged that the future research focuses on maximization of CBM effectiveness while optimizing costs and benefits of the process. Likewise, managerial and operational processes during the transition from PPM to CMB should be a key research focus towards the endorsement of CBM in practice.

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The Nigerian Quantity Surveyors in an Emerging Market

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Abstract

The roles of the quantity surveyor has evolved from been a simple building accountant to a respected professional vocation. The roles played by quantity surveyors are expanding both in scope and size. The expectations of quantity surveyors have increased due to the increasing inclusion of new technologies, changing rules and regulations, increasingly sophisticated projects, diverse clients, and the emergence of related professions with job descriptions that overlap with that of the quantity surveyor. There are daunting evidences that the threats will continue to pose challenges to the existence of quantity surveyors. Therefore, in order to remain both relevant and competitive, quantity surveyors need to diversify their services. This paper examines the roles that 'modern' quantity surveyors play in Nigeria. Primary data is collected through questionnaires. Twenty three (23) roles played by modern quantity surveyors are identified and addressed to the respondents to rank the rate at which they perform each of the roles. Data obtained were analysed statistically. The results of the findings led to the conclusion that the quantity surveyors were performing the emerging services expected of quantity surveyors. The results of the study could be useful to quantity surveyors and other stakeholders in the construction industry in general.

Keywords: quantity surveying; value for money, built environment; Nigeria

1. Introduction

There is some doubt on whether Nigeria is an emerging market (EM) or not, because not all organisations include Nigeria in their indexes. For instance, the IMF, the Economic, and FTSE are yet to consider Nigeria an emerging country, but the BRIC+Next Eleven, BBVA, Columbia University, EMGP and BMI include Nigeria in their list of emerging countries. The features most commonly found in the majority of indexes are that EM countries aspire to be 'developed' and as such aim to liberalise, deregulate, and globalise their economies. For this, these countries have in place vigorous strategies to improve and expand their infrastructures. Stakeholders interested to remain in or enter this market must provide competitive and value added services/products. Developing countries have rapid economic development and the rates of industrialisation are massive. As of December 2012, Nigeria's external reserves stood at US $43.83 billion (CBN, 2012). Nigeria's economy is set to experience a boom as it aims to close infrastructure gaps. As an emerging market, Nigeria has embarked on economic development and reformation initiatives for which it has begun to liberalize, diversify, and globalise its markets. Through it Transformation Agenda and Vision 2020, the Nigerian government seeks to increase jobs, reduce poverty, reduce food imports, develop infrastructures, reduce inflation, decrease domestic debts, reduce recurrent expenditures, increase foreign reserves, address its housing deficit, and move away from its dependence on oil. Nigeria like most countries in Africa, has established sovereign wealth funds to it infrastructures. For over a decade there has been a considerable increase in Foreign Direct Investment (FDI) in the Nigerian economy. FDI stood at N1, 113.5 billion, and constituted 28.3 per cent of the total inflow, 2012 (CBN, 2012). Nigeria accounts for 18% of all foreign investment in Africa and 60 per cent of all foreign investments in the ECOWAS Sub-Region (Jonathan, 2013). The implication of this is increases in the rate of physical development, which has many implications for the construction industry.

The Nigerian construction industry is expected to grow. This is occasioned by the need to urbanize, globalise, and to meet the infrastructural inadequacies. The construction outputs are expected to triple within the next decade and the allocation to construction sector. On the infrastructure gab, some of the major constraints militating against the provision of infrastructures in Nigeria are the lack of funds, absence of risk sharing structures, lack of clarity on the governance of the PPP framework, and a lack of competent experts to assist banks and other firms engaged in infrastructure financing (Sanusi, 2012). Nigeria requires over US$10bn annually over the next ten years to meet its infrastructural needs (Sanusi, 2012). The implication of this statistics is that there are many activities for the construction industry; however, in order to benefit from this development, professionals in the construction industry including quantity surveyors need to adopt best practices and provide best added value services. This requires quantity surveyors to offer services beyond those traditionally provided. Quantity surveyors are now required to learn and acquire how to better position themselves to manage supply and manage increased demand. Quantity surveyors must learn to work with expatriates as some of the projects are joint ventures with other countries that bring with them a different work culture. The example of this is now cited. Some of the projects will require alliance, joint venture, acquisition, counterpart partners from different countries with diverse and different working culture. Some of the countries have stringent discipline and regime regarding to public investments. The prequalification criteria are different from what most of the quantity surveyors in Nigeria are familiar with. To make it bit complex, some of the countries do not necessarily have the quantity surveyors in their countries. Access to capital is becoming more challenging. In this context, the quantity surveyors have the opportunity to diversify more to the upstream supply chain mainly by promoting different procurement strategy. Incidentally, the government of Nigerian has identified the PPP as a major strategy to meet its infrastructure need.

Given the increasing difficulty to access capital, quantity surveyors should take the opportunity to diversify more to the upstream supply chain mainly by promoting different procurement strategies. Incidentally, the Nigerian government has identified the PPP as a major strategy to meet its infrastructure needs. For instance, the proposed areas of PPP application outlined by the Nigerian Infrastructure Concession Regulatory Commission include power plants and transmission/distribution networks, roads and bridges, seaports, airports, railways, gas and water supply, housing, and health care. The construction industry must meet growing demands for sustainable built environments and harness technology to drive innovation, especially in energy efficiency. The construction industries in other emerging markets have been rapidly responding to this demand. This is a sharply in contrast, with the services that Nigerian QSs provides that are largely within the limited boundary of building projects

Quantity surveying is universal and is carried out under different names, such as building economist, cost consultant, management consultant, cost economist, project consultant, and commercial manager. This diversity robs the profession of an identity (Olanrewaju and Anavhe, 2008) unlike other allied professions. An engineer is an engineer and an architect an architect. The functions performed by modern quantity surveyors vary and its title is quite inadequate to describe the services it provides. Quantity surveying was initially conceived out of the necessity to have a dedicated person to manage the cost of building projects. From the time the client decides to build, the services of the quantity surveyors are required. Prior to the drawings and specifications, quantity surveyors provide cost planning services to the clients/developers. Costing is continuously monitored by quantity surveyors as further detail drawings and specifications are ready from the designers (architects and engineering). The essence of monitoring the initial estimate produced at the cost planning stage is to ensure that the initial estimate is not unnecessarily overrun. A Bill of Quantities will be produced once all relevant information is available and detail drawings and specifications are established.

The services quantity surveyors perform today depend on the nature of their organization as well as their position. For instance, quantity surveyors working for clients will offer different types of service as compared with quantity surveyors working with a contracting organization. Similarly, quantity surveyors working with oil and gas differ from quantity surveyors in real estate development. The training and expertise of the quantity surveyors allows them to venture into areas including value management, risk management, arbitration, and project management. However, available literatures on the roles that quantity surveyors currently perform in Nigeria have not being adequately investigated (see for example: Olanrewaju and Anavhe, 2008). The aim of this paper therefore is to evaluate the services of quantity surveyors in Nigeria. In light of this, the impetus of the paper is to create awareness on the various functions of the quantity surveyors.

2. Background and theoretical development

Quantity surveying is universal. However, it is carried out under different names. In countries like the USA, the roles played by quantity surveyors are similar to that performed by 'Cost Engineers'. Quantity surveyors are sometimes referred to as cost economists or cost consultants. However, quantity surveying is more than any of those names or titles. Traditionally, the services that quantity surveyors provide include estimating, cost planning, feasibility and viability studies for building works, compilation and documentation of contractual issues, and tendering. Perhaps the phrase "quantity surveying" is a catch-up term that hides a multitude of meanings. The modern quantity surveyors perform various types of services that extend beyond the services that the traditional quantity surveyors provide. Since the inception of the profession, there has been a paradigm shift in the practices and services that quantity surveyors provide, from someone who was concerned with cost reduction and substitution of materials and components to someone who is concern with the achievement of value and enhancing productivity. The quantity surveyor is the expert who is concerned with financial integrity, contractual matters, procurement, and delivering value for the clients' money invested. The services that the quantity surveyors currently provide have shifted from the 'downstream' to 'upstream'. The dynamism of quantity surveying enables it to venture into other areas like facility management, value management, knowledge management, risk management, arbitration, maintenance management, centre management, system management, and project management. In fact, quantity surveyors are adaptable creatures capable of reinventing themselves according to the demands of the modern progressive clients (Cartlidge, 2003).

The services of quantity surveyors are required in all sectors of economic endeavor including the financial, insurance, oil and gas, construction, as well as in the academic sector. The services that quantity surveyors provide place them in strategic position as process managers. Quantity surveyors provide advice on the strategic planning of a project. This advice affect clients' decisions on whether to build or not, and if the client decides to build what effect does cost have on other criteria within the clients/users value systems including time and quality, function, satisfactions, comfort and aesthetics. As it is usually the case, even under the traditional procurement system where the quantity surveyor is not usually the lead or prime consultant, all other members of the team, including the client relate with him and supply valuable information to the quantity surveyor (a converging point!) to enable him to prepare 'accurate estimates' to make meaningful contributions towards the successive completion of a project. Regardless of the procurement strategies adopted, the roles of quantity surveyors are prominent for a successful completion of projects. In fact, the modern procurement strategies like PPP have exposed the potential and relevance of the quantity surveyors towards best service delivery. Quantity surveyors could be engaged by the client or by the contractor. Quite a number of architectural or engineering practices also engage quantity surveyors to guide them in their design processes. However, the functions they perform in that capacity are restricted.

The history of quantity surveying in Nigeria dates back to the 70s, when it was offered as a programme at the Ahmadu Bello University. Quantity surveying is currently offered by 16 universities and 39 polytechnics. The Nigerian Institute of Quantity Surveyors (NIQS), the professional body that regulates the activities of the quantity surveyors in Nigeria was established in

1969 by some UK trained Nigerians. Since the late 90s, the Nigerian Institute of Quantity Surveyors (NIQS) is now a member of the International Cost Engineering Council (ICEC).

The roles that the quantity surveyors perform today have diversified into industries including petrochemical, manufacturing, automobile, mining, telecommunication, shipping, transport, and agriculture. The major impetus for this diversification is the changing requirements of the stakeholders. There is increasing awareness on accountability and transparency. Today's clients are more demanding than they used to be. In light of this, for quantity surveyors to remain relevant, there is a need to embrace value added tools, skills, and expertise. For quantity surveyors to be part of the transformation agenda of the government, they need to provide cutting edge services. The clients want their projects to be completed on schedule, within budget, with maximum performance, reliability, safety, and meeting other criteria within their client value system. The clients are pushing the construction industry to take a cue from the automobile and electronic industries. The stringent requirements of the progressive clients to achieve their value system are the drivers of the transformation in construction (Cartlidge, 2004) and it will continue to be so in the years ahead as clients will always demand for value for their money. Construction clients are increasingly becoming impatient with their investments in the construction industry. Therefore, Nigerian quantity surveyors, like QSs elsewhere, must equally expand on the scope of services they provide to their clients if they are to remain relevant and competitive.

3. Outline of the methodological issues

This study consists of a literature review and survey questionnaire. Altogether, 23 roles played by modern quantity surveyors provide are addressed to respondents. The 23 roles were identified based on a literature review and the authors' experiences (I.e. Cartlidge, 2003; Lee, et al., 2005 and Ashworth, et al., 2013). The survey was conducted in two stages. In the first stage, the questionnaire was administered on participants who attended the "1st NIQS Research Conference" entitled 'Innovation and sustainable management of building and infrastructure projects'. The NIQS conference was held at the Shehu Musa Yar'Adua Centre, Abuja September 2013. At this conference, a total of 63 useable responses were received. The second stage was based on convenient sampling. Here, the questionnaire was administered by hand and email through the office of the co-author. Sixty-nine useable questionnaires were returned from the second stage. The questionnaire was administered within three weeks, 8th-23rd September 2013. When the need emerged to measure the services provided by the quantity surveyors, the issue of 'extent' becomes important. Therefore, respondents were asked based on their current experience, to tick the extent to which the quantity surveyors have performed the identified roles on a six continuum scale; where 6 denotes extremely often, and 1 denotes not often at all. 2, 3 4 and 5 are located in between. The degrees at which the roles are performed are determined by Average Relative Index (ARI) (Equation 1). The index is based on the cumulative weighting of the initial frequency score of each of the roles.

$$ARI = \frac{\sum_{i=1}^{6} a_i x_i}{6\sum_{i=1}^{6} x_i} \qquad \text{(Equation 1)}$$

Where a_i is the index of a group; constant expressing the weight given to the group; x_i is the frequency of response; i = 1,2,3,4,5,6. $x_1, x_2, x_3, x_4, x_5, x_6$ are the frequencies of the response corresponding to $a_1 = 1, a_2 = 2, a_3 = 3, a_4 = 4, a_5 = 5, a_6 = 6$ respectively. The role with the highest index is considered as the role that quantity surveyors perform most often. Simply put, the closer to 1 the higher the degree at which the roles are performed. The questionnaire was divided into two parts. Part one focused on the respondent's profiles while the second part aimed to measure the degree at which the quantity surveyors perform the roles. The mode technique was used to analyze the demography of the respondents. Mode was also used to determine the distribution of roles with respect to the scales. The frequencies of the respondents are expressed as percentages. The measurements of the roles that the quantity surveyors perform are displayed in frequencies but the rating of the roles is determined by 'average relative index'. However, missing data (where the respondent refused to tick where applicable or there is multiple entry), could impact negatively on the outcome of the findings, however such effect could be improved during data analysis by either replacing the missing data with the mode or mean of the data. However, the mode is preferred because the variables are measured on an ordinal scale. In this paper, the missing data will not be treated as such. In other words, we have preferred to leave the data raw so that the outcomes will not in any way be influenced by the authors.

4. Analysis and Discussion

4.1 Respondents' Profile

Altogether, 132 usable questionnaires were received and analysed for this study. The results of the data analyses on the respondents' profiles are contained in Tables 1 to 5 and displayed in Figure 1. The profiles of the respondents indicated that most (63%) of the respondents were quantity surveyors (Table 1). In terms of professional qualification, 80% of them have professional memberships (Table 2). In other words, they are certified by their respective professional bodies. 64% of them were consultants (Table 3) and more than 70% of surveyed respondents have more than five years working experience with the construction industry (Table 4). Table 5 displayed the respondents' positions; obviously, more than 90% of the respondents held strategic positions with the organizations they worked with. It is also obvious that, 60% of the surveyed respondents have completed more than 10 projects in the last ten years and about 30% have actually completed more than 30 projects each in the last ten years (Figure 1).

Table 1: Respondent's academic background

Background	*quantity surveying*	*engineering*	*architecture*	*Others*	*Total*
Frequency (%)	*62.82*	*24.25*	*12.13*	*0.80*	*100*

Table 2: Respondent's professional qualification

Qualification	corporate	fellow	Member	honorary	probationer	technician
Frequency (%)	10.7	25.4	36.9	7.4	18.9	0.8

Figure 3: Respondent's organization

Organisation	Clients	Developers	Consultant	Government	Contractors
Frequency (%)	3.10	1.50	63.80	2.30	29.20

Table 4: Respondent's working experience

Experience	Not more than five years	5 - to 10 years	10 to 15 years	15 - 20
Frequency (%)	26.9	46.2	24.6	2.3

Table 5: respondent current position in the organization

managing director	partner	principal partner	contract manager	project manager	senior surveyor	surveyor	junior surveyor	others
4.8	19.4	24.2	4.8	15.3	12.9	13.7	4.0	0.8

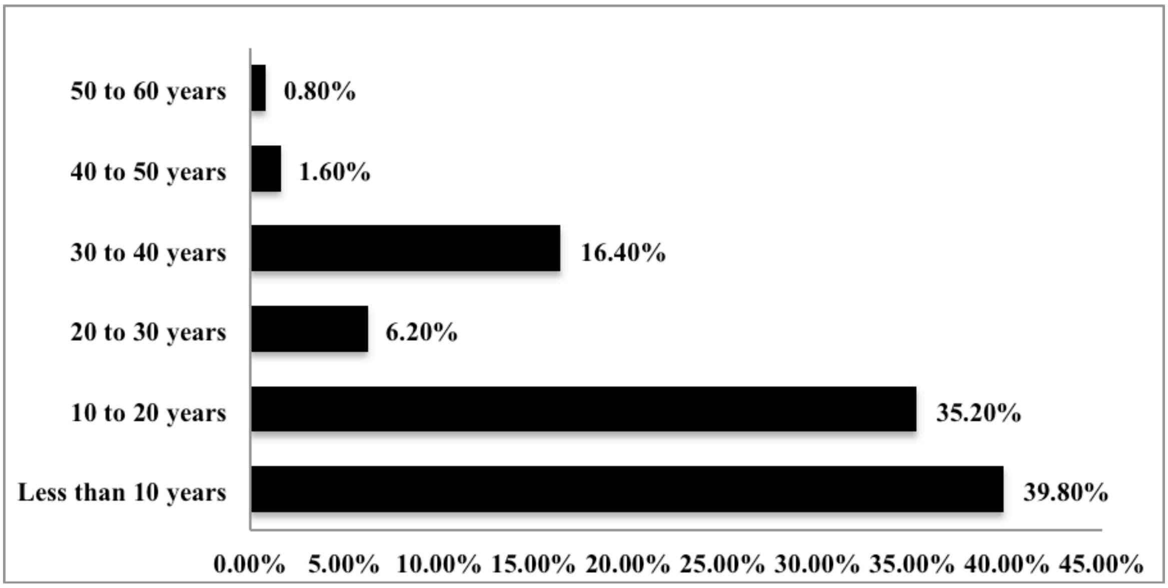

Figure 1: Number of projects respondent's organization completed in the last 10 years

On the basis of the respondents' profiles, their opinions on the Nigerian construction industry are considered reliable and sufficient to report the findings of this research.

4.2 Rating of the roles of the Quantity Surveyors

To determine the strength of the data, reliability and validity tests were performed. The reliability test results indicate that the Cronbach's alpha for all the roles are very satisfactory. The reliability ranges from 0.726 (for 'provide value engineering and management services') to 760 (for 'prepare BoQs for engineering works'). The validity test, using the 'Commonalities', produced values that ranges from 0.563 to (for 'provide insolvency services') to 0.813 (for 'provide project management services). In general, if the alpha reliability or validity test is above 0.50, it is sufficient to consider that the criterion is valid or reliable. Thus, the study is reportable. Based on the results of the scale statistics, 70% of the surveyed respondents measured that the quantity surveyors have performed the 23 roles on construction projects. The average cumulative score for roles is 0.659. Specifically, 25% of the respondents measured that the QS extremely often performed the roles, 23% believe they performed the roles very often and while 21% agreed the Qs often provide the services. Therefore, it is considered that the quantity surveyors offer most of the services with varying intensities. While there is no similar study that the findings of the study are comparable, some similarities based on study on competencies of the quantity surveyors could be considered. Therefore, the findings are similar to that of Said, et al. (2010). Furthermore considering that it has been established that quantity surveyors elsewhere (see Towey, 2001 and Ashworth, et al., 2013) now provide these roles it is be considered sufficient to examine the level at which the Nigerian quantity surveyors offer the modern services.

Because of space requirement, only five of the roles are examined in some detail. The most highly measured roles that the quantity surveyors provide is to provide preliminary cost advice / cost planning services on construction projects with relative index of 0.9116. In fact, close to 90% of the surveyed respondents maintained that this role is extremely or very often performed by quantity surveyors. The interpretation of this finding is that the quantity surveyors are involved in projects before major decisions are established. While the quantity surveyors are traditionally supposed to offer cost planning (see Hughes and Murdoch, 2001), this is not often the case in practice particularly in developing countries like Nigeria. This will allow quantity surveyors to provide more value added services. Traditionally, the major roles of the quantity surveyors are related with the production of bill of quantities, when all major drawings and specifications are completed. At this stage, it is often too late to provide value added service to the clients. It is interesting to find that the second role that quantity surveyors provide is the preparation of bill of quantities for engineering works. Normally, quantity surveyors find it hard to venture into engineering works, particularly civil and process engineering works. The NIQS has recently proposed specializations within the quantity surveyors practices into building works, oil and gas installations, project management and dispute resolution, civil engineering and mechanical and electrical engineering services.

While this is commendable, the quantity surveyors have not been able to get a viable headway on engineering works. For instance, civil engineers still want to perform cost management of civil engineering works even where the quantity surveyors are part of the design team. However, the reasons the NIQS has not include railways and petro-chemical like that of the RICS is not clear, because these last two specializations are identified as major areas for the quantity surveyors by the RICS.

Table 5: Response Rate on the Services of Quantity Surveying Practice (N=132)

Roles \ Frequency (%)	6	5	4	3	2	1	Index	Rank
Preliminary cost advice/ cost planning	90	23	12	5	2	0	0.9116	1
Prepare BoQs for engineering services	80	20	14	17	1	0	0.8699	2
Provides project management services	81	21	11	11	6	1	0.8598	3
Prepare cost options of developing difference sites	63	36	23	4	4	1	0.8472	4
Insurance Advice	68	26	17	10	2	5	0.8144	5
Provide information for use in future management and / maintenance of the buildings	19	64	34	7	6	2	0.7639	6
Prepare contract documents and participate in contract administration for building works	24	48	33	15	10	1	0.7348	7
Prepare development appraisal	31	41	27	20	9	0	0.7285	8
Provide value engineering and value management services	20	42	31	15	22	2	0.6881	9
Advise on entitlement to liquidated and ascertained damages	18	38	39	17	18	2	0.6856	10
advise effect of capital and revenue expenditure	12	40	32	37	5	4	0.6629	11
Provide advice on environmental impact assessment	16	31	45	15	20	4	0.6566	12
Assist in application of grants and its documentations	20	22	46	18	22	1	0.6477	13
Provide service to a contractor in connection with negotiations of claims	22	21	43	13	23	8	0.6338	14
Prepare life cycle cost studies and estimate of annual running cost	15	28	21	36	20	8	0.5934	15
Provide risk assessment and management services	11	42	46	8	17	3	0.5745	16
Advise on adjudication proceedings	22	18	16	24	35	14	0.5581	17
Provide services on arbitration matters	13	26	20	16	49	8	0.5581	18
Act as an adjudicator	15	23	14	28	43	6	0.5518	19
Advice on insolvency services	11	12	24	25	53	1	0.5101	21
Advise on litigation matters	15	13	34	38	22	4	0.4583	20
Advise on fire or other damage to the buildings and preparing claim associated with these	20	15	34	24	35	2	0.4482	22
Provide advice on cost benefit analysis	56	43	19	7	5	1	0.4078	23

While this could be because of the prevalent procurement used in Nigeria, there is the need for quantity surveyors to display more capabilities and expertise in this scope. However, it is difficult to examine the extent of the quantity surveyors involvement with engineering services. This is because most of the quantity surveyors do not provide detail cost estimates for the engineering services. For instance, in typical bill of quantities M&E works are priced as provision sum even when detail drawing and specifications are available. It is difficult to tell clients/developers that the estimate is not complete for a section of his works where 'sufficient' information is ready. This practice has to change. The quantity surveyors should be able to provide accurate estimate for the M&E works except where 'sufficient information' is not ready. This is very necessary even as that M&E now takes substantial part of the contract sum.

This study also found that the quantity surveyors now provide project management services. This is remarkable, but expected, as quite a number of quantity surveying firms now include this service in their portfolio. In fact, it was found that among the major professionals in the Nigerian built environment, the quantity surveyors are the most competent to offer project management services (Odusami and Ameh, 2006). This is probably due to client awareness. With the proliferation of modern procurement methods, quantity surveyors are entrusted with total management of the project as against only cost management. Suffice to say that quite a number of the members of the Chartered Project Management Institute of Nigeria are quantity surveyors. Some of the quantity surveyors hold membership of the Project Management Institute (PMI USA). Therefore, with this background, it is correct to conclude that the quantity surveyors are providing project management service with some hindrance from other allied professions. Project management is concerned with the client appointing someone outside the design team to coordinate, control and report to clients the activities of both the construction team and design team. Quantity surveyors possess the required managerial, behavioral and technical skills for the overall planning, control and coordination of a project from inception to completion.

If the quantity surveyors are involved at the strategic stage of the projects, the experience, perceptions and expectations of the various stakeholders will be considered and accommodated in the detailed design. This has wider implications on the project delivery. One, this will reduce / avoid the obvious consequence of cost over run that is associated with reworks. Obviously, this has multiplier effects on other criteria within the client value system including project's schedule, quality, client's satisfaction and functions. Advising clients on alternative sites is rated fourth. Site location has many effects on project costs. In some cases, due to site constraint, transporting plants and equipments is difficult due adjoining developments and topographical features. A practical example of site location was a Bank Project in Northern State of Nigeria which the construction land was in dispute between the State Government and the owners, the land was allocated to the Bank eventually and the state government had to re-allocate an alternative land because both parties did not agree and which resulted in the delay of commencement of the project after the contractor has already mobilized to the project site. The fifth role is providing insurance advice to clients. In general, this a is specialty area where experts exist who provide general insurance services, but due to the nature of construction projects, quantity surveyors are capable of preparing insurance reports for the clients. The insurance that is mostly used for projects is the Contractors All Risk Insurance (CAR) and workmen insurance which are usually provided at the inception of a project. At the pre-contract stage, contract samples of the insurance policy are provided in the tender documents collected by the contractor. The quantity surveyor provides report on the insurance conformity with the sample provided at the tender stage, which forms part of the requirement for projects.

Though not included in the survey, another area that the quantity surveyors could be useful is in the area of procurement and project finance. Advising clients on suitability of procurement methods is traditionally the role of quantity surveyors. Recently, new finance opportunity is increasingly opening up for alternative methods of project finance. For instance, the Sukuk bond market can also be applied to replace or improve the conventional interest-based securities. Sukuk is like a bond under the conventional banking systems. It has contributed tremendously to project finance in a number of countries. Malaysia has successfully employed this tool to raise money to finance a number of public projects. Quantity surveyors need to acquire more knowledge on this financing tool.

5. Conclusion

This paper evaluates the services that quantity surveyors provide to create awareness on the extent to which quantity surveyors are involved in the total procurement and management of built assets. Managing a construction from the design through to the operation stage requires a wide range of skills and knowledge and involves many professionals and expertise. Construction projects are required for any meaningful development. Professionals in the construction industry must provided the required expertise and skills. Throughout the life of a project, the quantity surveyors are required to advise clients, financiers, users and other stakeholders to advise on financial probity, procurement and achieving value-for money in the conceptualization, planning and execution construction projects. Clients have become more demanding; the regulatory framework has changed and has become more complex and sophisticated. What is found here is that the quantity surveyors have the required knowledge and skills to make development contributions to the Nigerian economy. The quantity surveyors in Nigeria provide services that quantity surveyors elsewhere provide. However, the quantity surveyors need to provide more services in order to meet the requirements of clients, particularly in those areas that their performance was not encouraging.

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Construction activity and built assets in emerging economies: Building for economic growth or fuelling a bubble?

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Abstract

Evidence indicates the existence of a positive relationship between economic growth and the level of construction activity in developing countries but transformation from a developing to a mature economy will, at some point, be evidenced by a diminishing reliance on the construction sector. The term emerging economies has been used to describe those countries making this transformation, often at a rapid rate of growth. Based on an analysis of United Nations time series data, comparisons are made for three groups of countries, classified according to World Bank categorisation into three groups in order to investigate the relationship between rapid economic growth, urbanisation and construction activity. The paper also deals with the question of what is the relationship between new investment in built assets and the rate of economic development? It is noted that emerging economies appear to be catching up to the built asset wealth of the more developed economies. Built asset data (residential and non-residential construction (including infrastructure)) for emerging economies indicates that they are bridging the gap in accumulated wealth and the implications of this are considered.

Keywords: Built assets, construction activity, economic growth, emerging economies

1. Introduction

In the years leading up to the financial crisis of 2007-08, some developing countries were beginning to have a growing impact on the global economy. Van Agtmael (2007) first used the term 'emerging markets' to give a more dynamic label to such developing countries. Even though the countries given this label do not share any common agenda, they are enjoying an increasing role in the world economy and, by 2025, six of these 'emerging economies' (Brazil, China, India, Indonesia, South Korea, and Russia) are, between them, likely to account for more than half of all global growth. Even though the emerging economies constitute a disparate group, an analysis of the relationship between construction activity and the macroeconomy in these fast growing economies is enlightening. Using time series data sets for 1971 to 2010 from the UN Statistics Division (United Nations, 2012), this research groups countries into three categories in order to assess the relationship between the construction industry and the macroeconomy across a range of economies. Rather than make comparisons based on a simple distinction between developed and developing, the purpose of a tri-partite split is to enable a separate analysis of this important category of emerging economies.

There are various alternative listings and classifications of emerging economies but for this research, the World Bank classification of economies was used. The World Bank's (2013) list of economies has the following classification by income group: High Income, Upper Middle Income, Lower Middle Income and Low Income. The High Income countries may be considered as advanced or 'developed' with the Low Income group as 'developing'. For this study, economies are classified as 'emerging' if they fall into the Middle Income groups and also have access to loans from the World Bank's International Bank of Reconstruction and Development (IBRD). This distinguishes them from the Low Income countries that only have access to funds from the World Bank's International Development Association (IDA), which is focused on the poorest countries.

1.1 Construction as a percentage of Gross Domestic Product (GDP)

The availability of data for four decades permits both comparisons over the long-term and, particularly interestingly for the analysis, over the short-term. Figure 1 depicts the average of construction output as a percentage share of GDP for each of the three categories of country.

For the High Income group, the average level of construction as a percentage of GDP showed a relatively steady decline over the four decades. If the average percentage of GDP attributable to construction activity is considered, all these countries suffered a reduction for the last decade with the exception of Australia, which was relatively immune from the economic crisis and Ireland and Spain, with their property bubbles. For the Low Income countries, the pattern was one of decline over the first two decades followed by increase over the last two decades, to the effect that it rose above the level of the High Income countries after 2005. There is less variation over time in average level for the Emerging countries but Emerging countries do show significantly high levels of variation.

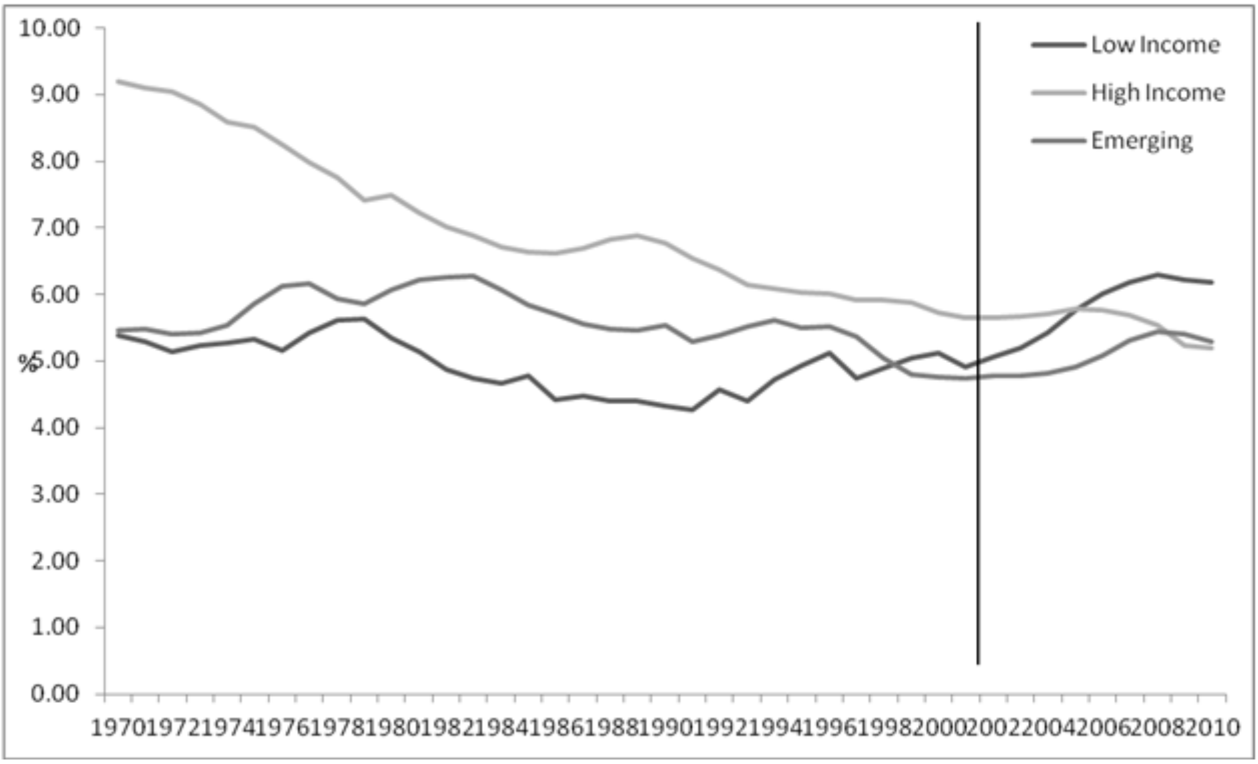

Figure 1: Construction output as a share of GDP (%)

2. The contribution of the built environment to the economy

The commonly 'accepted' basis for the evaluation of an economy relies on the use of GDP, a measure of the flow of output (and therefore income) from the various sectors of the economy to summarise total economic activity and, thereby, the 'worth' of the economy as a whole. Pioneered by Kuznets in the early 1930s (see Kuznets, 1934), GDP accounts have been used ever since by government and business officials to guide their economic policymaking. Economic growth occurs as an increase in the production and consumption of goods and services, and is indicated by increasing GDP. GDP, therefore, has become the standard measure of economic progress, even though it was only originally intended as a macroeconomic accounting tool.

The limitations of measures based purely on production or income as indicators of the welfare of a nation have been recognised by attempts to measure a nation's achievements in several dimensions that incorporate other societal goals. For instance, the *Better Life Index* of the Organization for Economic Cooperation and Development (Hall et al., 2010) incorporates eleven topics of well-being and the United Nations *Human Development Index* (United Nations Development Programme, 2014) which measures a nation's achievement in three dimensions of human development: long and healthy life (indicated by life expectancy at birth), knowledge (indicated by literacy and school enrolment rates), and decent standard of living. This latter dimension is indicated by GDP per capita and the economic aspect is still, therefore, based on a measure of income.

Efforts to appraise the economic importance of construction activity have concentrated on the value of the construction sector's output in terms of its contribution to GDP. Generally, the focus is the construction industry in its narrow sense, as defined by its Standard Industrial Classification, but attempts have been made to assess the importance of the construction sector in the economy by evaluating the output of a more widely-defined sector (from design activities through to property management) to show that built environment activity can contribute up to 20% of GDP in some developed countries and provide a foundation for all other sectors. (See the frameworks for analysing the structure of the construction sector in Pearce (2003), Carassus et al (2004) and Ruddock (2008)). Instead of using an income measure to assess the value of the construction sector, what if the focus was on wealth or assets instead?

Income or output refers to a flow of resources over time but the stock of assets at a point in time indicates the wealth of an economy. There has been, until relatively recently, no widely recognised measure of the wealth of an economy but the publication of *The Inclusive Wealth Report 2012* (UNU-IHDP and UNEP, 2012) has provided a 'balance sheet' for a number of countries utilising a monetary measure that sums up the stock of natural, human and physical assets. The report covered twenty countries, including all the large economies, for the period from 1990 to 2008. The methodology involved in drawing up the balance sheet required putting a monetary value to make all kinds of capital comparable and commensurable. While the calculations to determine wealth through the evaluation of assets may be considered crude (just as they were for GDP seventy years ago), the fact is that economic policy-making is now an asset management issue and the evaluation of an economy's assets is a prerequisite for such management.

While the contribution of the construction sector to physical assets through the construction of buildings, infrastructure etc. is obvious, its role in influencing human capital (education and skills) via, for example, the design of schools and its role in affecting the value of natural capital (land-use, minerals, forests etc.) is also significant. Since 2000, the Lisbon Strategy has been accompanied by various national strategies aimed, in essence at improving the quality of life 'for everyone, now and for generations to come'. One of the key areas of concern has been the use and development of the built environment.

Interestingly, the *Inclusive Wealth Report 2012* is sub-titled *Measuring progress towards sustainability* and the evaluation methodology is based on the development by Arrow et al (2012) of a consistent and comprehensive framework for assessing whether economic growth is compatible with sustaining well-being over time. It is an approach that concentrates on wealth rather than income.

The production of new buildings and other structures in any given period adds to a nation's economic wealth, in the form of the built environment – it also contributes to social capital. The nature of built capital formation therefore plays a major role in determining both quality of life and the nature of sustainable development, both as a goal and as an instrument of government policy.

2.1 Sustainable development

The desire for sustainable development at a global level has been confirmed at various Earth Summits since the Rio de Janeiro summit of 1992. It has led to a fundamental review of our economic, social and other activities, and inspired the development of a number of policy initiatives. One of the key areas of concern has been our use and development of the built environment. The built environment comprises buildings and infrastructure, and is one of the main components of a nation's wealth. Those structures and their collective placement play a major role in determining the quantity and quality of our activities, now and in the future. In some respects, they have had a positive effect on our quality of life, enabling the production of more and better goods and services and providing the basis for other creative social activities.

Pearce (2003), in his assessment of *The Social and Economic Value of Construction* indicated that the sustainability of economic activity rests on four pillars of capital stock, viz: man-made capital, natural capital, human and social capital. Figure 2 illustrates the pivotal position of the construction industry in utilising this capital to add value in terms of quality of life. As the real value of the total stock of assets grows, the industry must function to ensure that the quality of life derived from these assets also grows over time.

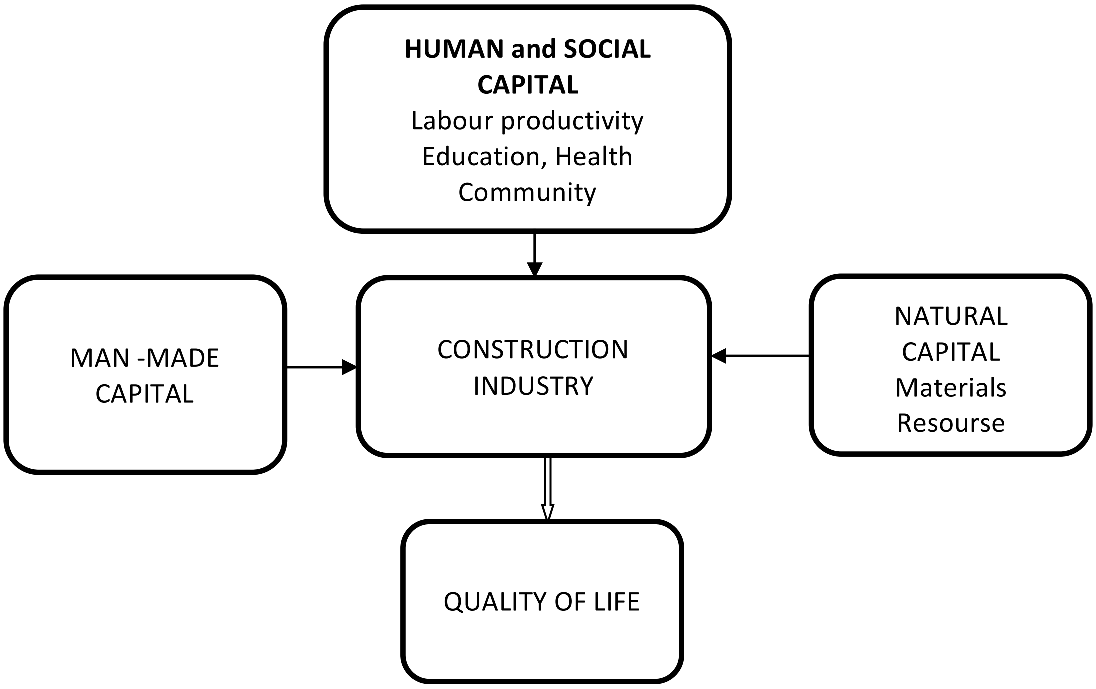

Figure 2: The construction industry and the pillars of capital stock (adapted from Pearce, 2003)

2.2 The relative importance of built assets

According to the United Nation's *System of Accounts 2008*, built environment forms part of a nation's fixed capital stock and, as such, forms part of the wealth of the nation. *Gross fixed capital formation* is spending on the production of new fixed capital in any given period, and includes spending on machines, computers, factory buildings and housing units. *Built capital formation* refers to the production of new buildings and other structures, and is measured by the amount of final spending on those items. As such it represents the broadest measure of construction activity, capturing the value-added by all the different stages of construction – not just the stage represented by the narrowly-defined construction industry.

Based on historical data for the period from Mitchell (1988) for a time series from 1760 to 1980, built assets accounted for around 66-90% of all man-made wealth. Coupled with a World Bank (1997) time series for over 100 countries, which showed that human capital accounted for 75% of the value of all assets of advanced European economies, with man-made assets accounting for most of the remainder, this led to the conclusion that built assets (if valid extrapolation is possible) would comprise about 16-22% of all wealth.

The data show that built wealth has fallen as a fraction of all man-made wealth, which is consistent with the rise of an industrialised and post-industrialised society. As Barras (2009) indicated, the share of the equipment element of total capital stock tends to increase over time at the expense of the building component, which was a stylized fact proposed by Kaldor in 1961. The empirical study by Carassus et al (2004) showed that the workload of the construction sector in developed countries had changed considerably by the beginning of the twenty first century due to the rise of the tertiary sector of the economy and the simultaneous decline in demand for new construction work. In the study, repair and maintenance work was found to constitute almost a half of construction work in the developed western countries. Beyond repair and maintenance work, management of the existing stock had become a strategic issue.

3. Measuring the value of assets

GDP is a current or short-run measure with little consideration of the capital base of an economy. It is intuitive that the elements comprising a society's productive base are not only the capital assets to which people have access but also the social infrastructure that influences the way those assets are put to work for human use, now and in the future so there is a need to address what precisely is being measured and the indicators that need to be developed. Accounting for the inclusive wealth of nations provides a different perspective from that of GDP for assessing the performance of an economy by switching the focus of attention from flows (income) to stock metrics (wealth). This stresses the importance of preserving a portfolio of capital assets to ensure that the productive base can be maintained to sustain the well-being of future generations. The *Inclusive Wealth Report* (IWR) data show that those countries with the highest rate of economic growth as measured by high GDP growth rates tend to have much lower rates of growth in inclusive wealth. One overall finding from the report is that there are clear signs of trade-off effects among different forms of capital, as witnessed by the increases and falls of capital stocks for the twenty countries over the nineteen year period. If a country with an inclusive wealth per capita annual growth rate that is less than its GDP per capita growth rate wishes to sustain higher GDP growth rates for the long term, increased inclusive investment will be required. To boost the levels of human capital, natural capital and physical capital respectively, in broad terms, the government would have to encourage education, reduce the extraction of natural resources and increase the construction of infrastructure. Is this true of growth in built environment assets?

3.1 OECD capital stock data

The Organization for Economic Cooperation and Development (OECD) provide measures of capital stock that are internationally comparable, although there are caveats acknowledged in terms of the compilation of the measures mainly due to different assumptions of national statistical sources (see OECD (2012) for more details). In the OECD database of balance sheets for non-financial assets, Built Assets are the summation of: Dwellings + Non-residential buildings + Other structures. In Table 1 the data on Built Assets for the thirty countries in the database are used, together with GDP and population data from the United Nations Statistics Division to allow comparison between the levels of

Built Assets per capita and GDP per capita for the thirty countries consisting of OECD members and other high income countries as well as higher- and lower-middle income countries.

Table 1: Built Assets per capita and GDP per capita 2012 ($ US) (Sources: OECD Analytical Database; United Nations Statistics Division – National Accounts Estimates of Main Aggregates)

Country	***Built assets per capita***	***GDP per capita***	***Country***	***Built assets per capita***	***GDP per capita***
Australia	*147*	*67 689*	*Netherlands*	*127*	*46 073*
Brazil	*23*	*11 347*	*Philippines*	*9*	*2 587*
Canada	*133*	*52 283*	*Poland*	*45*	*12 820*
Chile	*39*	*15 363*	*Qatar*	*146*	*93 831*
China	*25*	*6 070*	*Russia*	*39.5*	*14 178*
Egypt	*7.5*	*3 155*	*Saudi Arabia*	*73*	*25 136*
France	*125*	*39 617*	*Singapore*	*160*	*52 141*
Germany	*130*	*41 376*	*South Africa*	*22*	*7 336*
Hong Kong	*145*	*36 827*	*South Korea*	*126*	*23 052*
India	*8*	*1 516*	*Spain*	*128*	*28 278*
Indonesia	*13*	*3 557*	*Thailand*	*32*	*5 775*
Italy	*123*	*33 069*	*Turkey*	*26*	*10 653*
Japan	*148*	*46 838*	*UAE*	*124*	*41 692*
Malaysia	*41*	*10 422*	*UK*	*92*	*39 367*
Mexico	*40*	*9 795*	*USA*	*129*	*51 163*

The data from this table is plotted in Figure 3. It illustrates that the wealth gap, as measured by built assets, is more extreme than that measured by income. Also, the divergence in the GDP pc : Built asset pc ratio amongst high income economies is considerably greater than in the lower income ones.

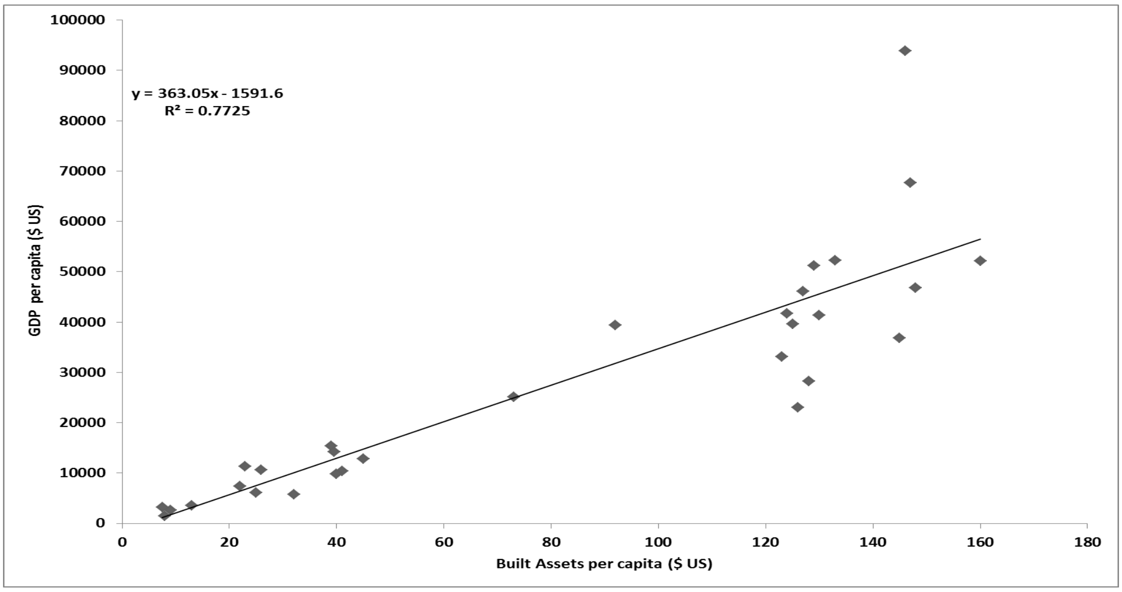

Figure 3: Built Assets per capita and GDP per capita 2012 ($ US) (Sources: OECD Analytical Database; United Nations Statistics Division – National Accounts Estimates of Main Aggregates)

3.2 Reducing the built asset gap

How does the money spent on developing a country's built environment impact its social and economic success? Some (emerging) countries are investing in their built environment at an unprecedented rate, whereas industrialised countries have aging and expensive to maintain infrastructure. Quantification of the value of built assets enables insights into how effective investments in built assets have been.

According to a recent report (EC Harris, 2013), emerging countries spend 1.6 times as much of their output on investment in an effort to catch up economically.

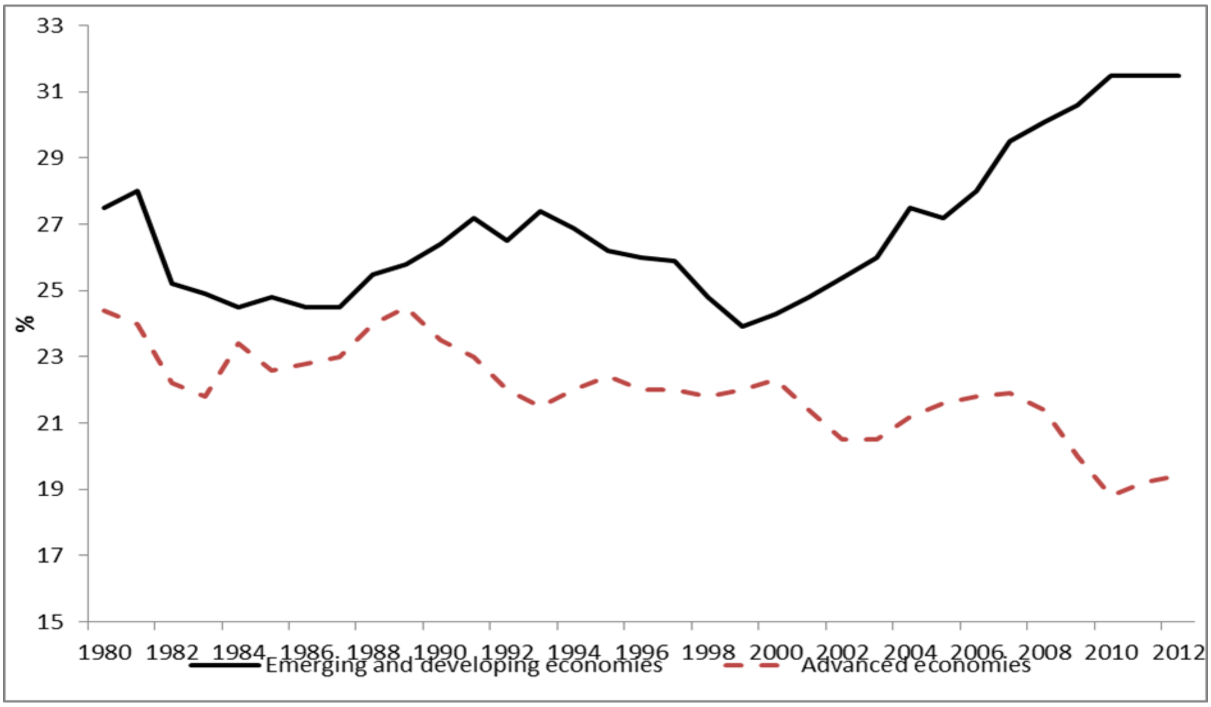

Figure 4: Investment as a percentage of GDP

With construction activity, the type of activity changes as countries develop with an established building stock find that building activity becomes more orientated towards repair and maintenance. This activity is not included as investment or capital formation in the national accounting system.

In the *Global Built Asset Wealth Index 2013* (EC Harris, 2013), it is noted that emerging economies appear to be catching up to the built asset wealth of the more developed economies with Qatar and China leading the growth.

The built asset data on the breakdown of fixed capital formation (residential and non-residential construction (including infrastructure)) for each country was either taken from a country's official statistical source or, if not available, estimates for the composition of fixed capital formation were compiled based on economic relationships derived from similar countries within the sample. Depreciation schedules for the components of fixed capital formation (residential and non-residential construction) were drawn from international best practice including the US Bureau of Economic

Analysis, the OECD and the World Bank. An average life of each of the components of fixed capital f ormation was established.

3.3 Implications of the emerging economies bridging the gap in accumulated wealth

In some emerging economies (such as Saudi Arabia, Qatar and Chile), built assets are being developed as an enabler for new and growing economies to develop, often on the back of resource derived wealth. The focus in these markets is on the planning and creation of assets that have a real impact and will be sustainable for the long term. Other emerging economies, like India and Malaysia, face huge challenges as a result of rapid population growth, urbanisation and economic transformation. Built assets need to be developed to address big challenges around the basic need for social infrastructure as well as productive capital. With urban population growth, a 'superheating' surge in investment the construction industry has been the danger particularly when the environmental/land aspect produces a requirement to go vertical (e.g. Hong Kong) or trans-national (e.g. Singapore) acquiring land from neighbouring countries for the development of industrial estates. Whilst a good deal of emphasis has been laid on the positive aspect of investment in infrastructure, the issue of property bubbles has been a feature of the financial crisis in countries across the spectrum.

Focusing on the BRICs (Brazil, Russia India and China), it is estimated that, by 2020, emerging economies will account for 55% of global construction compared to 46% in 2010. (Global Construction Perspectives and Oxford Economics, 2011). In these emerging economies, expanding populations and growing economic activity are driving higher growth in construction. China, the largest emerging economy, overtook the USA as the biggest construction market in 2010 and India, with its expanding population is set to become the world's third largest construction market by 2018. China's economy is driven by investment, which accounts for over 40% of GDP – over half of all investment is in infrastructure and property.

In their approaches to investment in built environment assets, the BRICs have shown notably different approaches. As illustrated in Table 2, Brazil and China have, since the beginning of the twentieth century, been devoting a far greater proportion of their construction investment to housing.

Table 2: Construction investment by category: Average % [2000-2011] (Source: SIMCO database)

Country	*Residential*	*Civil Engineering*	*Non-residential*
Brazil	*38*	*34*	*27*
China	*36*	*31*	*33*
India	*15*	*32*	*53*
Russia	*23*	*37*	*40*

While identifying a bubble - any kind of debt-fueled asset inflation where the cash flow generated by an asset itself does not cover the debt incurred to produce or buy an asset - is not an easy task but the focus on residential property in total investment in the two countries has elevated concerns.

In Brazil, rapid expansion of the mortgage market over the last decade has made housing finance easier and cheaper for millions. Ahuja et al (2010), in attempting to answer the question of whether house prices were rising too fast in China identified the mortgage market growth rate in 2008-9 (see Table 3) as the major factor.

Table 3: Mortgage growth rate (%)

	Average growth rate (%)	
	2004-7	*2008-9*
United Kingdom	*5.5*	*2.5*
Australia	*5.0*	*4.3*
China	*2.4*	*16.1*

Source: Ahuja et al 2010

There is a fear in such economies in which there is an overbuild / overcapacity issue in residential property that they could hit an investment wall and loans to the property and construction sectors could collapse. These and other emerging market economies with manifest property bubbles may be storing up a massive bust unless policy measures undertaken by their governments in the form of increases in real interest rates, targeted property taxes and the development of a financial market for alternative investments vehicle to housing are effective.

4. Conclusion

Since the designation of *Revaluing Construction* as a priority theme by the CIB almost a decade ago, the issue of assessing the contribution of the construction industry to the wider economy and society has gained prominence in research circles. In terms of the economic value, the basis of assessment has, in most cases, been value-added to the GDP. However, the role of the built environment and the value of its assets in the growing sustainability agenda have also brought greater interest in an evaluation of investment in built assets to the fore.

Attempts to assess the asset value of the built environment are still crude but the *Inclusive Wealth Report 2012* represents a promising start for such evaluation. The evaluation methodology, being based on the development of a consistent and comprehensive framework for assessing whether economic growth is compatible with sustaining well-being over time, is an approach that concentrates on wealth rather than income. The management of the existing stock of built environment assets is a strategic issue for policy makers and this paper has attempted to illustrate some of the issues of viewing the contribution of the construction industry through the ‘wealth’ approach.

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Electromagnetic pollution in power-supply systems of built environment facilities and its reduction

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Abstract

In built environment facilities (residential buildings, schools, hospitals, etc.) the use of equipment and devices with the latest electro-technologies is gradually increasing: energy-saving lamps for lighting, variable frequency drives in water-supply systems, heating, ventilation and air conditioning; welding machines for construction of built environment facilities, computers, video, household appliances, etc. On the one hand, the latest electro-technologies can significantly reduce power consumption (up to 10 times), as well as justify power-supply systems of built environment based on smart grids. On the other hand, implementation of new electro-technologies means using non linear power elements. While operating these elements create electromagnetic interference (EMI) in power-supply systems and become a source of electromagnetic pollution to the environment. EMI includes current harmonics with frequency spectrum from 1 to 2000 Hz emissioned by equipment and devices into power- supply networks; pulsed nature of loads leading to fluctuations and voltage dips. As a result, quality of electrical energy deteriorates. Other users connected to this power-supply system have to consume low-quality energy which affects their performance. Apart from all mentioned, it has extremely negative influence on human body. It is well known that cardiac rhythm is about 1 Hz, oscillation frequency of nerve cells in the brain is about 8.7 Hz, at the frequency of 1000 Hz hearing sensitivity is sharply increasing. It should be noted that the source of EMI in power-supply systems is not only electrical facilities of built environment but also industrial facilities connected to this network. When operating a number of power consumers generate current harmonics and consequently voltage harmonics on a frequency close to 8.7 Hz. These low-frequency oscillations penetrate into lighting networks and create a luminous flux on a frequency of 8.7Hz additional to light emission of 50 Hz. These resonance phenomena cause irritation and headache. Possible solutions for reduction of EMI and electromagnetic pollution. Regulations in the standards for permissible level of EMI for electrical equipment and appliances at the stage of production. Design circuits: isolation of non-linear loads on a separate substation busbars system, filtering devices that are connected directly to the terminals of electrical equipment with a high level of EMI.

Keywords: built environment, Electromagnetic pollution, Ecology, Electrical supply system, Power quality, Voltage

At the Gleneagles Summit (2005), the Group of Eight (G8) leaders identified the questions of tackling climate change, promoting clean energy and achieving sustainable development to a group of key global challenges. They agreed that one of the major ways of solving these challenges is a transforming the way we use energy. At their request, the International Energy Agency (IEA) carried out an analysis of the energy consumption and the energy development in the various fields based on long-term tendencies of development of IEA Countries: USA, Japan, Germany, etc. (a total of 11 countries). /1/. Economic growth in IEA countries has increased personal wealth of citizens. They have more spacious and comfortable homes, with a greater number and variety of household appliances and electrical equipment. As a result an increase of energy consumption takes place both in homes and in other built environment facilities: educational institutions, treatment complexes and so on (Figure 1 - Actual energy use).

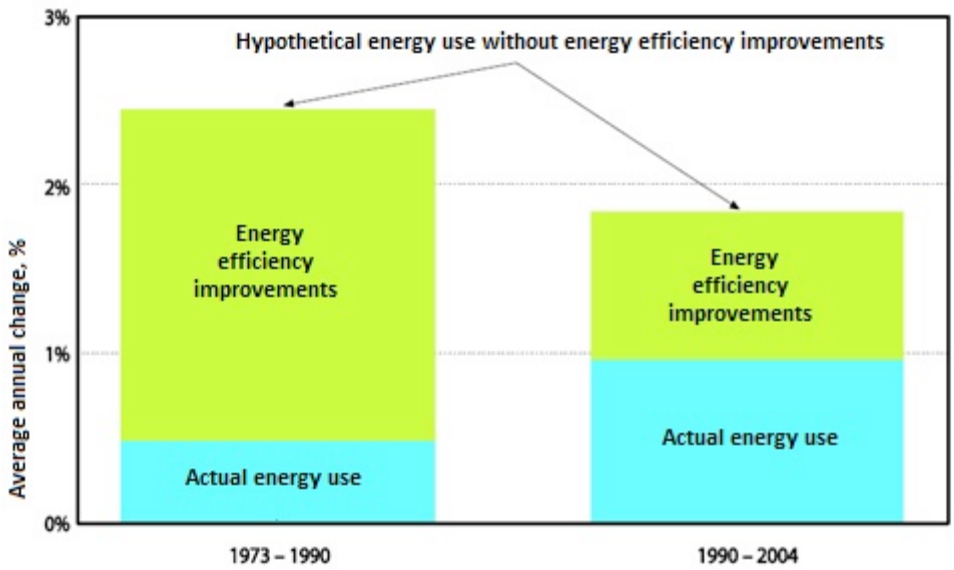


Figure 1: Impact of energy efficiency improvements on final energy use, IEA11

The increased demand for various services wouldn't have led to an increase of energy consumption, if energy-efficient measures had been fully implemented. It should be noted that in recent years inbuilt environment facilities (residential buildings, schools, hospitals, etc.) the use of equipment and devices with the latest electro-technologies is gradually increasing: energy-saving lamps for lighting, variable frequency drives in water-supply systems, heating, ventilation and air conditioning; welding machines for built environment facilities construction, computers, video, household appliances, etc. The latest electro-technologies can significantly reduce power consumption (up to 10 times), as well as justify built environment power-supply systems based on smart grids (Figure 2).

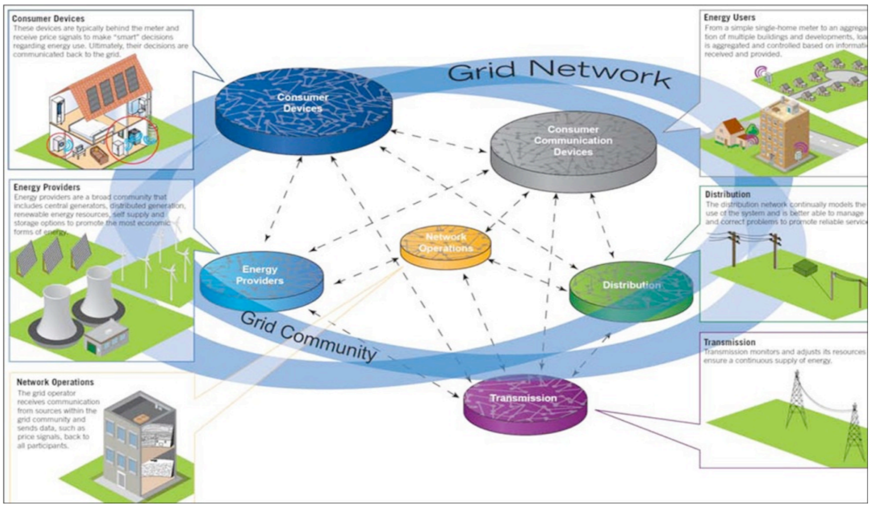


Figure 2: Smart grid power-supply system

Implementation of new electro-technologies means using non-linear power elements. While operating these elements create electromagnetic interference (EMI) in power-supply systems and become a source of electromagnetic pollution to the environment.

Further some devices will be considered and equipment implemented on these technologies and their contribution to the formation of EMI.

Lighting consumes up to 20% of the total produced electricity in the world (Figure 3), due to the extensive use of inefficient incandescent lamps (IL) (Table 1) / 2 /.

Figure 3: Panorama of a night city

Table 1: Energy characteristics of different types of lighting lamps

Type / *Characteristics*	*Incandescent light bulb*	*Fluorescent lamp*	*LED*
Theoretical luminous efficacy, lm/W	*25*	*80*	*300*
Maximum service life, hours	*1 000*	*15 000*	*100 000*

At first energy-saving lamps - gas-discharge lamps were developed one type of which is a low-pressure discharge lamps (fluorescent lamps) became popular in the lighting systems. The first compact fluorescent lamps (CFL) were created in 1978 (Philips) / 2 /. Despite their energy efficiency, the level of implementation of these lamps in the world did not exceed 20%. Causes: unreliability of inexpensive CFLs for the mass market, consumer dissatisfaction with the color characteristics of the lamps, necessity of the disposal (utilization) because of the use of mercury vapor in them. Research carried out by the author revealed also the low power factor and the high reactive power consumption (Figure 4, Table 2) / 3 /.

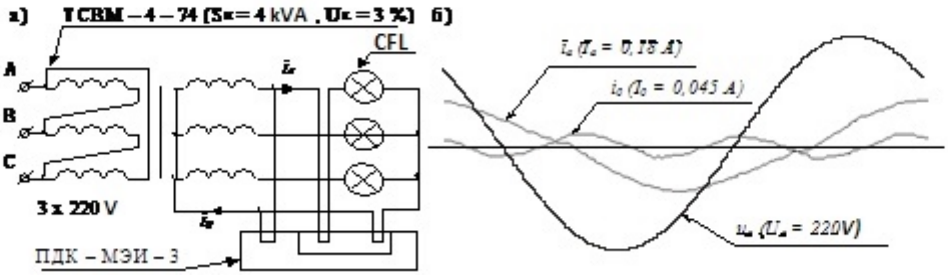


Figure 4: Scheme of the experimental setup (a), current and voltage oscillograms (b) of the CFLs series Ecotone Ambione (Pn = 21 W, Un = 220)

Table 2: Results of experimental research of CFL lamps

Voltage, V	I, A	P, W	$Q^{P}_{ЭКВ}$, VAr	K_U, %	K_I, %	Including the current harmonics				
						K_3, %	K_5, %	K_7, %	K_9, %	K_{11}, %
198	0,132	17	20	2,58	10,83	10,5	2,32	1,55	0,86	0,52
220	0,18	21	34	2,18	9,16	9,05	0,86	1,55	0,52	0,52
242	0,23	26	49	2,3	10,48	10,2	0,86	1,82	0,41	0,52

$$Q^{P}_{ЭКВ} = \sqrt{(U * I)^2 - P^2}\,, \qquad (1)$$

where, $Q^{P}_{экв}$ - calculated equivalent reactive power;

K_U, K_I – coefficients of total harmonic distortions (THD) of voltage and current;

$$K_U = \frac{\sqrt{\sum_{n=2}^{k} U^2_{(n)}}}{U_{(1)}} 100\% ; K_I = \frac{\sqrt{\sum_{n=2}^{15} (I^2_{(n)})}}{I_{(1)}} \cdot 100\% . \qquad (2)$$

I, U - RMS values of voltage and current.

Values of the current harmonics obtained in this experiment allowed to calculate the coefficients of n-th harmonic component of the current($K_{I(n)}$).

$$K_{I(n)} = \frac{I_{(n)}}{I_{(1)}} \cdot 100\% \qquad (3)$$

The current of the third harmonic mainly flows in the neutral conductor. This current is the triple sum of the third harmonic's currents of three phases as the currents 3, 9, 15 and higher create the zero sequence in the three-phase system. It should be noted that currents of harmonic 3 (150 Hz) create a noise in the communication lines.

There is a tendency in the world practice to use light emitting diodes (LED) lamps in lighting systems due to the progress in the field of creation of LED. It should be noted that CFLs have almost reached its theoretical maximum luminous efficacy (Table 1; lamp Siemens: model 30W/825 $\Phi_{уд}$ = 64.5 W / lm), while commercially available LED lamps have already exceeded the efficiency of CFLs (Table 1), and laboratory samples have already reached values of the specific luminous efficacy of 150 Lm/W / 2 /.

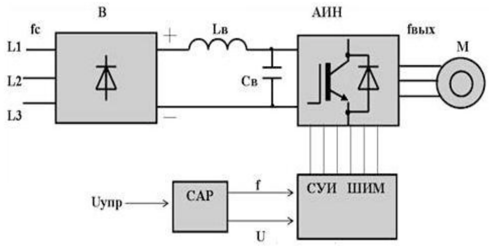
Our research of the LED lamps for circuit voltage, manufactured by leading companies are shown in Table 3 /4 /.

Table 3: Results of experimental research of LED lamps

Manufacturer	*Numbers*	*P, W*	*Φ, Lm*	K_U, *%*	K_I, *%*	*Coefficients of harmonic components of the current* K_n, *%*						$I_{ИЗМ}$, *mA*	$Q^P_{экв}$, *VAr*
						K_2	K_3	K_4	K_5	K_7	K_9		
Osram	*1*	*2*	*50*	*1,6*	*160*	*92,7*	*82,2*	*68,7*	*53,7*	*24*	*5,7*	*15,1*	*2,8*
	2	*4*	*100*	*1,6*	*102*	*2,9*	*82,6*	*1,9*	*54,4*	*25*	*6,6*	*33,2*	*6,1*
Melitech	*1*	*2,5*	*115*	*1,6*	*13,6*	*0*	*8,2*	*0*	*6,8*	*6,3*	*2,6*	*62,9*	*14,2*

Character of the current consumption, its harmonic composition, a value of the power factor of LED lamps, the voltage ripple factor for the voltage applied to the LEDs is determined by scheme and technical peculiarities of built-in power supply module for lamps. As gas-discharge lamps, LED lamps are characterized by emission of higher current harmonics in the supply grid, a large amount of the reactive power consumption. Using of energy-saving LED lamps with a specific luminous efficacy of 150 Lm/W and over in lighting systems in the future allows to realize a significant potential of energy efficiency in this area.

More than 60% of the electrical energy in the world consumed by electric drives based on induction motors (asynchronous motors). The use of variable frequency drives in water-supply systems, heating, ventilation and air conditioning in the built environment facilities allows, depending on the type of the load, to significantly reduce the power consumption by adjusting the frequency and the output voltage at the terminals of the induction motor. Variable frequency electric drive in the simplest version consist of unmanaged semiconducting six-phase converter (B), autonomous inverter (I); control system (СУИ ШИМ); automatic control system (САР), and the AC motor (M) (Figure 5).

a) 

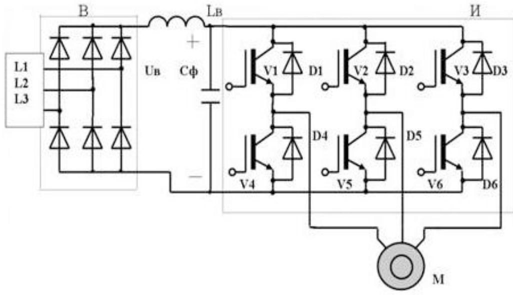
б) 

Figure 5: Structural (a) and schematic (b) circuits of the asynchronous variable frequency drive

The presence of semiconducting converters in the electric circuit of the asynchronous variable frequency drive determines a nonlinear character of the consumed current, and therefore emission of higher harmonics (In) to the supply grid: mainly 5th (250 Hz) and 7th (350 Hz) harmonics.

$n = (6p \pm 1) \cdot f_1$,

where $p = 1, 2, 3,$ etc.;

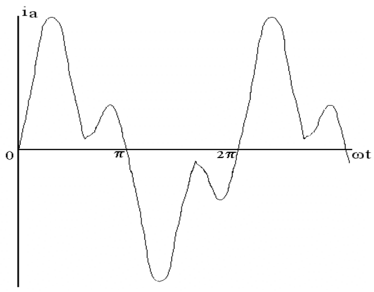
f_1- the main frequency.

According to the research carried out in the work / 5 / the presence of fifth and seventh voltage harmonics in the grid leads to a vibration of asynchronous motors with frequency of 300 Hz.

We have researched a large group of energy-saving household appliances and office equipment.

Modern electrical appliances of this group was also implemented with the widespread use of microprocessors and power electronics, and as shown above, these electrical appliances appeared to be a source of various EMI.

As an example, Figure 6 shows us experimental data of the consumption current for the microwave oven.

a) 

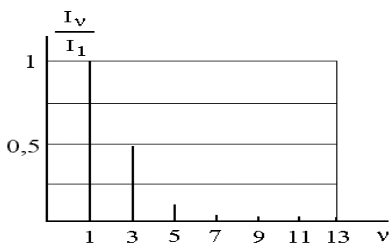
б) 

Figure 6: Oscillogram (a) and histogram (b) of the input current for the microwave oven

The pulsed nature of loads leads also to fluctuations and voltage dips. As a result, quality of electrical energy deteriorates. Other users connected to this power-supply system have to consume low-quality energy which affects their performance. It should be noted that the source of EMI in power-supply systems is not only electrical facilities of built environment but also industrial and other facilities connected to the regional electrical grid (Figure 7: ASS-arc melting furnace; RAILROAD-tram). Basis of the regional system is a meshed electrical grid of 110kV, local power stations (PS) operate in this grid and electricity supply systems of various objects are powered from this grid with the use of transformer substations (6-35/0, 4 kV) including the power supply system of the built environment (Sn).

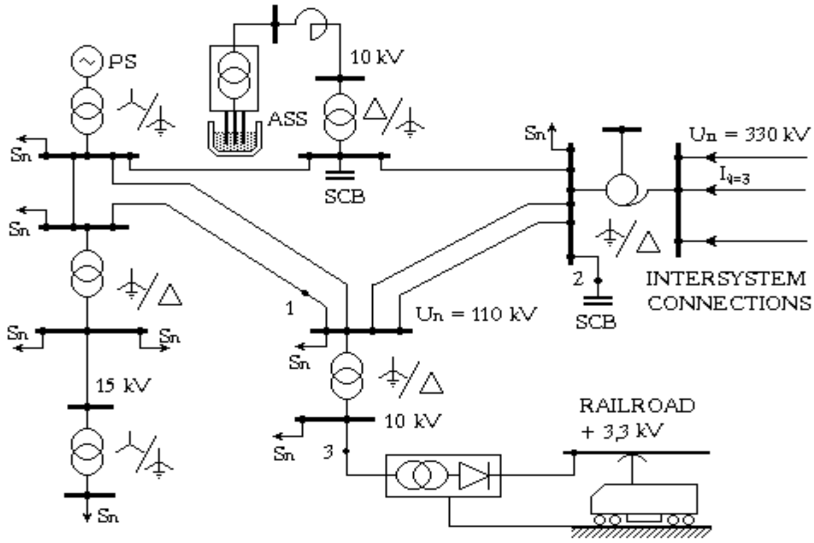


Figure 7: Simplified classic scheme of a regional energy system of the state, region

Figure 8 shows the character of EMI which appear in the regional power system during acceleration of the tram.

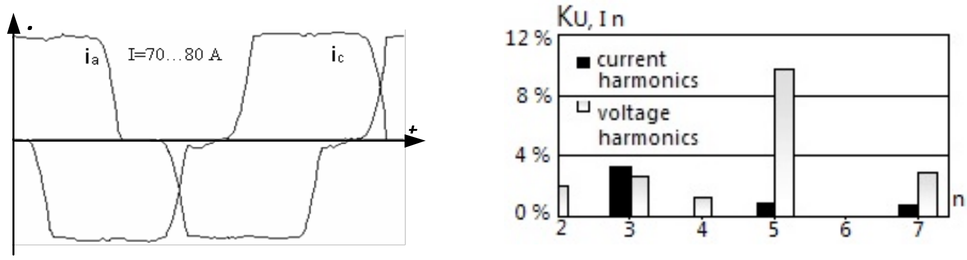


Figure 8: Oscillogram (a) and histogram of the input current and voltage (b) on the traction substation of 10 kV during acceleration of the tram.

Wind turbines connected to the regional system (Figure 9) are also potent sources of EMI / 6 /.

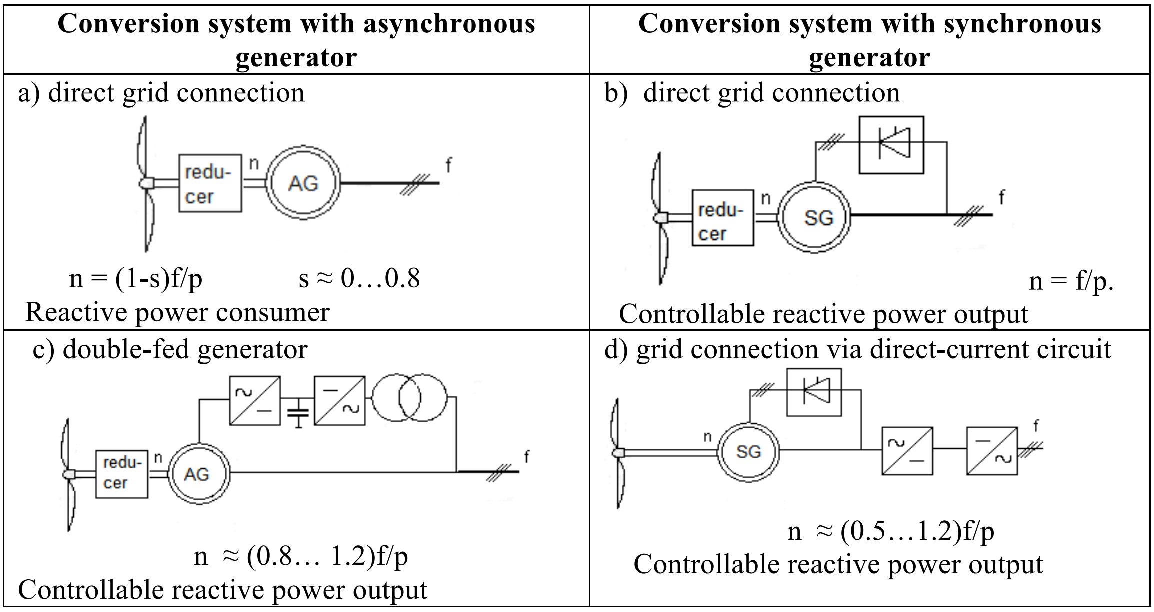


Figure 9: Connection of the wind turbines to the electrical grid

Powerful electrical receivers operate in modern regional systems characterized by the impulsive, nonlinear and changeable character of the consumption of active and reactive power at high speed during the day which leads to a high level of EMI from low-frequency 1Hz till 1000Hz or more. It should be noted that the current European power quality standard / 7 / regulates the level of voltage harmonics up to 30 (1500 Hz). In electrical systems the spread of voltage fluctuations and other EMI occurs towards the low voltage busbars almost without attenuation, and towards the high voltage busbars with attenuation of the amplitude. Hence, when voltage fluctuations appear at some point of the electrical grid and spread in this grid they have a negative impact on consumers sensitive to them: microprocessor-based systems, control systems, condensing units, lighting grids (changing the brightness of lamps - flicker) and so on.

Apart from all mentioned it is an extremely negative influence on human body, when a person is situated in electromagnetic fields. It is well known that cardiac rhythm is about 1 Hz, oscillation frequency of nerve cells in the brain is about 8.7 Hz, at the frequency of 1000 Hz hearing sensitivity is sharply increasing. It is found, that the large motors, wind turbines, arc melting furnaces are sources of voltage fluctuations with frequencies close to 8.7 Hz.

Possible solutions for reduction of EMI and electromagnetic pollution.

Normative. Regulations in the standards for permissible level of EMI for electrical equipment and appliances at the stage of production.

Design circuits / 5, 7 /

1. Isolation of non-linear loads on a separate substation busbars system

2. Increasing of semiconductor converters phases number. Currently mainly used six-phase converters (Figure 5), generating a high level of current harmonics. Increasing of the phases number of converters up to 12, and sometimes up to 24 and 48 dramatically reduces the levels of current harmonics.
3. Connecting of the non-linear load to a system with a higher short-circuit power $S_{sc.}$
4. The use at substations which supply electricity to the built environment facilities, transformers with the vector group Δ/Y_H and Y/Z_H.
5. Using of filtering devices: narrowband filters, compensating and balancing filter devices, active filters, static thyristor compensators (static VAR compensator).

Active filters recently become more and more popular. The active filter included in the grid generates a current harmonic of this magnitude and phase that ensures a full compensation of a current harmonic of the nonlinear receiver.

Static thyristor compensator (static VAR compensator) is the multifunction contactless device providing reactive power compensation, power quality, including filtering of current harmonics at the connection point. They are used to meet the challenges of localization and suppression of EMI at the large substations in territorial power systems and factories, where there is a great distorting load, for example arc melting furnaces.

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E-Business Use in the Ghanaian Construction Industry: The Drivers

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Abstract

This paper reports on a questionnaire survey undertaken to evaluate e-Business use in the Ghanaian construction industry. The views of construction professionals and local construction firms in Ghana were consulted in this questionnaire survey. Additionally, the survey is intended to show evidence of e-Business activities and professional groups within the industry likely to use e-Business. The initial result shows that, there are different levels of e-Business initiatives and understanding within the industry. Further, e-Business related activities are done in haphazard manner due to low technological capacity. This evaluation provides a unique opportunity to assess the capacity of contractors and other professional groups for e-business technology transfer either through joint ventures or collaborations, considering the significant amount of investment and foreign construction firm activities within the Ghanaian construction industry.

Keywords: e-Business, construction industry, professional groups, technological capacity

1. Introduction

Recent technological advances have improved performance within construction industry (Adzroe and Goulding, 2004, Goulding and Lou, 2013). Technological issues within construction have become ever more critical and ranging debates among researchers and construction industry professionals are still underway at different levels within the construction sector. For example, Smyth (2010) recently pointed out that, there have been several innovative initiatives within construction in many countries in the last two decades to introduce technological reforms to improve industry performance.

Substantial evidence in technology transfer literature suggest that technological know-how relating to developing countries construction industries is similar to the situation in Ghana. Technology transfer remains an essential component in the development of the construction industries in developing countries (Carrillo, 1996). One of the technologies that has the potential to achieve significant improvement in performance in the construction industry is 'e-business'. E-Business is this context refers to exploiting the capabilities of ICT and the Internet to aid business process to be more efficient and responsive. Evidence from literature suggest that despite the novelty and the little use of e-Business application within the construction industry in developed economies, there is a strong link to substantial research in the sector (Aranda-Mena and Stewart, 2004, Chen *et al*., 2011). On the other hand, empirical evidence on e-Business in construction in developing countries is scant. Therefore, there is the need for developing countries construction industries like Ghana to reform technologically and take advantage of the opportunities offered by e-business in order to attract the needed investment from their counterparts from developed countries. The way forward for the Ghanaian construction industry is to develop the capacity and capability of industry players to enable them to take advantage of the influx of foreign construction firms seeking partnerships and joint ventures in Ghana. Adzroe and Ingirige (2013) reported recently that utilising e-business in construction activities can bring substantial benefits to construction industries in developing countries.

In this regard, this research was developed to evaluate e-business use in the Ghanaian construction industry and also to assess the capacity of contractors and other professional groups for e-business technology transfer via joint ventures. The paper first presented a brief literature review followed by the research method adopted. It then presented the findings of the research and discusses based of e-business activities, drivers, impact and barriers. The paper concluded by presenting a way forward following from the findings of the survey.

2. Brief background of the construction industry in Ghana

The construction industry in Ghana is characterised by a multiplicity of small firms (Ayarkwa *et al.,* 2010). According to van Egmond and Erkelens (2007) out of a total of 7095 construction firms registered in Ghana, ninety per cent (90%) are small contractors who belong to lower classes and undertake less complex construction jobs with tender sums up to one million dollars ($1,000,000.00). This was confirmed by Amoah *et al.* (2011) in their work "factors affecting construction performance in Ghana: the perspective of small-scale building contractor". Industry reports indicate that majority of Ghanaian contractors do not have sufficient funds and credit facilities and also lack appropriate technological capabilities, plant and equipment as well as key personnel to handle construction projects properly, Owusu-Tawiah (1999) cited in (Ayarkwa *et al.,* 2010). This goes further to support the qualitative evidence provided by Ofori (1984) many years ago where key issues such as delay in payment to contractors for work done, lack of credit facilities and poor communication structure were identified. On the other hand, GBN (2009) also identified outmoded equipment, low level of trained personnel and lack of qualified supervision as some of the nagging problems confronting local contractors operating in the construction industry in Ghana. Based on the work of Cairns (1992), Ayarkwa *et al.* (2010) argued that construction activity is increasingly becoming highly technical and sophisticated with high standards of quality and specification arising from the development of new technologies, the growing sophistication of employers or clients and increasing competition across the industry. Issues of technological know-how and personnel development are concerns engaging industry practitioners and government discussions in recent time.

3. The current state with regard to e-business in construction

e-Business was originally coined by IBM in 1997. IBM explained e-business to mean the value "customers derive from network computing" (IBM, 1997). Since then several definitions of e-Business emerged. For example DTI 2000 believes that it is the utilisation of ICT facilities in collaboration with the internet to processes of any business including construction. According toAranda-Mena and Stewart (2004) and Li (2007) the terms e-business and e-commerce have created misconceptions. They explained that the misconceptions include the lack of understanding of the difference between 'e-business' and 'e-commerce'. e-Commerce is essentially a part of e-business that is concerned with financial transactions and therefore does not require shared or redesigned business processes. Typically, e-business is anchored on the capabilities of ICT facilities to thrive and this has been demonstrated in many economic sectors (Aranda-Mena and Stewart, 2004, Li, 2007). e-Business essentially has the potential to streamline organisations processes through integration thereby enhancing the traditional processes (Ruikar and Anumba, 2008). e-Business aims at ensuring optimisation of communication and sharing information without making any reservation of the traditional barriers that exist between design, engineering and construction within the construction industry (Worst, 2009). It is obvious that e-business has a solution to fragmented and geographical barriers within construction industries (Oyediran and Odusami, 2005, Worst, 2009).

Drivers, impact and barriers are important aspect of e-business implementation. Drivers and barriers to e-business have been identified in literature. For example, previous studies in the US, Australia and Italy (Minahan and Degan, 2001, Davila *et a*l., 2003, Hawking *et al*., 2004, Ronchi *et al*., 2010) have ranked these drivers and barriers for the general procurement of goods and services. Eadie *et al*. (2007) in previous research, ranked the drivers and barriers to e-procurement from a construction contractor's perspective in the Northern Ireland public sector. For the purpose of this paper and in the context of the Ghanaian construction industry: drivers of e-business are those factors that encourage and promote e-business implementation: impact of e-business on the other hand, is the ability to quantify gains, opportunities and benefits to an organisation: whilst barriers to e-business are factors considered as impediments to e-business adoption.

3.1 e-Business enabling technologies

From literature, it has been pointed out that e-business requires adequate technologies to survive. Within construction, there are several attempts to harness the capabilities of e-business technologies to provide innovative solutions, smooth partnering principles, easy global procurement and a shift in the image of the construction industry from labour workers to professional information controllers (Perera *et al.*, 2012). Perera *et al.* (2012) discussed the importance of enabling technologies for the conduct of e-business activities within construction. They identified two main technologies namely: cloud computing and BIM as recent e-business technologies, in complement with web-based project management software provided a platform from which e-business activities within the construction industry can be utilised, maximised and maintained. It is important to know also that technologies such as the Internet and CAD are identified alongside cloud computing and BIM as e-business enabling technologies within construction. This notwithstanding it is important to understand the capabilities and roles of this technologies and their tangible effects on construction industry activities most especially when considering it from developing countries perspective particularly Ghana where these technologies understandably have not fully attained maturity.

This survey is about e-business usage in the Ghanaian construction industry. To take this further, detailed review of literature and synthesis in the area of e-business activities and enabling technologies will assist in bringing into perspective the role of technology in supporting e-business initiatives and activities. The details of the survey analysis and findings within the context of the Ghanaian construction industry have been presented.

4. Research method

A questionnaire survey was conducted to investigate the usage of e-business in the Ghanaian construction industry. Based on the spread of construction firms in Ghana, the country has been divided into three (3) zones based on the advice and assistance offered by the association of building and civil engineering contractors of Ghana (ABCECG). To obtain adequate view of the subject matter, a total number of 105 questionnaires were distributed through the offices of the ABCECG to the three (3) zones to contractors who were randomly drawn from each of the three (3) zones. The questionnaire consisted of 6 sections: Background Information of Respondent Organisations, e-Business in Respondent Organisations, IT Investment Advice and e-Skills Development, Drivers, Impact and Barriers of e-Business, Improvement of e-Business and Future of e-Business in Respondent Organisations. A total number of 67 questionnaires were returned. Out the 67 returned 10 were incomplete therefore not suitable to be used for analysis. However, 57 questionnaires representing 54% was found accurately filled and complete, hence useful for analysis. This response rate is considered as hugely successful (Hoxley, 2008). Figure 1 shows the organisations that participated in the questionnaire survey exercise. Total number of 16 building contractors, 10 architectural firms, 7 property developers, 5 civil engineering contractors and 9 quantity surveying firms allowed staff at different management levels to participate in the questionnaire survey.

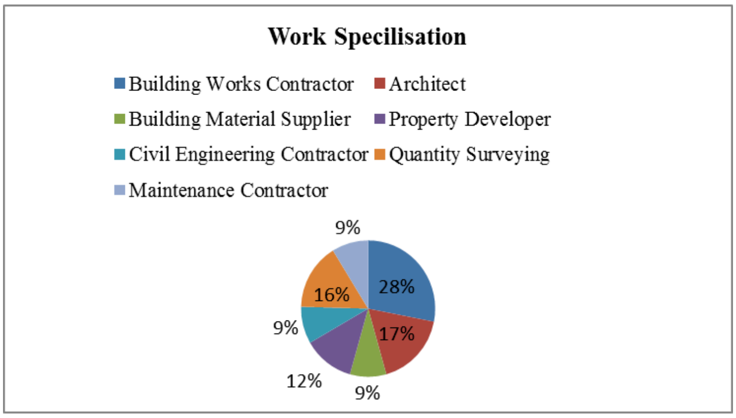

Figure 1: percentage of respondent organisations

The participating organisations varied in size as shown in figure 2. The largest type in this survey employed between 10-49 workers (46%), followed by 1-9 (19%) and 50-249 (19%) respectively and 250 and over representing 16% of the organisations that participated in the survey.

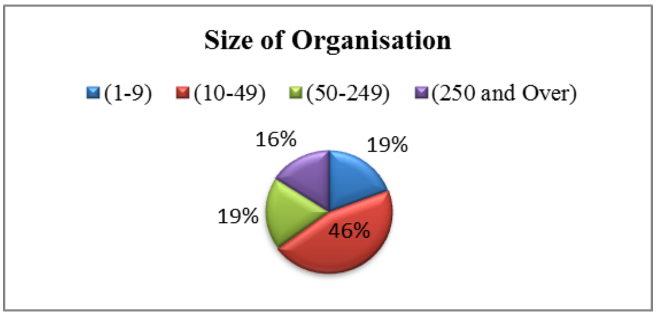

Figure 2: Percentage of Size of Respondent Organisations

The data collected from the questionnaire survey was analysed using SPSS software package. Descriptive statistics was used to analyse details of the data collected. According to (Pallant, 2010) descriptive statistics describes the basic characteristics of the data in a study. It provides summary about the sample in addition to simple to understand graphs. Also it provides what the study shows (Najimu, 2011). Descriptive statistics was adopted to provide a clear understanding of the trend of e-business usage in the Ghanaian construction industry.

5. Analysis and discussion of survey data

5.1 e-Business in respondent organisations

For e-business activities in the respondent organisations, respondents indicate the degree to which design activities (drawings) are computerised and exchanged electronically. Results from cumulative cross tabulation indicate respondents from architectural practice (architects) are the most to undertake this activity. For example, 70% of architects agreed to compress design documents and send them electronically using the internet. This is followed by property developers; a little over 56% confirmed undertaking this e-business activity. This is a confirmation that both architects and property developers are the most professional groups likely to use this activity (design). These results from both architects and property developers may require further investigation to determine the volume or figures for such e-business activity. Design activity is predominantly a core competence of both architects and property developers within the construction industry in Ghana. On the other hand, contractor categories such as civil engineering, building materials suppliers and building works results indicate they use less design activity within the construction industry in Ghana, as shown in Table 1. For example, just a little over 37% of building works contractors agree to use this activity, whilst civil engineering contractors and building material suppliers recorded 40% equally. Quantity surveying is the least professional group within the construction industry in Ghana that show interest in this activity, only 33% indicate they use design activity. These results confirm the fact that in the Ghanaian construction industry, design activity is completely done separately from building the facility hence; contractors are not part of the design solution.

Table 1: e-Business in Construction Organisations in Ghana

Cumulative Cross Tabulation of e-Business Activity (Design)												
Design Activity	None		Low		Medium		High		Total		Cum(NL) %	Cum (MH)%
	No	%	No	%	No	%	No	%	No	%		
Building Works Contractor	3	18.75	7	43.75	4	25	2	12.5	16	100	62.50	37.50
Architect	1	10	2	20	2	20	5	50	10	100	30.00	70.00
Building Material Suppliers	2	40	1	20	1	20	1	20	5	100	60.00	40.00
Property Developer	1	14.3	2	29	3	42	1	14.3	7	100	43.30	56.30
Civil Eng. Contractor	2	40	1	20	1	20	1	20	5	100	60.00	40.00
Quantity Surveying	2	22.22	4	44.44	2	22.22	1	11.11	9	100	67.00	33.00
Maintenance Contractor	1	20	2	40	1	20	1	20	5	100	60.00	40.00

From cumulative cross tabulation analysis of internet technology (see Table 2) in the Ghanaian construction industry, results indicate amply that there is high presence of internet within the construction industry in Ghana. For example, the entire respondent organisations surveyed, in exception of maintenance contractors who recorded lower that 50%, all the other organisations agree to have internet. However, it is not clear from the survey results if the internet is actually supporting their e-business initiatives and their core business activities. These results can be linked to the availability of some basic technological infrastructure for e-business initiatives in Ghana.

Table 2: e-Business Technology - Internet

Cumulative Cross Tabulation of e-Business Technology (Internet)												
Internet	None		Low		Medium		High		Total		Cum(NL) %	Cum (MH)%
	No	%	No	%	No	%	No	%	No	%		
Building Works Contractor	1	6.25	4	25.00	9	56.25	2	12.5	16	100	31.25	69.00
Architect	1	10.00	2	20.00	2	20.00	5	50.00	10	100	30.00	70.00
Building Material Suppliers	1	20.00	1	20.00	1	20.00	2	40.00	5	100	40.00	60.00
Property Developer	1	14.29	1	14.29	2	28.57	3	42.86	7	100	28.58	71.43
Civil Eng. Contractor	1	20.00	1	20.00	1	20.00	2	40.00	5	100	40.00	60.00
Quantity Surveying	2	22.22	1	11.11	1	11.11	5	55.56	9	100	33.33	66.67
Maintenance Contractor	1	20.00	2	40.00	1	20.00	1	20.00	5	100	60.00	40.00

5.2 IT Investment advice and e-Skills development

Figure 3 shows general outlook of IT investment obtained by the respondent organisations. 51% of the various organisations procured IT investment advice through the assistance of professional IT service provides as against 39% who depend on their IT department for IT investment advice. These organisations may fall within 50-250 and over categories as shown in figure 2. Results indicate 7% and 4% obtained advice through university and government or third part recommendations.

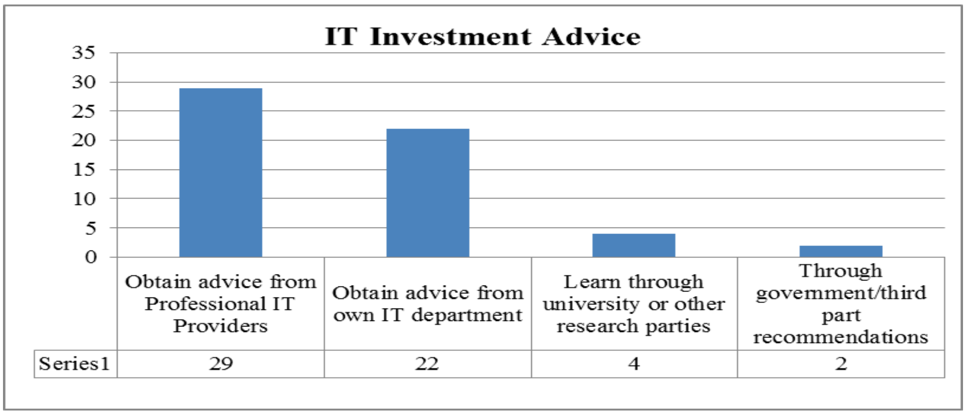

Figure 3: IT Investment Advice

5.3 Drivers, Impact and Barriers of e-Business in the Ghanaian Construction

5.3.1 Drivers

Results indicate reasons respondent organisations engages in e-business. As shown in figure 4, as many as 36 of respondent organisations confirm that their main driver of e-business is the competitive advantage it offered. Other variables like customer expectation, competitor engage in e-business and supply chain expectation received mixed responses as indicated in figure 4. These results underscore the fact that there is a growing interest and awareness of e-business within the Ghanaian construction industry.

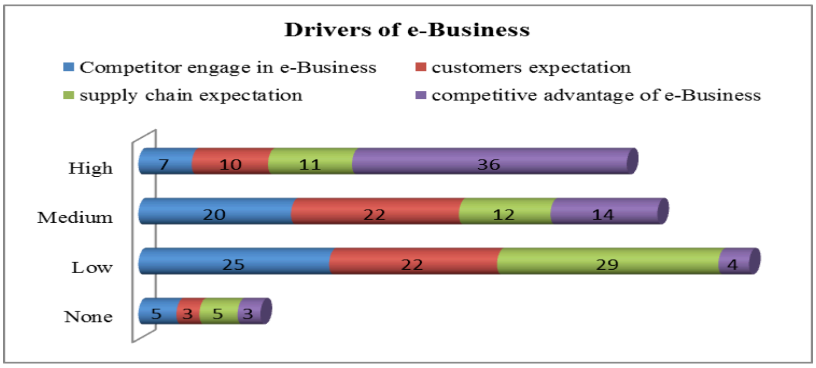

Figure 4: Drivers of e-Business

5.3.2 Impact of e-Business

Table 3 shows respondent organisations ranking the following and their influence on the decision of implementing e-business in future to enhance their business activities. Respondents ranked growth of revenue as the most influential factor offered by e-business followed by quality of products and efficiency of business processes in second and third positions respectively as the three most important influential factors offered by e-business. As an immature technological industry, their ranking reflects offerings of e-business that in their view would support construction business activities.

Table 3: Ranking of Impact of e-Business in the Ghanaian Construction

Impact	*N+L Cumulative f*		*M+H Cumulative f*		*Ranking Based on Cum f M+H*
	Cum f	*Cum %*	*Cum f*	*Cum %*	
Growth of Revenue	*0.23*	*14.10*	*1.23*	*86.00*	*1st*
Efficiency of Business Processes	*0.12*	*7.00*	*1.36*	*93.00*	*3rd*
Procurement Cost of Supplied Goods	*0.35*	*22.80*	*1.41*	*77.10*	*4th*
Quality of Products	*0.34*	*22.80*	*1.34*	*72.20*	*2nd*
Quality of Customer Service	*0.36*	*33.40*	*1.85*	*66.70*	*15th*
Productivity	*0.52*	*47.40*	*1.90*	*52.60*	*16th*
Management & Control	*0.19*	*12.30*	*1.65*	*87.70*	*10th*

Accounting & Adm	*0.34*	*24.60*	*1.69*	*75.50*	*11th*
Internal Organisation Relationship	*0.29*	*24.60*	*1.76*	*75.50*	*13th*
Staff Training	*0.27*	*17.60*	*1.51*	*82.40*	*7th*
Market Research	*0.25*	*15.80*	*1.56*	*84.30*	*8th*
Innovation	*0.31*	*26.30*	*1.73*	*73.70*	*12th*
Research & Development	*0.22*	*29.90*	*1.50*	*70.10*	*6th*
Time & Cost Savings	*0.60*	*52.60*	*1.92*	*47.40*	*17th*
Organisational Innovation	*0.13*	*8.80*	*1.49*	*91.30*	*5th*
Competitive Advantage	*0.51*	*43.80*	*1.81*	*56.10*	*14th*
Expansion of Partnership	*0.24*	*19.30*	*1.56*	*80.70*	*8th*
Visibility to Supply Chain	*0.30*	*22.80*	*1.60*	*77.20*	*9th*
Improving Collaboration	*0.75*	*64.40*	*1.94*	*31.60*	*18*

N=None L=Low M=Medium H=High Cum *f*=Cumulative frequency

5.3.3 Barriers to e-Business Implementation

Respondent organisations were requested to identify the level of influence of the following barriers (see Table 4) of implementing e-business within the Ghanaian construction industry. Considering the most ten influential barriers to e-business implementation in the Ghanaian construction industry as indicated in Table 3, the respondent organisations ranked lack of research and development in IT as the most influential factor followed by lack of electric power supply, legal barriers in that order. Some of the identified barriers appear to have direct bearing on e-business development within developing countries construction industries.

Table 4: Ranking of Barriers of e-Business in the Ghanaian Construction

Barriers	N+L Cumulative *f*		M+H Cumulative *f*		Ranking Based on Cum *f* M+H
	Cum *f*	Cum %	Cum *f*	Cum %	
Cost of Investment	0.29	19.3	1.64	80.70	13th
Resistance to Change	0.30	21.10	1.61	79.00	12th
Con in Using New Tech	0.19	14.10	1.53	86.00	9th
Lack of IT Skills	0.12	7.00	1.20	93.00	5th
Legal Barriers	0.13	8.80	1.18	91.30	3rd
Interface with other systems	0.29	17.50	1.27	82.50	8th
Security of Data Transaction	0.14	8.80	1.23	91.20	7th
Changeable IT Needs	0.21	14.00	1.19	86.00	4th
Modification of Legal System	0.19	14.10	1.57	86.00	10th
Lack of Power Supply	0.15	10.60	1.15	89.50	2nd
Basic Competence in IT	0.50	45.70	1.73	54.40	14th
Availability of Professional Software	0.21	14.00	1.21	85.90	6th
Cultural Influence	0.27	22.80	1.60	77.20	11th
Socio-economic Problems	0.29	24.60	1.78	75.40	15th
Lack of R&D in IT	0.12	7.00	1.12	93.00	1st

N=None L=Low M=Medium H=High Cum *f*=Cumulative frequency

5.4 Improvement of e-Business

Results indicate in figure 5 shows that almost all respondent organisations agrees that to improve e-business implementation with regards to internal resources, there should be more investment funds, more expenditure in IT infrastructure, increase IT working staff, more senior management involvement and better training for working staff.

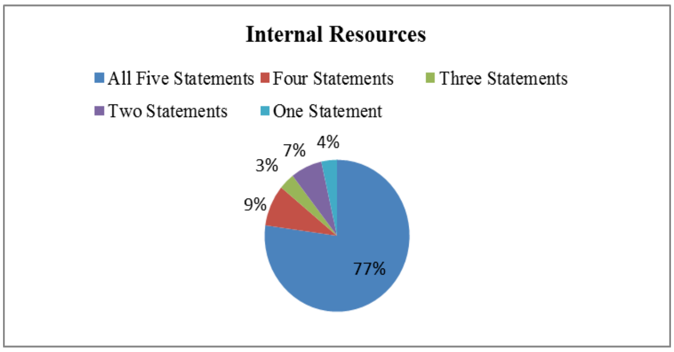

Figure 5: Improving e-Business Implementation

Figure 6 shows respondent organisations heavily agrees that improving e-business with regard to business process requires automation of business process, integration of different business processes, reengineering business processes and the connection of e-business value to business performance.

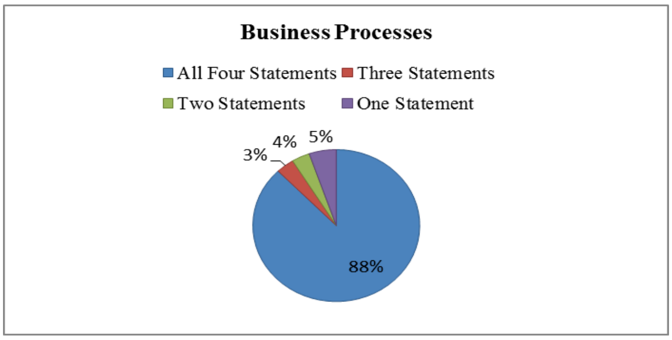

Figure 6: Improving e-Business with Regard to Business Processes

5.5 Future of e-Business in respondent organisations

Results from figure 7 indicate organisations willingness to commit resources for future investment in e-business. For example, out the 57 organisations surveyed, 22 agree to commit resources between 6-12 months, 10 plans to do investment in e-business between 19-24 months whilst 8 organisations believe to invest in e-business between 13-18 months. 12 respondent organisations indicate no plan for investment in e-business.

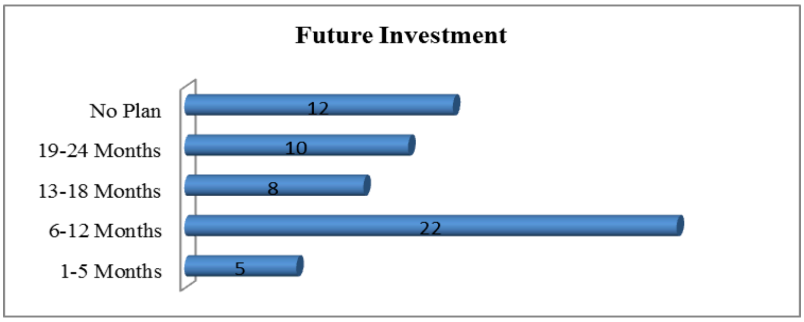

Figure 7: Organisation's Commitment to e-Business

6. Conclusion

This paper has evaluated e-business use in the Ghanaian construction industry and gauged the e-business activities amongst the various key players within the construction industry in Ghana in line with CIB Task Group 83 worldwide survey on e-Business in the construction industry. The study was conducted using questionnaire survey administered to different professional groups within the construction industry in Ghana. Findings of this study reveal different levels of e-business activity amongst key players within the construction industry in Ghana. For example, architects are found to undertake e-business activity in the area of electronic transfer of design documents followed by property developers. However, this activity is not found popular amongst contractors and other professionals like quantity surveyors. It is also evident that all the organisations that participated in this research have access to the Internet, this suggest that there is future for e-business initiatives and activities based on this common platform to launch e-business applications. Investment advice towards e-business vary, majority of the organisations sought investment advice from IT service providers whilst others obtain advice from own IT department or from third party recommendations. Drivers for e-business implementation may vary depending on the organisation type; results reveal most of the organisations believe e-business can bring about competitive advantage. In the context of the Ghanaian construction industry organisations ranked *growth of revenue* as the most influential factor offered by e-business followed by *quality of products* and *efficiency of business processes*. On the other, they identify *lack of research and development in IT* as the most influential barrier followed by *lack of electric power supply* and *legal barriers* to e-business implementation. They indicate that to implement and improve e-business organisations should provide adequate investment in IT infrastructure and staff development. Indications from tables 1 and 2 suggest that there is adequate capacity within the construction industry in Ghana for e-business technology transfer opportunities. This study will further inform the future trend of e-business in the Ghanaian construction industry.

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A review of the ‘smart technology’ currently being explored globally and its potential impact upon the construction industry on a micro level

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Abstract

The following paper will review literature that covers the use of ‘Smart Technology’ and ‘Big Data’ in the context of Smart Cities currently being explored globally. By investigating into the perceived benefits of implementing the digital economy in to essential infrastructure the paper will look at how the construction industry can benefit. The literature covered found that through the adoption of Smart Technology within a Smart City framework there are benefits available for all industries; such as greater efficiencies and forecasting ability, resulting in savings. However the integration of real time data on-site could possess great potential for construction managers as they look to make more informed and accurate decisions. However the extents of the benefits are unclear as many pieces of literature state that the potential use of Big Data is almost unimaginable currently. Urbanisation is forcing city authorities to adopt more strategic approaches to their decision making processes which has resulted in the emergence of ‘Smart Cities’. Case studies around the globe have shown promising and innovative potential for a range of stakeholders. These are promising signs for the industry as it still seeks considerable investment and testing before it can be scaled up. However further work should look to investigate first-hand how construction managers could benefit from open source ‘Big Data’ collected by city authorities. This would add evidence to the many theoretical benefits that are possible.

Keywords: Smart Cities, M2M Interactions, Urbanisation, ICT Infrastructure, Sensor and Actuator Networks (SAN)

1 Introduction

In 2013 the human race reached an unprecedented level of urbanisation (50% of the world's population now live in cities) with cities containing an increasingly large share of the world's highly skilled, educated and entrepreneurial population (Dirks et al. 2010; Nokia Solutions and Networks 2010). In reaction to this economic shift, city authorities have looked towards smarter and strategic approaches in order to react to this changing demographic (Dirks et al. 2010).

Smart City technology has been tipped by many to play a large role in reducing the environmental impacts of urbanisation (Nokia Solutions and Networks 2010). Literature has shown the use of ICT and Machine to Machine (M2M) interactions can impact upon key industries such as education, healthcare, transport, real estate and utilities, by becoming more 'aware, interactive and efficient' (Hernández-Muñoz & Vercher 2011). There are reports suggesting that by 2020 ICT efficiencies will translate into a global financial savings of €600 billion (The Climate Group 2008). A 'Smart City' has been defined as when investments in human and social capital along with traditional (transport) and modern (ICT) communication infrastructure fuels sustainable economic growth and a higher quality of life (Schaffers et al. 2011). The digital economy is suggested to possess huge potential which is driven by the recent advances in Sensor and Actuator Networks (SAN) along with rising broadband penetration (Hernández-Muñoz & Vercher 2011; Schaffers et al. 2011). However it is important that city authorities implement strategic initiatives that will promote this practise whilst sustaining a viable long term business model (Schaffers et al. 2011; Dirks et al. 2010).

It is anticipated that further collaboration of 'real-world' urban data will improve the understanding and ability to forecast flows whilst pushing the intelligence of cities forward (Schaffers et al. 2011). There is currently a large amount of live research regarding the distribution of ICT and M2M infrastructure on a large city scale; this naturally carries several barriers i.e. up scaling.

The following paper will comprise of several case studies and literature to show examples of potential areas where the theory behind 'Smart Cities' can be applied on a micro/project based level. Whilst exploring the potential relationships between an open source stream of data from ICT infrastructure and a construction site. Typically a project manager or site manager will consider transport to and from the site, resource allocation and distribution, management of waste and its implications to local inhabitants, performance measuring/benchmarking, site security and hazard awareness. All of which are potentially measurable and the sharing of such information with a local authority could aid planning and efficiency along with potential time and cost savings.

2 Smart Cities

Recently the number of people living in urban environments has just exceeded that of rural areas for the first time – shown in figure 1(The Climate Group 2008; China Development Research Foundation 2010). Reports suggest that by 2050 70% of the world's population will inhabit urban cities (China Development Research Foundation 2010). This changing demographic has forced city authorities to become more strategic in order to compete.

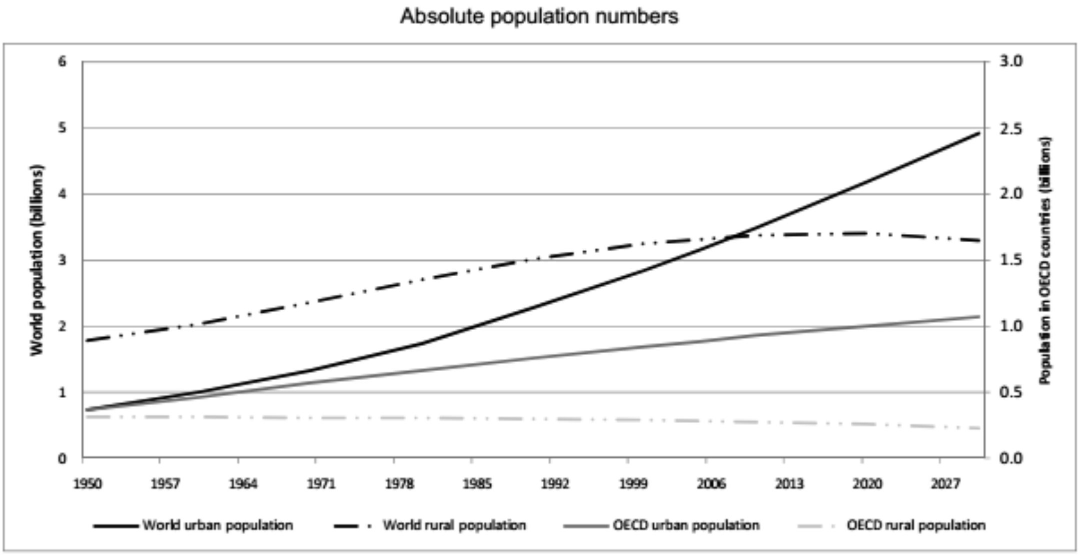

Figure 1: Urban and rural population in the world and the OECD (1950-2030) (China Development Research Foundation 2010)

Traditionally the focus for ICT innovation has been on the penetration and implementation of broadband infrastructure (Schaffers et al. 2011). However this is changing as attentions are pointing towards enhancing the quality of life for citizens (Schaffers et al. 2011). As mentioned in section 1, a Smart City represents a city that strategically integrates technology into sustainability, citizen well-being and economic development (Vilajosana et al. 2013; Schaffers et al. 2011; Hernández-Muñoz & Vercher 2011). The Smart City market is estimated to become worth €600 billion by 2020, a lucrative market for potential investors (Vilajosana et al. 2013; The Climate Group 2008). Through improved efficiencies, emission savings of approximately 7.8 GtCO_2e can be achieved by 2020 globally (The Climate Group 2008). Attached to the aforementioned point; the production and collection of 'Big Data' is a promising field for exploitation (Vilajosana et al. 2013) a point explored later in this paper. Furthermore Smart Cities have the potential to create a new generation of services that cannot even be envisaged currently (Hernández-Muñoz & Vercher 2011) – a positive view`, however one that carries uncertainty.

"Investments in making a city's core systems smarter will create cost savings and increased efficiencies whilst positioning it for long-term economic growth." (Dirks et al. 2010)

2.1 Barriers

The idea of a 'Smart City' has strong societal, industrial and political drivers; however large investments are not of abundance yet; barriers to the introduction of Smart Cities are (Vilajosana et al. 2013):

- Laborious Policy Change
- Limited Capital Availability
- 'Piecemeal' Funding Structures
- Future Political Uncertainty

European Union grants are funding the first run of trials which not only contain financial and political barriers but also geographical (Vilajosana et al. 2013). The dispersed nature of these small scaled projects is seen as a risk by investors, therefore a barrier to 'up scaling' (Vilajosana et al. 2013). Schaffers et al. (2011) devised a two stage approach required to successfully create a Smart City. Firstly a sufficient amount of broadband infrastructure along with a large amount of embedded sensors and smart devices are needed. These systems will need to be coupled with applications capable of collecting and analysing vast amounts of real time data. Finally, encouragement of large scale participation in the innovation process of applications (Schaffers et al. 2011). This will be required to explore the wide range of benefits to different sectors across the city. The range of key application areas of 'big data' are shown in figure 2.

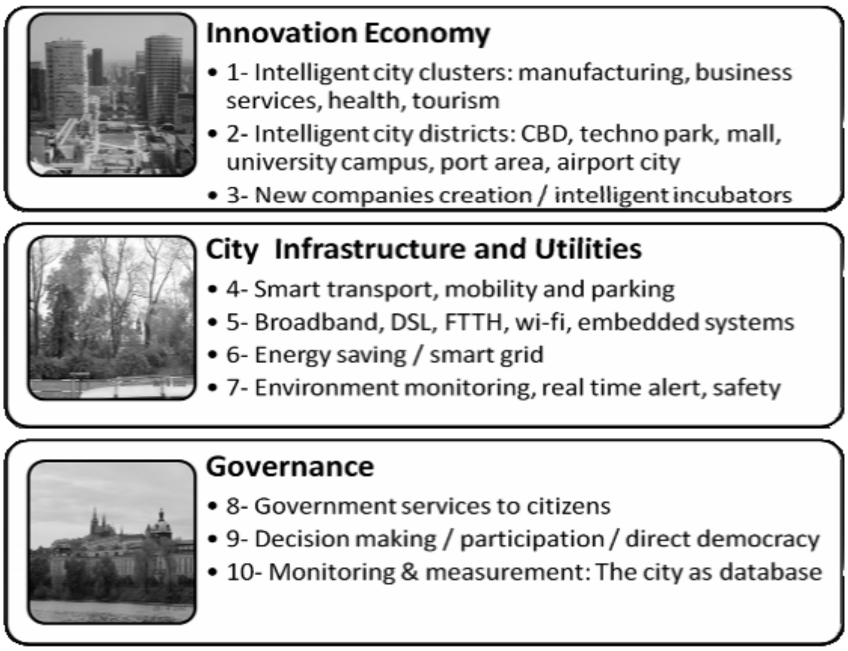

Figure 2: Application areas for Smart Cities (Schaffers et al. 2011)

3 Smart technology

Thanks to recent advances in computing efficiencies, sensor technology and energy storage there is currently a push towards Smart Technology; a new breed of devices that are small, cheap and are so low power they can operate for long periods (Koomey et al. 2013; Hernández-Muñoz & Vercher 2011). Smart Technology has the potential to vastly improve our capability to observe and react to the environment around us (in this context cities) (Koomey et al. 2013). A key characteristic of Smart Technology is that the amount of computing carried out by a single sensor is negligible, however collectively as part of a system real value can be delivered through live data (Koomey et al. 2013). Furthermore relatively small amounts of electricity used within Smart Technology can have large effects when used within big systems (Koomey et al. 2013). A simple example could be washing machines; the tiny on-board sensors and computer technology make savings in hot water and motor use resulting in large net energy savings (Koomey et al. 2013). This example shows in theory how Smart Technology ties in with the idea of Smart Cities.

When designing M2M networks comprising of sensors; wireless interactions are cheaper to install and offer greater flexibility as opposed to more traditional wired networks (Koomey et al. 2013). By using a network of many devices the energy required to deliver signals is considerably smaller; constrained to distances of around 10m – the energy requirement increases as the square of the distance (Koomey et al. 2013). A point that supports the use of Smart Technology on a construction site.

It is important to note that the adoption of Smart Technology is not a substitution for traditional manual methods; as demonstrated by Cheng & Teizer (2013), new approaches and technologies are more support mechanisms.

This section has primarily covered M2M networks and sensor technology which will typically measure light, temperature and pollution (Kramer 2013). However there are other sources for data, such as; personal sensors like Fitbit and Up wristbands which record location, activity and physiology of a user (Kramer 2013). Open source social media such as Twitter and blogs are home to a vast array of searchable live data (Kramer 2013). Crowd-source monitoring of infrastructure status or condition is also possible through the use of ‘smart phones’ and applications (Kramer 2013). Even older technology such as RFID tags to monitor flows of citizens and vehicles could be further utilised and collaborated (Kramer 2013). The benefits of such infrastructure would be the monitoring, management and optimisation of live data for example the management of traffic flow or the notification of pot holes in roads (Kramer 2013).

This section has not delved into much technical detail; however it is clear from the literature that the advancement of sensor technology and ICT in recent decades has driven the Smart Cities agenda and opened an array of new opportunities. In summary both Koomey et al. (2013) and Hernández-Muñoz & Vercher (2011) have highlighted that applications of Smart Technology within the context of a Smart Cities cannot be completely comprehended, there is a huge amount of potential for growth.

3.1 Big Data & IoT

Big Data has been labelled the ‘new buzz word’ for the technology industry; there is also a range of conflicting definitions however the following one is very applicable to Smart Cities:

“Big data is a collection of data from traditional and digital sources inside and outside your company that represents a source for ongoing discovery and analysis.”(Arthur 2013)

In the context of Smart Cities the production of Big Data is something that several pieces of literature see as a new area for exploitation that posses’ large potential (Schaffers et al. 2011; Koomey et al. 2013). The ability to collect live data and analyse it on a city scale will help improve the ability to forecast and manage urban flows, making cities more intelligent (Schaffers et al. 2011).

Additionally the term Internet of Things (IoT) is commonly used in conjunction with Smart Cities and Big Data. The IoT refers to the use of Smart Technology in a network that communicates, changing the way that decisions are made. The following definition is used by Cisco an American multinational corporation that manufactures and sells networking equipment:

“The Internet of Things (IoT) is the network of physical objects accessed through the Internet, as defined by technology analysts and visionaries. These objects contain embedded technology to interact with internal states or the external environment. In other words, when objects can sense and communicate, it changes how and where decisions are made, and who makes them.” (Cisco Systems 2013)

Hernández-Muñoz & Vercher (2011) reported that the IoT brings not only greater efficiencies and accuracy but also through creating an ‘open innovative platform’ future applications can be conceived. Something of importance to the European Union as it seeks for a homogenous platform to encourage scalability across the continent (Hernández-Muñoz & Vercher 2011).

In summary the IoT and Big Data are key components to the ideology of Smart Cities; however Koomey et al. (2013) highlighted the importance of adapting and developing how data is perceived and analysed.

4 Case Studies

4.1 Santander, Spain

Frayer (2013) reported on the Smart City pilot project initiated in 2010 by the European Commission within the small Spanish port of Santander. An $11 million grant to implement 12,000 sensors with many underground to measure everything from pollution levels to free car parking spaces illustrated in figure 3 (Frayer 2013; Kramer 2013). The project integrated the IoT and smart sensors into many forms of infrastructure along with applications to engage the citizens of the city.

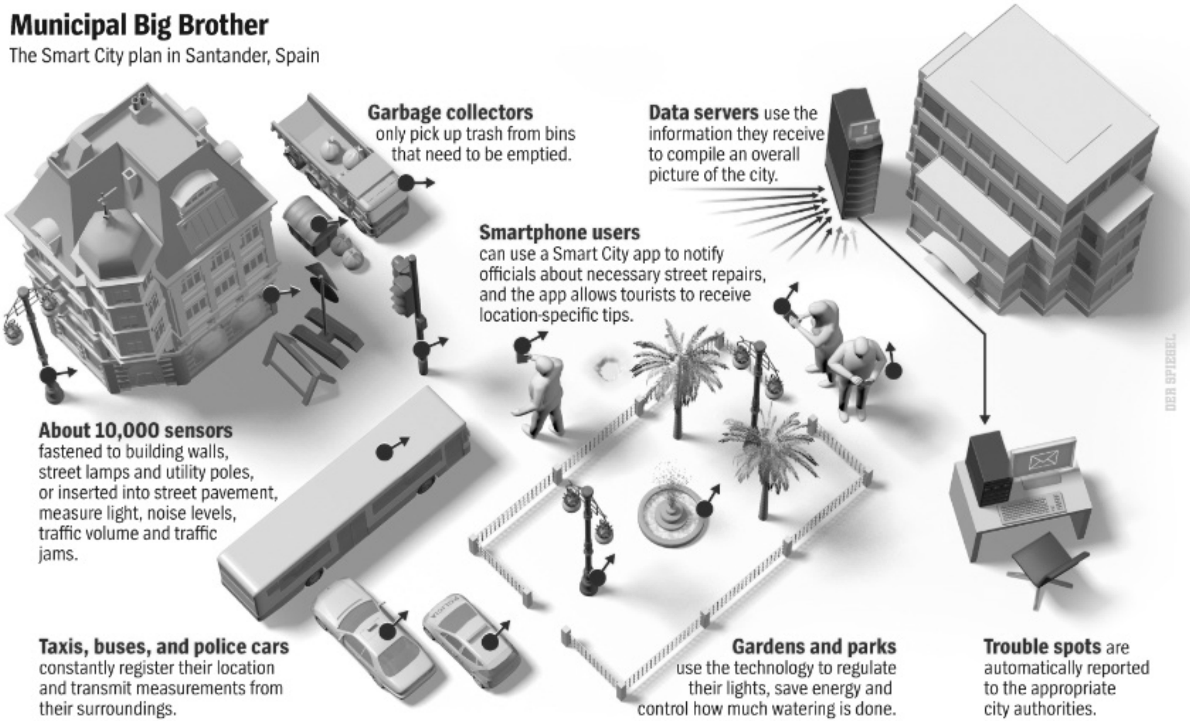

Figure 3: Info graphic of Santander Smart City Case Study (National Geographic 2013)

Since its introduction the project has received constant feedback via social networks such as Twitter as how to enhance the experience and lives of the citizens. As a result, the city of Santander has seen reductions of 25% on electricity bills and 20% on municipal waste – it is also important to note that utility companies foot the bill for life cycle maintenance of sensors due resultant money savings. Such an interactive IoT opens commercial revenues that may not have been possible otherwise; such as a 75 year old shoe shop 'Benito's Shoes' has a 'Smart Santander Sticker' on its window (Frayer 2013). This interactive sticker allows shoppers to instantly access the shops website for online shopping during out of hours – something that has shown real potential and use.

4.2 Los Angeles, United States of America

Similar to Santander the authority of Los Angeles, United States of America have gone into partnership with Xerox Research on a pilot project to implement a range of sensor technology. Bisson (2013) explains how like many cities around the world Los Angeles is experiencing citizens moving out of the city centre to suburbs, which is having direct impacts of the types of transport being used. The authorities have ambitions to attract citizens back to the city centre for leisure however they face an issue with parking (Bisson 2013) – this is where both ‘Smart Technology’ and ‘Smart City’ thinking apply.

There were 7,000 sensors deployed which monitor car space usage; figure 4 illustrates the usage, showing the peak or hot zones (Bisson 2013). Firstly the visualisation of such data is useful for city planners; however by manipulating this Big Data further real application can be developed.

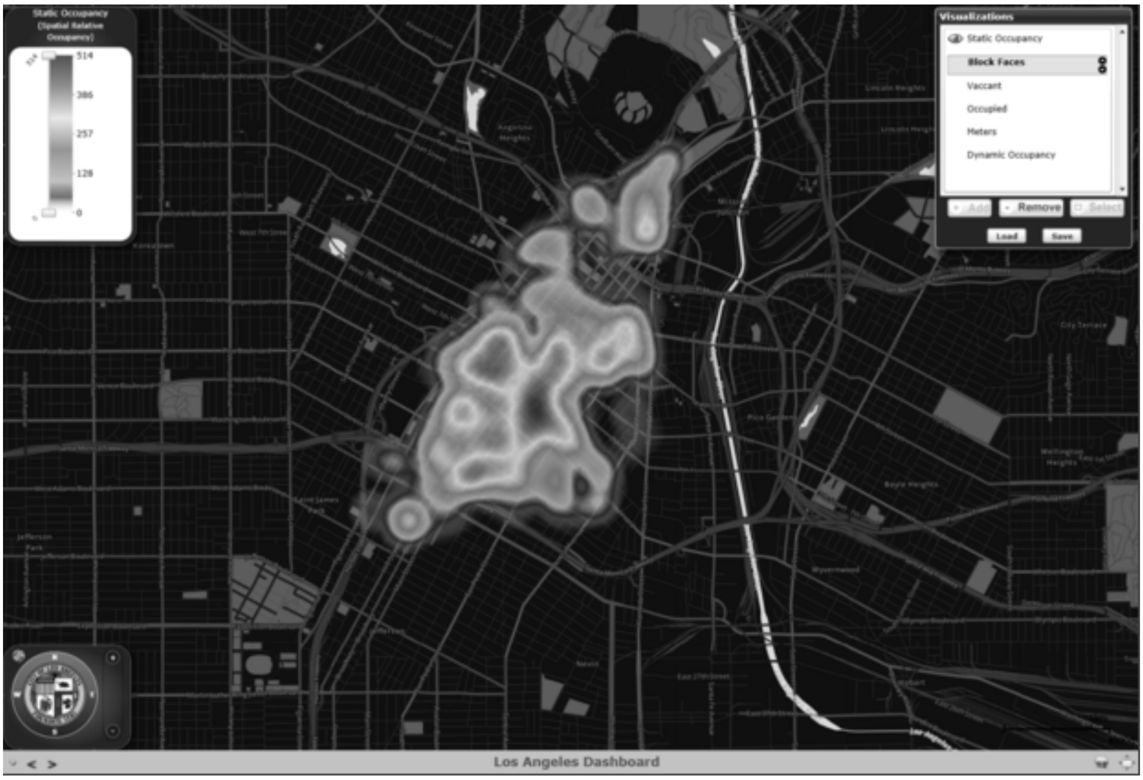

Figure 4: Car Park Usage in Los Angeles, USA (Bisson 2013)

This pilot project has taken this data and attached it to a dynamic pricing model, allowing for the prices of parking to be manipulated depending on availability. For example, to encourage usage into areas of low demand prices will be reduced and to discourage usage in high demand areas prices will be increased. The hope of such a project is to influence the parking behaviours of citizens and also to monitor certain areas of the city that could be further designed to improve quality of life.

The final step of this project is the availability of this information to the public through the use of 'smart phones' and applications; this allows for great interaction and feedback between the user and authority. This pilot project is a prime example of Smart Cities allowing both authorities and users to make better, more informed decisions which result in greater convenience and improved quality of life (Bisson 2013).

5 Future trends and relationships

"What is happening at an urban scale today is similar to what happened two decades ago in Formula One auto racing. Up to that point, success on the circuit was primarily credited to a car's mechanics and the driver's capabilities. But then telemetry technology blossomed. The car was transformed into a computer that was monitored in real time by thousands of sensors, becoming intelligent and better able to respond to the conditions of the race. In a similar way, over the past decade, digital technologies have begun to blanket our cities, forming the backbone of a large, intelligent infrastructure." (Kramer 2013)

The following section will address the future relationship between the construction industry (micro level) and the Big Data (macro level) use of Smart Technology and their collaboration. From the perspective of a construction site manager there is improved capability to make more effective and efficient decisions both on and off site (Cheng & Teizer 2013). Through further integrating on site operations with that of the wider environment through Big Data, site managers can enhance and improve decision making.

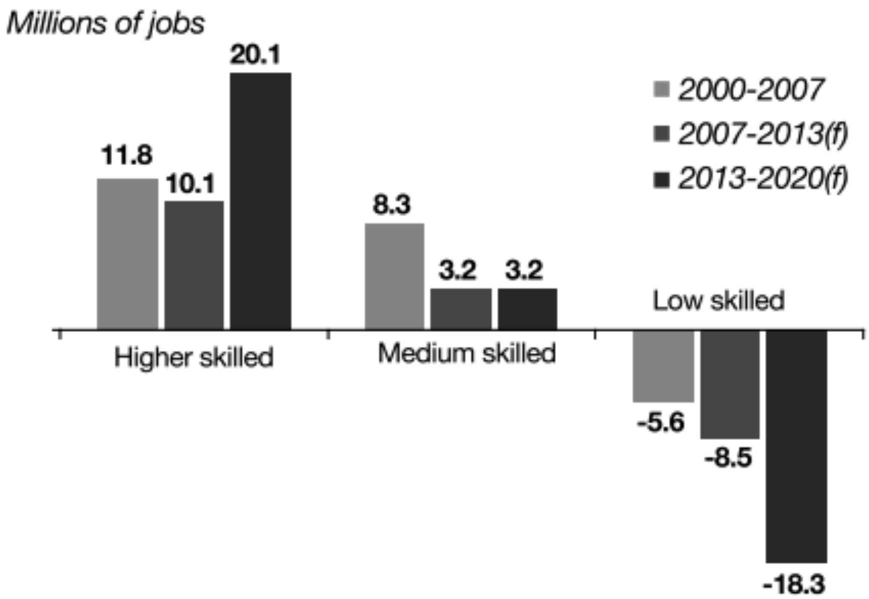

Figure 5: Changes in demand for skills in European Union (Dirks et al. 2010)

Virtual Reality (VR) technology has been used commonly on construction sites to aid project management and the spatial planning of resources (Cheng & Teizer 2013). However one particular relationship that` has not been explored is one between onsite VR and real time data from surrounding infrastructure, for example on site waste management and local waste services. Construction managers would potentially have the capabilities to coherently integrate known wastage from construction of their site into local collection services through collaboration and communication. Aside from the technical advances of ICT and their potential to improve efficiencies and the intelligence of cities, there are important social impacts of such change. Dirks et al. (2010) explained that a consequence of urbanisation would lead to greater competition between cities to attract skilled workers. Figure 5 illustrates how currently in Europe there is a growing demand for higher skilled workers; a driver for further competition (Dirks et al. 2010). Further to this trend it is also important to retain this desired demographic as well simply attract (Dirks et al. 2010; Schaffers et al. 2011). This is achieved through the creation of a sustainable policy structure along with a viable business model in order to attract investment both from the public and private sectors (Schaffers et al. 2011). This demographic change with have a knock on impact to the construction industry within these cities; it is of benefit to construction organisations to be based within cities that have the capability to attract and retain a skilled labour force. Dirks et al. (2010) reported that in order to successfully attract and retain a skilled labour force, city authorities must improve ICT infrastructure, analytics and take a more citizen centric approach to services. However in contrast to attracting a highly skilled labour force, Kramer (2013) highlighted the potential for citizens to feel at risk of privacy invasion; this is a barrier avoided by reassuring anonymity.

6 Conclusion

The above paper has highlighted the range of benefits that Smart Technology can have upon the efficiencies and management of Smart Cities. The range of applications of this emerging trend is not entirely clear yet; however it is clear that the construction industry is well placed to exploit these technologies. Construction managers will have the capabilities to adopt a more coherent and proactive approach to project management allowing for greater efficiencies and performance. It is important that both the construction industry and city authorities look to the future at emerging trends in order to benefit from changing market conditions, a point echoed by Dirks et al. (2010).

A particular challenge for Smart Technology and Smart Cities is the scaling up of projects and the platforms used to handle and analysis Big Data. Therefore it is a suggestion of this paper to further collaborate with current projects to begin planning towards adopting what may become a very diverse market of different software packages.

Under future work it is suggested that further research into current live projects would be beneficial, looking particularly at exactly how Big Data could be used to benefit a construction site manager. First hand exploration of that relationship would provide a good basis for further direction for research within this field. Reports have given theoretical examples of how the construction industry would benefit, however there is little to no actual evidence to support these claims.

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A Systems Approach to Assessing Organisational Viability-An Oil and Gas Project Based Organisation Case Study

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Abstract

Extant literature highlights the increasing inability of Project-Based Organisations (PBOs) to meet infrastructure client's expectations, particularly as it concerns the delivery of socio-economic outcomes during the delivery process. Viability is defined as connoting the ability of PBOs to withstand endogenous and exogenous influences to deliver on the client's objectives. As its central proposition, this study holds that the prevalence of unclear communication channels and adversarial relationships among parties within such PBOs was capable of negatively affecting their degree of internal cohesion; posing strong challenges to their viability. This study forms part of an on-going multi-case study, system-oriented doctoral research however only a single case is reported in this particular study. This qualitative study seeks to assess a particular infrastructure delivery PBO, situated in a developing country, with the aim of identifying where such gaps likely to affect the internal cohesiveness of the PBO, existed. Whereas semi-structured interviews and project documents were used as data collection tools, the collected data was analysed qualitatively with the aid of the Nvivo software. Pre-set themes were used and the data obtained was analysed qualitatively. A systems approach -Viable System Model – (VSM) was used to assess the PBO's viability. According the study's findings, an absence of a prevalent common identity was observed among the various parties to the PBO. Contractors' capabilities to deliver on time and to budget based on their expertise remained pivotal within the PBO thus abandoning the attainment of the Client's pre-defined socio-economic objectives. Cases of faulty and ineffective organisational architecture, functional and communication issues were observed. It was discovered that these observed anomalies impacted upon the internal cohesiveness of the PBO thus rendering it unviable. Based upon these findings, it was recommended that the VSM be adopted at the commencement of the PBO lifecycle and at intervals by project managers and other stakeholders for assessing the levels of organisational viability as is obtained in the use of AGILE in the IT industry.

Keywords: Viability, Viable System Model, PBO, Infrastructure Delivery, Socio-economic benefits

1. Introduction

Project-based organisations within the realm of infrastructure delivery consist of multi-disciplinary, inter-organisational project teams with diverse cultures, and values (Hobday, 2000, Thiry and Deguire, 2007). Projects of such magnitude are increasingly being delivered through collaboration between the public sector and the private sector (PPP) according to Van Marrewijk et al. (2008). This is especially so in developing countries where there is shortage of funds to embark upon such projects(Gidado, 2010b). The involvement of several parties representing the public and private sector within Public Private Partnerships (PPP) has increased the complexity in the delivery process. This has led to unclear communication channels and prevalence of acrimonious and adversarial relationships among parties to such an activity thus posing challenges to the overall governance of such projects(Gidado, 2010a). Previous studies highlight the increasing failure of managers of project-based organisations to meet the expectations of infrastructure project clients (Adetola et al., 2011,Akinyosoye, 2010, Estache and Limi, 2008). This has been blamed on the focus of such organisations on timely and cost effective delivery schedules to the detriment of other important client objectives.

Globally, governments have decided to pay heed to the increasing advocacy for the utilization of the huge expenditure committed to public procurement in driving socio-economic objectives aside the key issues of time, cost and quality(Esteves et al., 2009, Arrowsmith, 2002, Hawkins and Wells, 2006). Accordingly, the Nigerian government has shown increased commitment to the delivery of social value through procurement of infrastructure across several sectors of its economy, particularly the oil and gas industry. This is evident in the plethora of existing public policy documents and legislations such as the Nigerian Oil and Gas Industry Content Development Act, 2010 (MPR, 2010). The government has not hidden its intention to develop local competencies within its oil and gas industry, intending that domestic suppliers will achieve a higher degree of international competitiveness. The oil and gas industry has been adjudged as one of such sectors critical to revamping the Nigerian economy as it accounts for, approximately 86% of the country's total revenue(Iwayemi, 2008, Adewuyi and Oyejide, 2012). To this effect, the government has promulgated laws seeking to develop local content within the industry(Ehondor, 2009). Public Procurement and infrastructure delivery activities have been used in different climes to achieve similar objectives in countries such as the UK, the USA, South Africa and Malaysia (McCrudden, 2004, McCrudden, 2007, Hawkins et al., 2006).

However, Thiry and Deguire (2007) cited extant literature which highlighted that policy implementation, in most cases, never went past the planning stage of such projects, thus signalling the existence of a disconnection between the two stages. Furthermore, they discussed the inability of existing policy models such as the balanced scorecard model and the business excellence model to discover the causes of this disconnection. So the question is- is there really a disconnection and if yes, where does it occur? This remains the mystery which this paper shall seek to unravel; albeit from a project perspective since DeGroff and Cargo (2009) have described the policy implementation process as one which connotes change wherein policies are transformed into projects, programmes, regulations, and legislations with expected deliverables.

PBOs are organisational forms consisting of temporary systems developed solely for the purpose of executing particular projects (Sydow et al. 2004) and include: organisational units; whole organisations; interpersonal and inter-organisational networks; and organisational fields comprising of several parties. Hobday (2000) pointed to the prevalence of PBOs within the construction industry, ship-building industry as well as other major capital projects, stressing its non-suitability for the production of mass products. The structure and business process of a PBO is usually shaped around the certain variables such as the changing profile of projects, such as size, level of complexity, and the duration of such projects. They are confronted by severe dilemmas which affect their governance, constitution and overall performance. These dilemmas as described by (Sydow et al. 2004)include: the prevailing dichotomy between the "*autonomy requirements of the project participants and their embeddedness within organisational and inter-organisational settings that demand integration of project activities within organisation command and control routines and/or inter-organisational coordination efforts"*; and the tension between the "*immediate task and performance demands of the project at hand versus the opportunities for learning and disseminating project practices that can be employed in subsequent projects*" (1476-1477). This implies that it is difficult given the numerous actors within a given PBO to come to terms with making the needed sacrifices towards achieving its overall goal instead of their respective individual goals.

To establish the source of this disconnect, this study adopts a systemic approach to assess the PBO set up to deliver such government policies through infrastructure projects in developing countries. This paper shall commence with a review of the PBO and organisational viability concepts. Subsequent sections would highlight the methodology used in the conduct of the study, findings, discussion and the conclusion.

Given the attributes of the PBO mentioned earlier, it becomes apposite to refer to parties involved in the execution of socio-economic policies through infrastructure delivery processes and the relationships between such parties as constituting a PBO.

2. Organisational Viability and the VSM- A Review

The concept of viability was propounded by Sir Stafford Beer (Beer 1979). Deriving from the law of requisite variety as put forward by Ron Ashby and the Conant-Ashby theorem, see (Schwaninger, 2012), he observed that for a system to remain viable and deliver its purposes whilst maintaining its identity within the ever changing world, it would need to consist of several integral layers all which must be present to make for a viable whole. This led to the eventual development of the Viable Systems Model (VSM) by Beer in the late sixties (Leonard and Beer, 1994). According to Beer (1979), viability remains a common goal-either long term or, in the case of temporary organisations, considerably long enough to accomplish its intended purposes. Hoverstadt and Bowling (2002) describe viability as an essential organisational attribute which "*implies the ability of organisations to become ultra-stable, that is capable of adapting appropriately to their chosen environment, or adapting their environment to suit themselves*".

Having successfully likened the policy implementation execution through infrastructure delivery processes to a PBO, it becomes apt for such a PBO to be assessed from an organisational viability perspective in the search for the causes of the apparent disconnect. This assessment would be carried out using the VSM, a model which currently enjoys very low levels of falsifiability (Schwaninger, 2012). The VSM serves as an appropriate model for such task given the proclivity of PBOs to appear as a variety of loosely coupled organizational and trans-organizational contexts which necessitate the use of only multidimensional and multi-level conceptualisations to capture their inherent complexities (Sydow et al. 2004).

3. Methodology

Abductive reasoning was selected for the study. This strategy differs from deductive and inductive reasoning respectively as it allows the researcher to utilize extant theoretical foundations in his/her bid to understand a particular phenomenon better (Meyer and Lunnay, 2013, Reichertz, 2004, Reichertz, 2010, Blaikie, 2010, Saunders et al., 2012, Bryman, 2012). . In this case, the concept of organisational viability, as embodied by the VSM, was to gain a better understanding of the PBO.

The case study approach was selected as the approach of choice for this type of study given its ability to allow for in-depth investigation of a phenomenon in its natural context (Yin, 2009). Dickinson et al. (2007) identified with the capability of the case study approach to allow for in-depth understanding of policy implementation processes. Dubois and Gadde (2002) in their work, observed that when applied in certain contexts, case studies were confronted with the daunting challenge of handling the interrelatedness of the several elements and factors evident in the research activity. This hindrance has been effectively provided for in this study through the VSM. The multi-layer and recursive nature of the VSM allowed for easy identification of these relationships within case studies.

Figure 1 below shows a diagrammatic illustration of the relationships between the parties to the PBO for project X's delivery. This study is concerned with the relationship between the PBO members shown within the area labelled as 'the infrastructure delivery system' and not the relationship between the PBO and its external environment as shown by the area labelled 'the project's host environment'. The PBO is divided into two sections to highlight the parties involved in either policy formulation (subsystems 5, 4 and 3), policy implementation (subsystems 3, 2 and 1), or a combination of both (subsystems 4, 3, 2 and 1 respectively).

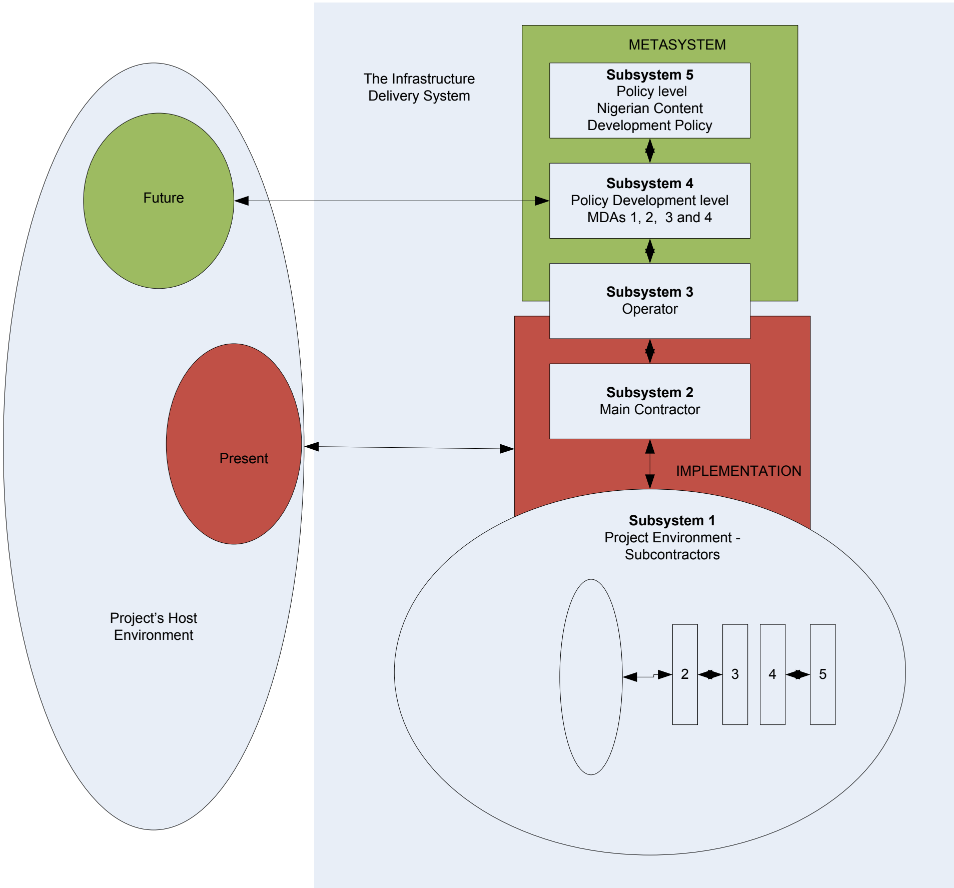

Figure 1 The Viable Systems Model for Project X's PBO.

The MDAs at subsystems 4 represent Ministries, Departments and Agencies saddled with the task of regulating and monitoring policy implementation within the O and G industry. MDA2 is particularly involved with the monitoring of local content development in the sector.

Project X was selected based on the criteria which were relevant to the attainment of the study's central objective. The case comprised of the PBO set up to deliver an Oil and Gas project in a developing country (Nigeria). The O and G project was part of the programme of infrastructure assets through which the government sought to deliver its local content development objectives during their delivery processes. Purposive sampling technique was adopted as only participants to this PBO in policy-making, implementation monitoring, project sponsorship, main contractor, and subcontractor capacities were selected and subsequently interviewed.

Semi-structured interviews and project documents were employed to ensure construct validity (Yin, 2009). These techniques have been known to provide appropriate platforms for the unrestricted expression of personal perspectives and do come highly recommended by several researchers (Denscombe, 2007, Kvale, 2006, Hartley, 2004, Miles and Huberman, 1994). Thirteen face-to-face interviews, each averagely lasting for an hour, were concerned with developing an appreciation of the actual tasks carried out by these organisations within the PBO during the delivery process.

The table below shows the profile of the interviewees.

Table 1 Profile of Interviewees

System	*Organisation*	*Position*	*Code*
4	*MDA 1*	*Programme Officer, Projects*	*A1*
4	*MDA 2*	*Project Evaluation and Monitoring Officer;* *Senior Planning Officer*	*A2;* *A3*
4	*MDA 3*	*Project Monitoring Officer*	*A4*
3	*JV OPERATOR*	*Programme Manager;*	*B1;*
		Project Manager	*B2;*
		Project Officer (Nigerian Content);	*B3*
2	*Main Contractor*	*Project Manager*	*C1;*
		Project Procurement Lead	*C2;*
		Community Relations Officer	*C3*
1	*Sub Contractors*	*Managing Director (1)*	*D1*
		Managing Director (2)	*D2*
		Procurement Engineer (1)	*D3*

The interviewer also sought to establish if there were any challenges encountered by the various parties in the delivery of assigned tasks. These interviews were recorded and transcribed verbatim. Policy documents and project documents were also reviewed to check for any contradictions with the emergent findings from the interviews. These contradictions and observed anomalies were grouped together and categorised according to pre-set themes, namely: structural, functional; and communication-related pathologies.

The concept of using pathologies to reveal results emanating from organisational viability assessments has been severally espoused by Schwaninger and Ríos (2008) and Ríos (2010). After using the VSM to diagnose an organisation, they classified the findings of their diagnosis into three pathologies: structural; functional; and communication-oriented pathologies. These pathologies posed as barriers to the attainment of organisational viability. Ríos (2010) defined these pathologies, stressing that whereas structural pathologies were those pathologies that affect the ability of the organisation to combat the complexity confronting it due to the design of its management and governance structure, functional pathologies were those which resulted from failure of certain subsystems to perform assigned roles, necessary for the attainment of viability, within the system. The pathologies associated with communication channels were described as those which hinder the flow of information within the organisation or system(Ríos (2010).

3.1 Case description

The single case study which was selected for this study is a PBO responsible for the delivery of a gas pipeline within the Niger-Delta geographical region of Nigeria. The project at the centre of the PBO shall be referred to as Project X. Project X involves the laying of a 42" diameter pipeline measuring a distance of approximately 50kilometers (Km). The project transverses twenty (20) major communities situated in four different local government areas of a state in the Niger Delta region of Nigeria. Whereas the client/project sponsor was a JV company, owned by a subsidiary of the Nigerian state and an International Oil Company, the main contractor was a foreign business concern which engaged several local subcontractors. The construction of project X commenced in 2010 and was completed in early 2013.

4. Findings and discussion

Following on from the analysed interviews and documents, certain gaps capable of causing a series of disconnections within the delivery PBO were identified.

Figure 1 below highlights the various pathologies discovered whereas the subsequent sections below discuss some of these pathologies and their effects.

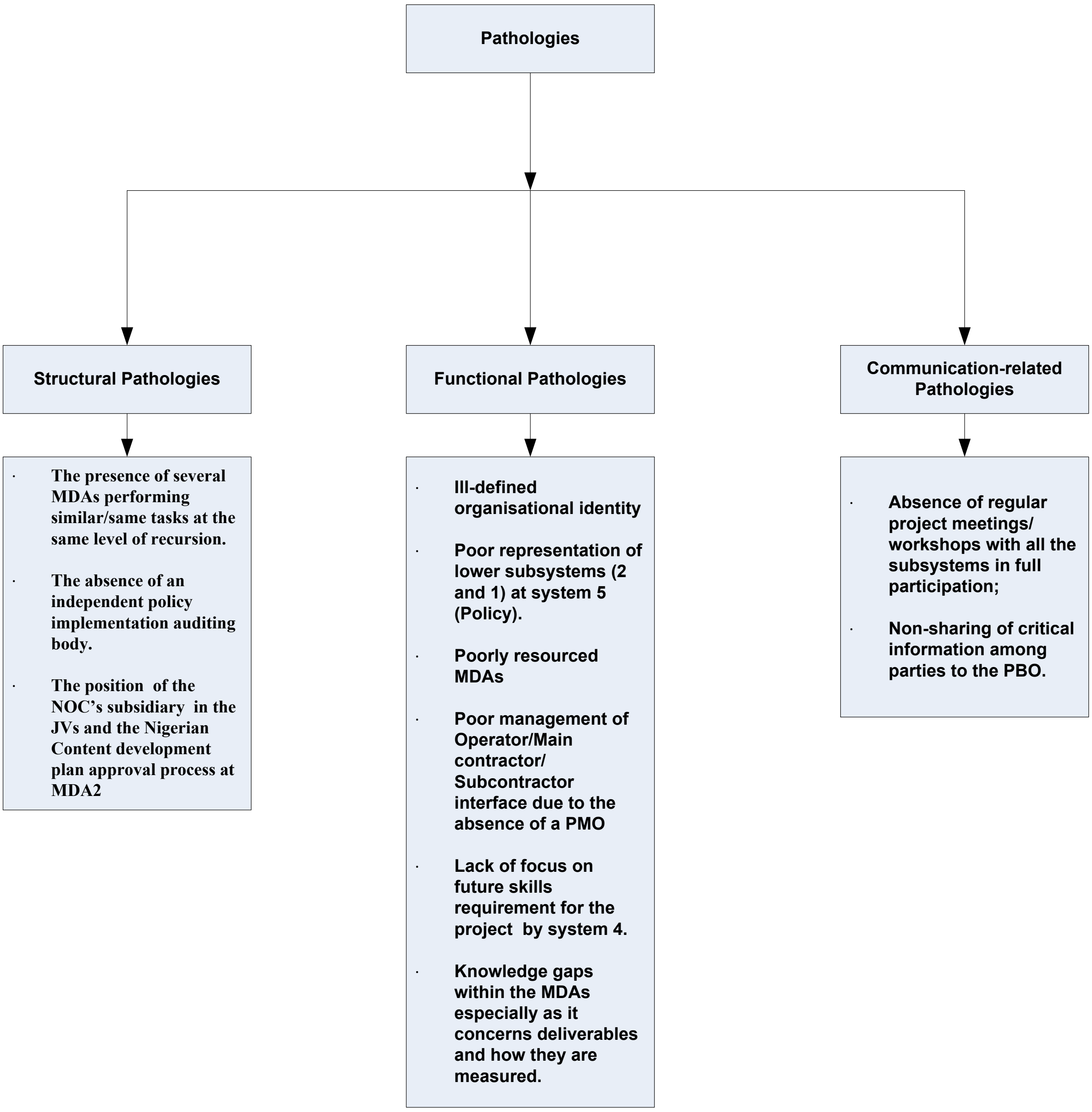

Figure 2 Identified Pathologies

4.1 Structural pathologies

The authors discovered certain factors capable of causing the disconnection between the entire PBO as it concerns the achievement of the client objects. Most prominent among these factors is the presence of several MDAs performing similar/same tasks at the within the same subsystem otherwise referred to as entangled vertical unfolding with various inter-related memberships.

Entangled vertical unfolding with various inter-related memberships: According to Ríos (2010), the presence of many departments within particular level of an organisation could lead to the defeat of the organisational purpose due to the ensuing confusion. Within this PBO, the presence of several government agencies carrying out similar tasks was discovered at subsystem 4. All interviewees situated within subsystems 3, 2, and 1 agreed that this proved a major hindrance to the effective organisation of the project delivery exercise in line with the expected outcomes.

According to B1...

> "*We were taken aback when we were asked to submit our plans for the development of Nigerian and Niger Delta content respectively within Project X in accordance with the dictates of the law to MDA 3 as we had done so two years before the coming on stream of the MDA to MDA 1...This was a major setback especially in financial terms..*"

This apparent confusion was also observed in the area of application for expatriate quotas. The Nigerian Content Development Act (2010) had stated that the minister's consent must be obtained before the increment of expatriate quota by companies involved in the sector.

CI acknowledged this problem when he stated that...

> *"For project X, We stated at the commencement of the project that we did not possess enough in-country capabilities to deliver certain work packages within the project and would have to hire more expatriates. Although the procedure for this was spelt out in the Act, we ended up spending three months in trying to ascertain which MDA, out of the several, was responsible for this as they were all under the Minister"*.

4.2 Functional Pathologies

The following functional pathologies were discovered from the data:

Ill-defined organisational identity: To attain and maintain viability, organisations such as the PBO being understudied should share a common identity (Ríos, 2010). Hence for project X's PBO to be viable, all parties to the PBO in project x should share a common objective as regards what the project deliverables are and accord them similar or equal weightings. Unfortunately, it was discovered that this was not the case from the data. The MDAs, particularly the MDA responsible for the monitoring of content development signified their desire to ensure that appreciable progress was made in the retention of capital expenditure arising from the O and G projects in-country. The statement made by A3 below reveals this determination.

> *"Here, we place so much emphasis on the content development plans of industrial players before allowing them to carry on with any development of infrastructure as that is the core of our mandate as an organisation...a project can be described as having failed if it does not add value to the lives of the host community or national economy and we tend to view proposed projects from that perspective."*

But on the other hand, B1 pointed to other deliverables from project X as being of paramount importance to his organisation...

> *"...project X is a very strategic one for us here at 'operator's company' as it is central to boosting our productivity level. Having this project delivered on time and to budget would enable us meet our production targets for the next five years."*

From B1's statement, it can be discerned that the achievement of the Nigerian content policy objectives during the delivery phase was a secondary objective as timely completion and functionality of the completed asset remained crucial to the client/ project sponsors. According to Tordo et al. (2013), this disparity is to be expected as several production companies do yet not see the attainment of local content objectives as a fundamental part of their respective business cases. These signposts point to prevalence of divergent views on what the central objective (identity) of the PBO should be

Poorly resourced MDAs: There was an evidence of a poorly resourced implementation monitoring MDA. Both main contractors and the operator's PM (B2) complained about the lack of appropriate measurement reporting standards for their Nigerian content development strides within the project. They insisted that the MDA's officials lacked the skills to comprehend properly, the measurement indices contained in the Act.

> *"...there were instances where officials from the government agency (MDA 2) had disapproved of our style of reporting Nigerian content within the project which was according to the index provided in the Act.....it was apparent that the MDA needs to do a lot of work in training their staff to understand how to measure the deliverables associated with the Act within projects.." (B2)*

On the other hand, the interviewee representing the MDA (A2) argued that although they did not possess adequate manpower and resources to monitor all the projects for Nigerian content development, their major concern lay in the absence of a standard framework for measuring the deliverables on projects such as project X.

> *"...whilst the law is clear on the deliverables expected of projects being carried out in the oil and gas industry, via-a-vis the development of Nigerian Content, we have often been confronted with the problems of deciding how to measure these deliverables being reported to us by the Operators as they are the ones whom we hold responsible for any breaches and project X is not an exception...whereas the Operator has reported huge increment in the number of local man-hours used, the massive disparity between the expenses made to cover the wages of the local resource and the one made to hire expatriates and machinery for tasks on the project calls for serious concern".*

This observation corresponded to findings arising from recent research on the implementation of the local content within the O and G industry wherein Tordo et al. (2013) observed that there was a need for proper alignment of the policy objectives with the instruments.

Poor OPERATOR /main contractor/subcontractor interface management: The subcontractors; D1, D2 and D3 respectively accused the main contractor of being unfair in the allocation of certain work packages to them, insisting that the MDA responsible for the monitoring content development was in cahoots with the main contractor and the operator in undermining their capabilities.
D3 maintained that they were neglected in the award of lucrative work packages within the project....

> *"...the more lucrative jobs which would have afforded us the opportunity to provide our local employees with firsthand experience of on very sensitive tasks such as underwater welding and fabrication were outsourced to foreign firms or local firms who have expatriate staff under their*

employ and surprisingly, you know....the Nigerian factor, the MDA officials remained silent when we complained to them".

But B2 and C1 agreed that this was not the case but rather identified the shortage of local skills for the execution of certain tasks as the driving factor such decisions...

> *"...most of these subcontractors don't possess actually the required skilled manpower to do some tasks within the project and don't forget that this is a very critical project where we cannot afford to compromise on standards hence the need to contract tested and trusted subcontractors...in the past, some of these subcontractors have collected contracts for work packages only for them to turn around and sell them to overseas based companies, increasing the delivery costs as it were...we ensured that such lapses were not allowed for in project X." (C1)*

This exchange highlighted the nature of a poorly managed interface between the main contractor and the subcontractor as they all accused each other of engaging in shoddy acts capable of undermining the achievement of PBOs identity. There is need for an effective management of the interface between parties to a project delivery exercise so as to attain organisational viability especially in areas relating to trust, transparency, and accurate communication (White and Marasini, 2014).

4.3 Communication-related pathologies

Effective communication has been described as a very important part of any successful organisation-PBO. As if to buttress the salient nature of communication to organisational viability, Gallagher et al. (1997) described organisations comprising of information processing and disseminating units which rely on effective communication channels. Furthermore, whereas Pinto and Slevin (1987) list effective communication as one of the CSFs for achieving successful project implementation outcomes, Ochieng and Price (2010) observed the importance of effective management of communication within]teams as being pivotal to the attainment of success.

In project X, the lack of an effective communication channel within the PBO was discovered, based on the accusations and counter accusations being levelled by various parties to the PBO.

According to D1...

> *"everything about this industry is always covered in secrecy....we did not know about the Nigerian content development targets set by the MDA 2 for the OPERATOR upon the approval of the OPERATOR'S Nigerian content plan...If we had prior knowledge of that and the areas where they were to take place within the project, we would have gone into partnerships with other local firms with such capabilities to fill up those spaces but…no....they kept same away from us all through the project"*

This absence of a properly defined communication channel for sharing project information between the parties to the PBO was capable of enhancing the gulf between the parties thereby undermining its viability.

5. Conclusion

This study set out to assess the viability of a PBO for a particular O and G project (project X) as it concerns the delivery of socio-economic benefits through the infrastructure delivery process. A PBO case study was selected and assessed for viability with the aid of a VSM. Project participants from the policy level to the project implementation level were interviewed and the policy document on Nigerian Content Act was also reviewed in the course of the study. From the findings gathered from the series of interviews and documents analysed, it was discovered that the project did not possess the requisite viability needed for it to deliver on the expected socio-economic benefit-local content. Its inability to attain viability was traced to various factors categorised as pathologies-structural, functional and communication-related pathology respectively.

Furthermore, this study was able to highlight the successful application of a systems approach-VSM-in the assessment of organisational viability within PBOs.

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Emergence of the Business Models in the Building and Construction Literature

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Abstract

Business models play a key role on successful businesses since they describe how an organisation creates and delivers value for its customers and subsequently captures value. A good business model can separate a company from its rivals by creating a competitive edge. However, there is limited research on business models in the building and construction field. This paper aims to contribute to this limited literature by exploring how the business model concept is understood and conceived by the building and construction literature to shed some light on the concept and its associated benefits, establish a common language, and help position future enquiries. Yet, it becomes vital to cover the literature in the business and management field where business models originated. This approach helps gaining thorough understanding and seeing the big picture of business models. The findings suggest that there is a growing interest in the use of business models concept in the building and construction disciplines but most articles refer to business models without explicit definition which can lead to uncertainty on using the concept. Furthermore, recent studies provide explicit definition of business models and seek to develop an understanding of the concept with reference to the construction context. As suggested by the literature, business models concept can be relevant for sustainability studies since it helps companies converting their abstract environmental strategies into viable business concepts thus creating value for customers and capturing this value. Moreover, concentration on the business model can facilitate better evaluation of current construction companies' business models and assess their future suitability of sustainability aspects and competitiveness. To benefit from business models in the building and construction context, they need to be considered and developed at the level of field of operation with clear explanation on what they mean.

Keywords: Business models, Construction, Competitive advantage, Strategy, and Value creation.

1. Introduction

The term ‘business model’ has steadily gained prevalent popularity since the 1990s. The term is populating the business and management literature and widely used as an effective management tool for designing, analysing, and comparing a company’s value creation logic (Pekuri, Pekuri, & Haapasalo, 2013). In addition, it can help companies to become sustainable and more competitive. Current literature considers a business model as a key for successful business since its main aim is to differentiate a company from others and to give it an advantage over its rivals. The creation of visual representations of business models such as business model canvas developed by (Osterwalder & Pigneur, 2010) has resulted in a better understanding of different business logics and an effective management tool to communicate and convert abstract strategies into viable business concepts. The significance of the business model stems from its systematic character – it is not about details of isolated elements, but how the elements are interrelated and how they strengthen each other to form a well-functioning entire system (Pekuri et al., 2013).

Nevertheless, business models are a less discussed and researched topic in the field of building and construction. Pekuri et al. (2013) highlighted the role of the business model in Finnish construction companies on finding a new competitive edge and argued the importance of finding a common language across the construction field to be able to create value for customers. This paper aims to explore the way the business model concept is conceived and understood in the building and construction literature. It will shed some light on the benefit of the business model concept, establish a common language, and will help position future enquiries. Following this introduction, the reminder of this paper will be structured as follows: in Section 2 we present method adapted followed by literature review of the business model as documented in the business and management literature including origins, its relation to the strategy, and definitions in Section 3. Section 4 reviews the building and construction literature to explore how it understands and deals with business models concept and suggests future directions in the research. Finally, key issues from the literature are grouped together for conclusion in Section 5.

2. Method adapted

Since the aim of this paper is to explore business models concept, a review of the literature across the disciplines of business and management is conducted to gain thorough understanding of the concept and its origin. Main papers and reviews were identified using Google Scholar, EBSCO, and Harvard Business Review databases in addition to the book entitled Managing Green Business Model Transformations. Furthermore, articles include the terms “construction” and “business model” in their title, abstract, keywords, or subjects were collected from the EBSCO database, SCOPUS, and Google Scholar.

3. Emergence of the business models in the business and management literature

The business model concept became well established with the beginning of the Internet in the mid 1990s, and it has been disseminated since then. From that time, ideas revolving around the concept have resounded with scholars and business practitioners as documented by different scholars (Afuah, 2004; Osterwalder, Pigneur, & Tucci, 2005; Shafer, Smith, & Linder, 2005; Timmers, 1998; Zott, Amit, & Massa, 2010). More precisely, the business model is popular among e-business – doing business electronically or Internet-based businesses- boom started in the late 1990s (Amit & Zott, 2001; Osterwalder et al., 2005; Timmers, 1998). In spite of its roots and origins, the concept effectiveness is not limited to dot-coms (Linder & Cantrell, 2001) cited in (Sommer, 2012). Furthermore, the business model concept examines the logic behind economic value creation and guides companies to become sustainable and more competitive (Osterwalder, 2004; Teece, 2010). Nevertheless, the empirical use of the business model concept has been criticised for being ambiguous, superficial, and not grounded in theory (Hedman & Kalling, 2003). Michael Porter stated that *"the business model approach to management becomes an invitation for faulty thinking and self delusion"* cited in (Sommer, 2012). To utilise the business model concept and to reduce the ambiguity around the concept, it becomes necessary to clarify the relationship between business models and strategy. The next section aims to help remedy this situation.

3.1 Business models and strategy: What's the difference?

The business model concept builds upon central ideas in the business strategy and its related theoretical traditions. However, the business model needs to be distinguished from the business strategy (Sommer, 2012). Business strategy plans for the future success of a business in a competitive and dynamic environment (Porter, 2008). In contrast, the business model translates a strategy into a logical framework for economic value creation (Osterwalder, 2004). Teece (2010) argued that the business model is more generic than a business strategy and in order to protect competitive advantage resulting from designing a new business model, the coupling between strategy and business model analysis is essential. Consequently, business strategy and business model are interlinked. Furthermore, Zott et al. (2010) identified two main differentiating factors between a business model and a business strategy. Firstly, strategy is more concerned with competition, whereas a business model is more concerned with value creation, cooperation and partnership. In general, the business strategy of a firm focuses on value capture and competitive advantage, while the business model combines a dual focus on sustainable value creation and value capture. Secondly, the focus of the business model is on the value proposition with emphasis on the customer role, which is less apparent in the business strategy literature and tradition. This view is also echoed in (Seddon & Lewis, 2003) where they stated that the business model is more concerned with the core logic that enables a particular firm to create value for its both customers and stakeholders. They proposed a detailed definition of business model in relation to strategy: *"A business model is an abstract representation of some aspect of a firm's strategy; it outlines the essential details one needs to* *know to understand how a firm can successfully deliver value to its customers."* Moreover, Casadesus-Masanell and Ricart (2010) viewed the business model as a translation of a realised strategy of a particular firm. Therefore, the business model concept is important when translating business strategy into business process. In other words, the business model concept can be viewed as a moderator between business strategy and the operational level of a firm (Sommer, 2012). The business strategy, business model, and operational model determine the competitiveness of a firm (Sommer, 2012). The relationship between them is depicted in Figure 1.

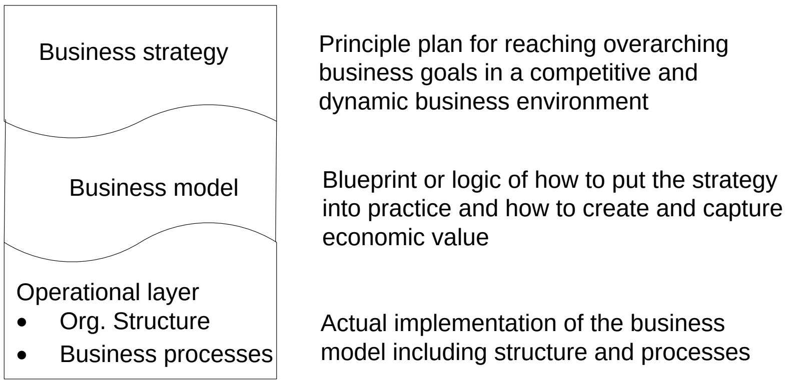

Figure 1: Relationship between business strategy, business model, and the operational layer adapted from (Sommer, 2012)

In short, scholars argue that to unlock the potential of business models, they need to be clearly defined and not to be seen in isolation from strategy (Casadesus-Masanell & Ricart, 2010; Sommer, 2012; Teece, 2010). Detailed definitions of the business model are presented next.

3.2 The business model definitions

As stated above, the business model concept is often used in e-business research and it becomes vital to cover the concept as conceived by e-business literature. From e-business research, two schools of thought can be identified. The first school aims at defining and describing the components of an e-business model. The other school aims at developing descriptions of a particular e-business model (Hedman & Kalling, 2003). It can be argued that these two schools of thoughts are complimenting each other since the first one is concerned with more general classification of e-business model while the second one is concerned with specific e-business models and is looked at in greater detail. With regard to the first school of thought, Timmers (1998) defined an e-business model as: *"An architecture for the products, service and information flows, including a description of the various business activities and their roles."* In the same context, Amit and Zott (2001) described three components of e-business models to create value through utilisation of business opportunities. The components include: content, structure, and governance of transactions. In addition, Afuah and Tucci (2001) offered a list of components containing scope, customer value, connected activities, capabilities, implementation, price, revenue sources, and sustainability and as suggested by Hedman and Kalling (2003) this list is relevant to both e-business and conventional business models. The other school of thought on e-business describes specific business models and explains how businesses can use the Internet to interact with customers and stakeholders and how value is created for them. For example, (Weill & Vitale, 2001) cited in (Hedman & Kalling, 2003) defined eight e-business models based on a systematic analysis of several case studies and they explained how each model works by defining the way it makes money, the core competencies, and the critical factors or capabilities required.

Zott et al. (2010) conducted a comprehensive literature review on business models by searching and critically reviewing articles published in leading academic and practitioner-oriented management journals during the period of January 1975 - December 2009. Their review revealed that scholars do not agree on what a business models is, and that the literature is growing in silos, according to the subject of interest, to the respective researchers. In addition, the review demonstrated that academic research on business models lags considerably behind practitioner-oriented journals such as Harvard Business Review, MIT Sloan Management Review, and California Management Review. Nevertheless, they were able to identify four emerging common themes amongst the business model literature that can be summarised as follows:

1. The business model is a new unit of analysis.
2. Business models emphasise a system-level, holistic approach towards explaining how firms do business.
3. The conceptualisation of business models usually dependent upon organisational activities.
4. Business models seek to explain how value is created and captured.

These four themes can demonstrate the usefulness of the business model concept in understanding businesses and companies' behaviour.

As stated earlier, the business model is relatively a new concept that lacks a consensus definition. However, the majority of business models definitions contain value creation for customers and value capture as one of their core elements (Afuah, 2004; Nielsen & Bukh, 2011; Osterwalder & Pigneur, 2002; Zott et al., 2010). Additionally, Osterwalder (2004) provided a definition based on a synthesis literature on e-business model. According to him the business model is a conceptual tool that consists of a set of elements and their relations, which enables a company to express the logic of earning money. It portrays the value that a company offers to target customers and the architecture of the firm and its partners for creating, marketing and delivering this value, in order to generate sustainable and profitable revenue streams. In summary, *"A business model describes the rationale of how an organisation creates, delivers, and captures value."*(Osterwalder & Pigneur 2010, p.14). Having presented an overall backdrop of emergence of the business models in the business and management disciplines, the following section presents the business models development in the building and construction disciplines.

4. Emergence of the business models in the building and construction literature

The business model research in the building and construction disciplines is as yet in its embryonic stage at this point of time. This proposition is based on two reasons: firstly, previous researchers works such as (Aho, 2013; Pan & Goodier, 2011; Pekuri et al., 2013) who stated that the knowledge and theoretical development of business model in the construction context, seem to be far under-developed. In addition, (Pan & Goodier, 2011) searched for articles from (Jan 1990 – Nov 2010) that include the terms "business model" and "construction" using the EBSCO and the informaworld databases. Although some of the searched articles provide an implicit description of the business model based on the context of study, none of these provide an explicit definition of the business model. Thus the concept of business models seems to have been borrowed from business and management fields to building and construction fields by default. However, the above scholars argued that the borrowed concept in the building and construction research appears to lag behind the theory development in the business and management research. Secondly, search for articles (from 1990 to 2013) that include the terms "construction" and "business model" in their title, abstract, keywords, or subjects using the EBSCO database, SCOPUS, and Google Scholar. A sample of 18 articles, that are deemed relevant for this review, are presented in this section. Appendix 1 summarises the searched articles and shows the publication outlet and any description of business models provided.

The vast majority of articles reviewed refer to business models without explicit definition. In general, business models are associated with the following words: progress, uptake, transformations, change, new, future, improve, opportunities, seize, and rethink. For example, (Sweetser, 2012) referred to the business model in seeking solutions for retrofits building and he suggested that guaranteed savings performance contracts business models can support the uptake of energy savings. In addition, (Wong, Thomas Ng, & Chan, 2010) approached business models as a means towards managing transformation and changing the business environment of the construction industry to support the sustainable development. They have also recommended alliance business model between SMEs and large companies to seize business opportunities. Furthermore, (Tykkä et al., 2010) referred to close interaction of clients to production processes, at timber farmed firms in the construction sector, as a new business model. Similarly, (Ekholm & Molnár, 2009) referred to strategic partnering as a new business model to encourage cooperation and communication in product development. Terms such as competitiveness and competitive advantage are populating the literature of business models in building and construction research. Typical statements reported include (Li, Li, Skitmore, Wong, & Cheng, 2009) who studied the real estate firms in China in which the business model is understood as a form of competitive advantage and they recommended that developers need to create a new form of competitive advantage and rethink their business model to survive in the market. In addition, an earlier study by (Seaden, Guolla, Doutriaux, & Nash, 2003) of strategic decisions and innovation in construction, in which they referred to the business model in developing their conceptual model of innovation analysis but their reference was merely based on the competitive advantage theory, which has been criticised for its ambiguity (Green et al. 2009) cited in (Pan & Goodier, 2011), unlike the first example of real estate firms in

China. More recent studies have presented a clearer definition of the business model which has originated from business and management fields, such studies include (Aho, 2013; Mokhlesian & Holmén, 2012; Pan & Goodier, 2011; Pekuri et al., 2013). A common definition of the business model was noticeable in these studies: value creation and value capture. For example, (Aho, 2013) stated *"The business model defines the architecture, principles, logic and capabilities that an enterprise applies for creating, delivering and capturing value"* (p.113). In a related vein, (Pekuri et al., 2013) defined it as *"A good business model defines the way a company operates, how it creates value for its customers and how it captures value from its operations to make a profit"* (p.13).

Even though there are limited articles that deal with the business model in the building and construction context, the trends of research can be drawn from them. These trends can be summarised as follows: Firstly, early papers of business models started with e-business, e-commerce, and ICT movements in the construction context, for more details refer to (Anumba & Ruikar, 2002; Cheng, Li, Love, & Irani, 2001; Duyshart, Walker, Mohamed, & Hampson, 2003). Secondly, some studies associated business models with competitive advantage but without clear definition of business models, for more details see (Li et al., 2009; Seaden et al., 2003). Thirdly, studies that referred to business models in different topics but without explicit definition of a business model which account for the vast trend, examples can be found in (Boddy, Rezgui, Cooper, & Wetherill, 2007; Brady, Davies, & Gann, 2005; Li, Guo, Skibniewski, & Skitmore, 2008; Wasiluk, 2013). Finally, recent studies present explicit definition of business models and deal with business models as a main theme of the study and seek to develop an understanding of the concept with respect to the construction context examples include (Aho, 2013; Mokhlesian & Holmén, 2012; Pan & Goodier, 2011; Pekuri et al., 2013).

4.1 How to pave the way for business models?

The existing literature reflects the growing appreciation of the business model in the building and construction disciplines. Such a growing appreciation is quite evident in sustainability studies. For example, (Mokhlesian & Holmén, 2012) analysed green construction from a business model perspective. They have argued that such a perspective facilitates better understanding of green construction processes and helps to separate green construction from "greenwashing". Their approach was particularly useful in explaining how and why construction firms can be successful, in terms of creating and capturing value when engaging in green construction. In a related vein, (Aho, 2013) suggested that the future of sustainable construction research, is on industry structure and business model transformation and he argued that the current research omitted these niche areas. Therefore, the business model concept can explain sustainability in terms of creating value and how value is defined (Abuzeinab & Arif, 2013). In addition, the business model can help companies to transform their abstract environmental strategies into viable business concepts. Furthermore, concentration on the business model can help better evaluation of current construction companies' business models and assess their future suitability regarding sustainability aspects and competitiveness.

However, it is vital for studies on this field to define business models explicitly to reduce the ambiguity around the concept.

The business model is often designed and implemented at the level of a firm or a business unit in other industries such as e-business and manufacturing (Hedman & Kalling, 2003). However, this seems difficult to replicate in the construction industry because the construction business is heterogeneous in nature. For example, the same company may involve in residential, commercial, or infrastructure projects and it may provide services or products to a customer or a business. Therefore, as suggested by (Pekuri et al., 2013) *"that business models in the construction industry should be studied and developed at the level of field of operation"(p.21)*. According to them, this approach will help understanding value creation in different construction projects and developing business models that will better meet the needs of specific target group or customers segments therefore increasing customer satisfaction while also providing a competitive advantage for construction companies.

5. Conclusion

This paper focused on reviewing the literature of the business models. The main aim was to understand the concept from the building and construction perspective and establish a common language to facilitate better understanding and utilising of business models in the construction context. The review revealed that the concept seems to have been borrowed from business and management fields to building and construction fields by default. In addition, the research efforts are still limited yet growing which justify the need for this paper. The rational of this research focusing on business models was the dual focus of business models on value creation and value capture with emphasis on the customer role. This particularly relevant to the construction industry for its customer/client driven nature thus business models can help better understanding of customers needs and increase their satisfaction. Moreover, the review suggested that business models concept can be useful on sustainability studies because it helps companies transform their abstract environmental strategies into viable business concepts therefore creating value for customers and capturing this value into forms of profit and credibility. To unlock business models potentials in the building and construction context, they need to be studied and developed at the level of field of operation with clear definition on what they mean.

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Appendix1: Construction and business model literature

Author/Year	Explicit description of business models	Implicit description of business models	Publication outlet
Aho (2013)	"The business model defines the architecture, principles, logic and capabilities that an enterprise applies for creating, delivering and capturing value" (p.113)		Building Research & Information
Pekuri et al. (2013)	"A good business model defines the way a company operates, how it creates value for its customers and how it captures value from its operations to make a profit" (p.13)		Australasian Journal of Construction Economics and Building
Wasiluk (2013)		"The CS [Corporate Sustainability] literature also highlights that firms need to manage their financial and non financial resources, including their IC [Intellectual Capital], in order to response to the challenges of operationalising SD [Sustainable Development] into practice. For example, several frameworks document the phases a company progresses through as they operationalise SD into their business model" (p.103,104)	Journal of Intellectual Capital
Sweetser (2012)		"A well-understood business model that could improve the uptake of energy savings retrofits is that of guaranteed savings performance contracts. Essentially removing the capital risk through a performance contract eliminates an owner's capital requirement for a long term contract based on energy savings" (p.348)	ASHRAE Transactions
Mokhlesian and Holmén (2012)	"To put it simply, a business model is articulating the logic and providing data and other evidence that show how a business creates and delivers value to customers by the architecture of revenues, costs, and profits associated with the business enterprise delivering that value" (p.762)		Construction Management and Economics
Pan and Goodier (2011)	"The business model in offsite construction research is also a unit of analysis in addition to the product, firm, industry, or network levels. Such an approach emphasize a systematic perspective on taking up offsite in housebuilding businesses; encompasses organisational activities; and seeks to explain both value creation and value capture in the process of housing delivery"		Journal of Architectural Engineering

Wong et al. (2010)		"Timely diversification and appropriate adjustments in business model are crucial to manage transformations and changing business environment of the construction industry" (p.261) "This alliancing business model could also be adopted by SMEs to alliance with large companies to seize business opportunities elsewhere" (p.262)	Habitat International
Tykkä et al. (2010)		"A similar development is apparent in the Swedish, Estonian, and Norwegian cases where incumbent construction actors were restricted by their traditional behaviours, which opened opportunities for new business models including close interaction of clients to production processes" (p.204)	Forest Policy and Economics
Li et al. (2009)		"Developers need to rethink their business model and create a new form of competitive advantage in order to survive" (p.567)	Construction Management and Economics
Ekholm and Molnár (2009)		"New business models, such as strategic partnering will stimulate communication and cooperation in product development" (p.439)	Journal of Information Technology in Construction Special Issue
Hong-guang, Yun-he, Chen-yang, and Qiang (2009)	"Business models mainly relate to basic profit business ways, objects and contents of service..." (p.3014)		Information Science and Engineering 1st International Conference
Li et al. (2008)		"Through the use of virtual prototyping (VP) technology, the lean production process engaged in the IKEA business model (IKEA model) is studied and implemented in a real-life construction project" (p.991)	Construction Management and Economics
Boddy et al. (2007)		"We have also envisioned a business model that allows the small to medium enterprise, typical of the construction sector, to participate in what would otherwise be the preserve of the largest, wealthiest and most technologically advanced organisations in the industry" (p.677)	Advances in Engineering Software
Brady et al. (2005)		"It has recently been suggested that the future of the construction industry lies in adopting a new business model based on the concept of integrated solutions" (p.571)	Building Research & Information

		"In summary, the key features in moving towards an integrated solutions business model are developing new approaches to creating a customer value, building new capabilities – especially in systems integration – and harnessing learning to allow the firm to exploit economies of project repetition" (p. 574)	
Seaden et al. (2003)		"do typical Canadian construction firms behave according to the current competitive advantage business model?" (p.604)	Construction Management and Economics
Duyshart et al. (2003)		"concentrates on the business model content and objectives, briefly indicates the evaluation framework that was used to evaluate ICT effectiveness" (p.179)	Construction and Architectural Management
Anumba and Ruikar (2002)		"Electronic commerce business models are reviewed and the enablers and barriers to their uptake in the construction sector presented" (p.265)	Automation in Construction
Cheng et al. (2001)		"It is proffered that the proposed e-business model not only will benefit those organisations who operate in the construction supply chain, but may also be useful to other types of business-to-business e-commerce when cooperation between business partners is necessary to improve organisational performance and gain a competitive advantage" (p.69)	Logistics Information Management

Investigation of Relationship between Results of Work Sampling and Productivity Measurement

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Abstract

The use of lean tools and related concepts in the Indian construction industry is presently at a nascent stage, but is gradually gaining importance. Currently, productivity measurement system is the only predominantly used tool to monitor performance at micro level across large construction projects in India. However, without any established nationwide benchmark on productivity, it is difficult to assess and evaluate the performance using productivity rates alone. In such an environment, work sampling serves as a very effective tool to measure and monitor the performance of construction projects at micro level, along with productivity measurement. One of the key aspects of work sampling is its ability to provide timely information to the management about workforce efficiency. However, it is crucial to understand the relationship between the results obtained from both the techniques, before they are used to monitor project progress in complementary roles. In line with lean philosophy, work sampling is broadly classified into direct, supporting and idle category. This paper explores the relationship between various categories of work sampling and productivity rates. Earlier research studies in this field show wide variation, as some conclude that work sampling is a good predictor of productivity whereas others found no substantial correlation between them. Crew based work sampling and productivity measurements are conducted on shuttering gangs working on high rise building construction projects. Subsequently regression analyses on collected data, reveal that idle category component has a strong correlation with productivity rates whereas direct or supporting categories show no significant correlation. These results are discussed in the context of this study as well as broader applicability.

Keywords: Productivity, Work Sampling, Construction Management, Lean Construction

1. Introduction

Delay in completion of infrastructure projects in India, including commercial and residential apartments, is a common complaint. According to the 12th Five Year Plan, India is going to invest heavily in infrastructure projects and if proper management systems are not put in place, the losses are going to be immense. About 50% of the ongoing projects are experiencing time overrun and about 32.5% are experiencing cost overruns (MOSPI-GOI 2009). Waste of resources and low productivity rates, are the major sources of the cost and time overrun.

In an effort to avoid this, most construction companies have started adopting the lean construction concept. Lean construction is a radical shift from traditional construction. It is an adaption of lean manufacturing principles to the construction realm (Koskela 1992). Lean principles primarily focus on maximizing the value by reducing or eliminating wastes at every stage of a project life cycle.

There are several lean tools, which have been successfully adopted in construction projects. The ease of adoption is not the same for all tools. This is because of the varying prerequisites in terms of knowledge and supervision, each tool requires for successful adoption. It has always been a challenge, to implement new systems in any given environment and Indian construction industry is no exception.

Success of a project largely depends on, how well it is monitored and controlled at micro level. In India, large construction companies widely use productivity measurement system, for micro level monitoring and control. Inspite of its wide usage, there is no common consensus on methods and procedures for measuring productivity. With no established nationwide benchmark on productivity, it is difficult to compare and improve the performance based solely on productivity values.

In this context, simple tool like work sampling, can be very useful. Not only is it easy to adopt, but also time and cost effective, as it is an observation based tool. Work sampling primarily measures the time utilization by a work force. One of the most prominent benefits of using work sampling is its ability to provide timely information to the management about effectiveness of workforce. There are instances, where monitoring performances using conventional productivity measurement is ineffective, due to its time consuming nature. Liou & Borcherding (1986) also suggested that, work sampling is useful in irregularly occurring activities, which is commonly seen in all construction projects. Thus, implementing work sampling and productivity measurement in complementary roles, would result in a more informed project teams, which eventually leads to a better management. However, it is critical to understand the relationship between the results obtained from both techniques, before they are applied to evaluate the performance of construction projects in complementary roles. This paper primarily reports the work done to:

- Investigate relationship between values obtained for different categories of work sampling and productivity rates.

It is essential to note that, productivity in Indian construction industry, is usually defined in line with theoretical definition of output by input i.e. units produced per man-hour or man-day.

This research study is conducted primarily on high-rise residential building projects. Crew based sampling and productivity measurement are carried out on the shuttering crews working on the high-rise buildings. Crew based sampling is broadly classified into direct, supporting and idle categories, in line with lean philosophy. Regression analyses are carried out on the data collected from various sites, to evaluate the relationship between the three categories of work sampling and productivity rates.

2. Literature review

There have been many research studies, in the field of finding the relationship between productivity rates and results of work sampling. Thomas et al. (1984), on the basis of a 10 week crew based sampling study found that, the correlation coefficient between direct work portion of work sampling and ratio of earned to actual man-hours would increase, if the definition of direct work was restricted. The relationship between work sampling values and productivity measurement were investigated, with an objective of using work sampling as a surrogate productivity measure. The research concluded that work sampling could be used as a reliable estimator of construction productivity, provided the definition of direct work was narrowly defined.

Liou & Borcherding (1986) using 45 work sampling data points, collected from 11 nuclear power projects and 4 fossil fuel power projects, supported the existence of relationship between work sampling and productivity rates by statistical analysis. The study established that, work sampling was a good labour productivity indicator and also a valuable predictor in productivity projection model.

Thomas (1991) reinvestigates the relationship between, direct work category of work sampling and labour productivity rates, as reported in earlier research studies. Seven data bases, collected from nuclear power construction projects were used in the study. Using linear regression, the study proved that direct work category of work sampling was not related to the productivity rates. This research concluded that, work sampling studies only indicates the ‘busyness’ of crafts and it cannot be used to forecast productivity or to measure unproductive work hours.

Forsberg & Saukkoriipi (2007) compared and discussed the terms ‘waste’ and ‘productivity’ in relation to lean construction. The study shows, although the term waste has a closer relation to lean thinking as compared to productivity, but both were essential in improving construction efficiency. Efficiency is defined here as, reducing production cost by either increasing productivity or reducing waste. This study concludes that, measurement of productivity and waste can complement each other by providing more information about present situation, which aids in future improvements.

Josephson & Bjorkman (2013) using the case of plumbing works in Scandinavia, asserts that work sampling is of insignificant value for measuring productivity and comparing performances over time. The prime reasons for not using it in evaluating performance over time can be attributed to the change in working condition and situations. Inspite of the afore mentioned drawbacks of work sampling, the authors experiences convey that, the findings of work sampling studies are relevant in stimulating discussions among the workers and the managers on improvement opportunities.

Most of these research studies focused on relationship between direct work category of work sampling and productivity rates. The outcomes from research also show a wide variation, as some find very strong correlation to exist between direct work values and productivity rates, while others find no correlation at all. One of the key objectives of these research works were to either use work sampling as a surrogate productivity measure or to use them as a predictor of productivity rates using equations.

3. Work sampling background

The central idea lean philosophy is to maximize customer value, by eliminating waste and through continuous improvement. Waste can be defined as anything that does not add value to the customer. In this research study, we are primarily using work sampling as a lean tool to identify the wastes. In line with the objective of the study, if idle category of work sampling has a strong correlation with productivity rates, then the waste identified by idle category of work sampling when reduced, should increase productivity. Since work sampling and productivity measurement are continuous processes, this would result in continuous improvement of productivity, which is in line with the lean ideology.

In the Indian context, we are essentially trying to implement work sampling not as a surrogate, but as a complementary to the existing productivity measurement system. The key idea in doing so is to overcome, some of the short comings of using, either one of them. Work sampling is not only effective in providing timely information, but also highlights the major causes for non-value adding works. Work sampling is faster and easier to perform in comparison to productivity study which requires a lot of effort in quantifying both, work output as well as work input.

Work sampling can be either tour based or crew based. In this study, we are carrying out the investigation using crew based work sampling. In line with the lean philosophy, crew based work sampling values are categorized into direct work or value added work, supporting work or non-value added but necessary work and idle or non-value added work. Generally, it is easier to classify an activity, into idle category, as for other two categories they are largely dependent on perception of the observer. As lean philosophy believes in doing things right at very first time, hence rework is considered non value added.

It would be interesting to see how each of the three broad categories of work sampling correlates with productivity rates. Sampling results have dependence on how strictly the categories are defined (Thomas et al. 1984) and also whether it is conducted on a micro or macro scale. In this research, we also intent to see the variation in relationship between work sampling values and productivity rates as the scope of investigation is increased from micro to macro level.

4. Research methodology

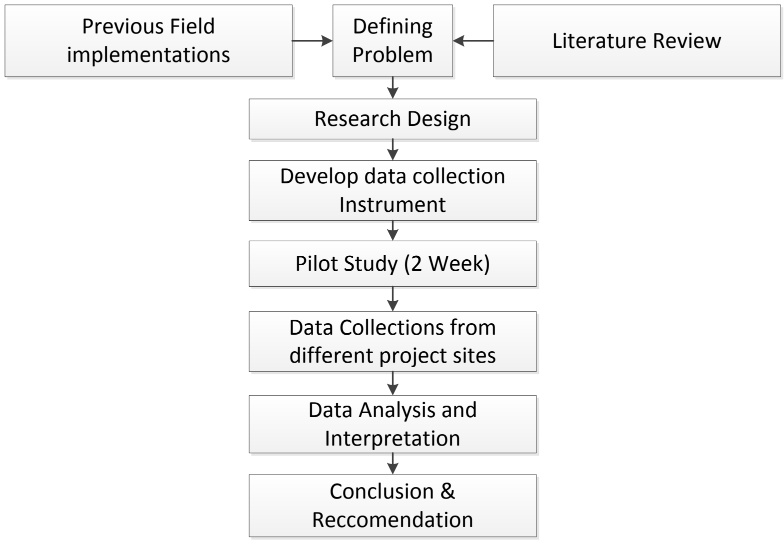

Figure 1: Flowchart of research design

The research framework used in this study is shown in Figure 1. Data collection instrument includes direct observation datasheet. This datasheet has been refined during the pilot study.

4.1. Data collection methodology

In order to investigate the relationship between various categories of work sampling and productivity rates, data are collected form construction sites using the direct observation sheet. Crew based work sampling is conducted on shuttering (carpentry) gang working on aluminium system formwork. The reasons for focussing on shuttering crews are as follows:

- It is easy to quantify the output for calculating productivity, as shuttering panels are of standardized sizes.
- In this type of formwork system entire shuttering crew are present within the same floor area, unlike other trades of work, where some portions of work are executed in different locations.

The crew based work sampling values and corresponding productivity rates are collected, starting from a micro level (narrow definition of crew based work sampling) and then gradually scaled up to macro level (typical definition of crew based work sampling). This has been explained by the illustration shown in Figure 2.

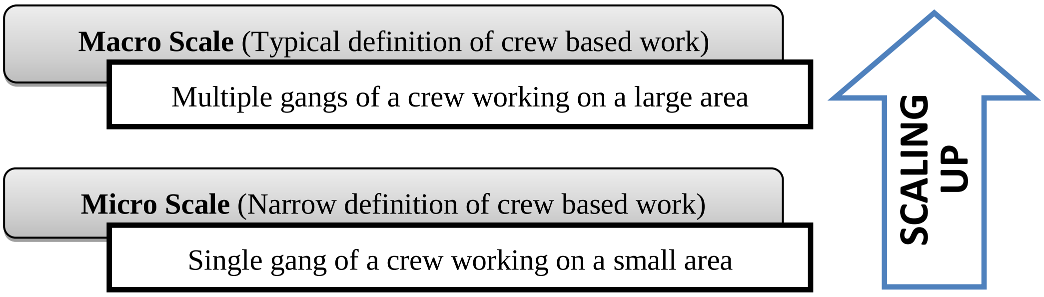

Figure 2: Illustration showing the micro and macro scale for data collection

Based on the requirement, an observation datasheet has been developed as shown in Figure 3. This sheet captures the work sampling values and also the corresponding productivity rates, by noting down the time and panel details the crew worked on. The number of observations required to be taken for conducting the work sampling, is calculated by using the following statistical formula:

$$\sigma p = k\sqrt{\frac{pq}{n}}$$

Where, σp is the standard error of proportion; n is the number of observations or sample size

k is the factor value dependent on the confidence level desired (k=1 for 68% confidence level);

p is the percentage occurrence of a given activity; q is 1-p

Even nomogram method can be used to find the number of observations required at a given confidence and accuracy level. This is a much quicker and easier way to calculate the sample size. The observations for work sampling are made randomly. As the number of observations increases, the confidence level also increases. The minimum number of data points aimed for collection, is based on attaining a confidence level of 90% with a standard error of ±10%.

Direct Observation Sheet								
Date :	Location & Condition:				WS Type:		Ref No.	
TIME	Start Time	Stop Time	Start Time	Stop Time	Start Time	Stop Time	Start Time	Stop Time
Trade/Craft								
Head Count								
Work Details (No. & Size of panels)								
Direct Work								
Material Handling / Supporting Work								
Preparatory Work								
Instruction/Safety								
Waiting / Idle								
Travel								
Personal/ Breaks/ Others								
COMMENTS								

Figure 3: Direct observation sheet for collecting work sampling and productivity values

The productivity rates are calculated in either square meter per man-minute or square meter per man-hour, using the theoretical definition of output by input, which is predominantly used in Indian construction industry. When the observations are made at a micro level, the shuttering work can be further classified into sub categories as shown in Table 1. This sub classification is based on the fact that, at micro level they all require different amount of effort, due to different levels of intricacies involved. Two among these sub categories, shuttering of wall and slab panels are shown in figure 4.

Table 1: Sub categories of shuttering work (using Aluminium Formwork system) at micro level

Shuttering of slab panels	*Shuttering of wall panels*	*Shuttering of beam panels*	*Shuttering of end joints*
De-shuttering of slab panels	*De-shuttering of wall panels*	*De-shuttering of beam panels*	*De-shuttering of end joints*

To accurately assess the relationship between work sampling values and productivity rates, it is very essential to classify the different activities involved in shuttering work into the right work sampling categories. In general, there are always some differences that can be found, in the way how different individuals categorize a given activity. Hence it is important to fix the categories in which the major activities are to be classified, upfront to avoid errors and confusion. The major activity classifications for shuttering works, used in the study are shown in Table 2. In this study, the work sampling data are collected by a single observer to avoid any error due to individual's own judgement.

Table 2: Work sampling categories for major activities of shuttering work

Category	*Activity*
Direct Work or Value added work (VA)	*Placing of shuttering panels*
	Aligning of panels
	Fixing of pin and wedge
	Application of shuttering oil
Supporting or Non-value added but necessary work (NVAN)	*Holding the panel in position while pins are fixed*
	Shifting of panels
	Receiving instruction from supervisor
	Assisting in fixing of pin and wedge
Idle Work or Non-value added work (NVA)	*Waiting for material (like pins wedges etc.)*
	Waiting for Instruction
	Personal breaks
	Travel empty hand
	Rework

Figure 4: Photograph showing slab panel (Left) & wall panel (Right) shuttering works

After sufficient data collection, which is based on the level of confidence and accuracy targeted, regression analysis (Livingstone 2009) is carried out. Subsequently, Pearson product-moment correlation coefficient (r) is determined, which gives the measure of linear correlation. This coefficient varies between ±1. When the correlation is very strong, the absolute value of the coefficient would be close to one and when there is no correlation, the value would be close to zero.

5. Pilot study findings

The two weeks pilot study was conducted on a high rise residential project located in Chennai, India. The project scope comprises of 20 numbers of 17 storied towers, spread over an area of 25 acres. One of the on-going towers was chosen for the purpose of the study. The shuttering crew consisted of nearly 50 workmen, working on different areas of ongoing floor. In the pilot study, data collection was done only at micro level (refer figure 2), that is, single gang working on a small area. Out of the eight sub categories of shuttering works described in Table 1, the pilot study collected sizeable data for only two of the categories; which are slab panel and wall panel shuttering works. A comparative work sampling results, between slab and wall panel shuttering has been shown in the Figure 5.

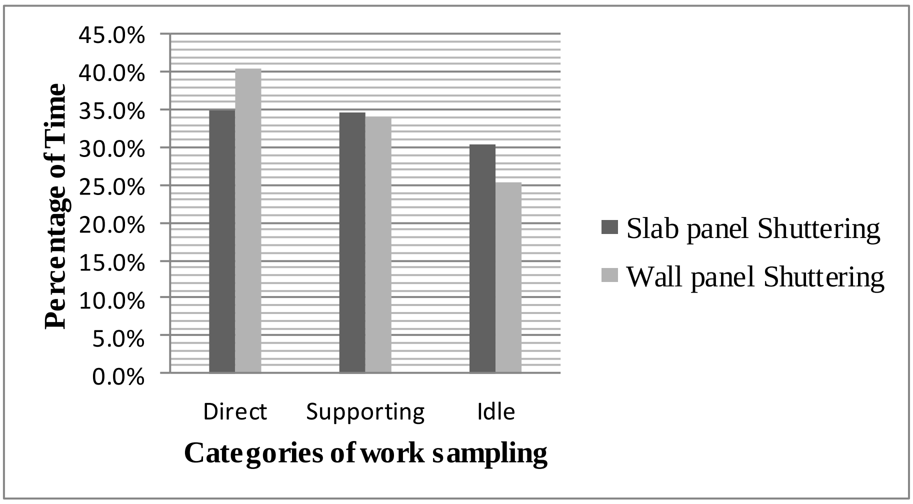

Figure 5: Comparative work sampling results between slab panel and wall panel shuttering

The work sampling was conducted with a minimum confidence level of 75% and an accuracy of ±10%. In both the categories of shuttering work, the supporting work has a considerable portion. This can be attributed to the fact, that usually the skilled workers are accompanied by a helper, which is a common practice in Indian projects. The average productivity computed for both the sub categories of shuttering works and the corresponding standard deviation and variance are listed in the Table 3. The huge variations in productivity values especially for wall panel works can be attributed to the fact that, wall panels used have higher variation in their panel sizes as compared to slab panels. The gang sizes remain more or less constant despite the change in panel sizes, thus having varying productivity rates.

Table 3: Comparative productivity rates between Slab panel and Wall panel shuttering

Sub Category of Shuttering works	*Average Productivity (Square-meter/Man-Min)*	*Standard Deviation*	*Variance*
Slab panel shuttering	*0.071*	*0.031*	*0.001*
Wall panel shuttering	*0.206*	*0.082*	*0.007*

The scatter plots with linear regression lines, between productivity rates against direct work category of work sampling and productivity rates against idle category of work sampling are shown graphically in the Figure 6 and Figure 7 respectively. Both the plots are for wall panel shuttering works.

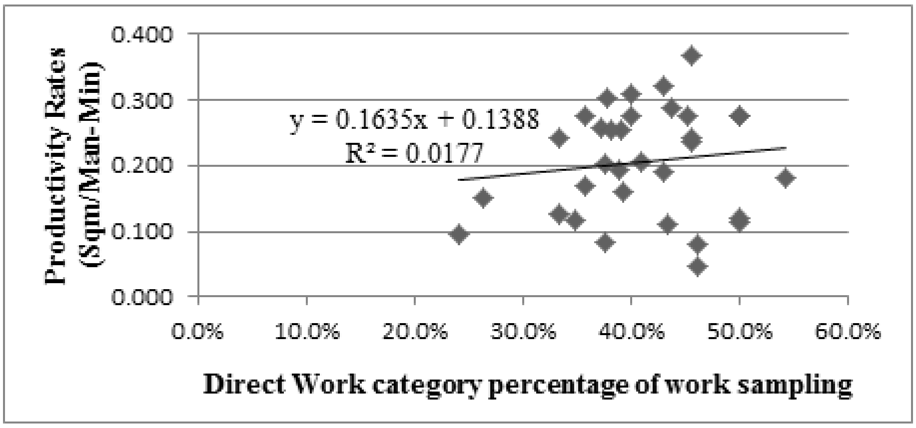

Figure 6: Plot between productivity rates and direct work category of work sampling for wall panel shuttering

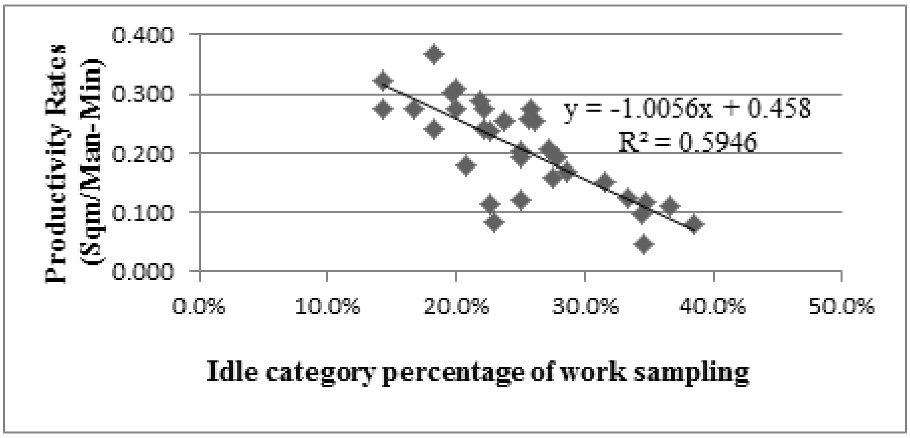

Figure 7: Plot between productivity rates and idle category of work sampling for wall panel shuttering

Similar plots like the ones shown in Figure 6 and Figure 7 are plotted for productivity rates against supporting work portion of work sampling of wall panel shuttering works. The entire sets of plots are repeated for slab panel shuttering works. The summary of all the plots with corresponding Pearson product-moment correlation coefficient and R-squared value are listed in Table 4.

Table 4: Summary of correlation coefficients and R-squared values for the various plots

Category of shuttering work	*Number of data points*	*Plot Details*	*Product-moment correlation coefficient 'r'*	*R-Squared*
Slab Panel Shuttering	*32*	*Productivity Rate Vs Direct Work Category of Work sampling*	*0.20*	*0.04*
		Productivity Rate Vs Supporting Work Category of Work sampling	*0.55*	*0.30*
		Productivity Rate Vs Idle Category of Work sampling	*-0.77*	*0.60*
Wall Panel Shuttering	*33*	*Productivity Rate Vs Direct Work Category of Work sampling*	*0.13*	*0.02*
		Productivity Rate Vs Supporting Work Category of Work sampling	*0.52*	*0.27*
		Productivity Rate Vs Idle Category of Work sampling	*-0.77*	*0.59*

Based on the results from pilot study, it can be seen that the idle category has a strong correlation with productivity rate. Direct work category of work sampling has essentially no correlation with productivity rates.

6. Discussion and conclusion

Although the pilot study results indicate that idle category of work sampling has a strong correlation with productivity rates, but the level of confidence is not very high. At present, work sampling and corresponding productivity data are being collected from different high rise residential project sites across India, to increase the level of confidence. Pilot study results also support the findings of Thomas (1991) by showing, that direct work category has no correlation with productivity rates. It would also be interesting to see how the relationship between work sampling values and productivity rates is affected as the scope of observation is scaled up from narrow definition to a typical definition of crew based work sampling (as shown in Figure 2).

It is already a known fact, that both work sampling and productivity measurement have their own shortcomings, but it can be reasonably believed that in complementary role they would overcome many of their individual drawbacks. This idea is also supported by Forsberg & Saukkoriipi (2007) where they conclude that, measurement of waste and productivity can complement one another. The strong correlation between idle category of work sampling values and productivity rates would convince the project management to eliminate the waste captured by the work sampling results, in order to improve the productivity. Thus work sampling would become an indispensable tool that would complement traditional productivity measurement system.

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Minimising Error: Artificial Neural Network Configurations for a User Overridable Dynamic Shading System

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Abstract

This research explores the possibilities of integrating environmental and human inputs to achieve precise architectural goals. Specifically, the aim is to create an adaptive façade, trained on historical data relating to human (an override capability) and environmental inputs to maintain optimal internal lighting conditions for inhabitants. The study was conducted using a physical louvered shading system constructed in the Bartlett School of Architecture, University College London. The historical data collected by the system provided a sample data set to train the Artificial Neural Network (ANN) for which the system would operate. A multi-layer perceptron was the neural network used in the study and a series of experiments allowed for the optimal network architecture to be ascertained. Based on the trained network, further testing was carried out to assess the accuracy of the results with regards to the louver angle suggested during system recall. It was found that the complexity derived from receiving both environmental and human data provided some confusion when recalling, however the system displayed a high level of accuracy, correctly recalling the desired blade angle over 70% of the time. Further testing found that the remaining recall error could be accounted for through environmental input data similarities. By physically building and testing the system this research suggests that a trained physical system based on computational principles can provide an adaptive architectural entity that considers building occupants behaviour and wants as well as the external environments natural imposition.

Keywords: Artificial Neural Network, Multi Layer Perceptron, Adaptive Façade, User Interaction, Envelope Design.

1 Introduction

Dynamic shading is one of many routes currently being explored under the environmental agenda. The building envelope is seen by many to be one of the most important design parameters determining the indoor physical environment related to visual comfort and occupant working efficiency (Oral & Yilmaz, 2003). However, the generic rules with which many autonomous systems operate often require routinely consistant input from the user should they wish to alter its behaviour for their own comfort (and in many cases this option may not be available at all). Artificial intelligence displays the characteristics of being able to integrate such user input with diminishing user involvement over time through the learning of human behavioural desires.

Most non-residential spaces have regular occupancy hours. With regularity – particularly in spaces with fixed open/closed times – conformative behavioural trends result. While the thought of devices learning occupant behaviour is a seemingly attractive prospect, it is peoples' reluctance to adopt such technology which has been deemed to be the reason for its lethargic uptake. Even rudimentary forms of regulation, such as operating a thermostat are inordinately difficult for people (Gregorek, 1991). There has been a plethora of pioneering research surrounding the topic of automation in buildings (Miller & Seem, 1991; Seem & Braun, 1991; Scott, Shavlik & Ray, 1992). Michael Mozer's *Neural Network House* was an important study with regards to systems learning occupant behaviour. Mozers' study highlighted the importance of inhabitants' behaviour on the chances of prediction success, "the question we must answer is whether there are *sufficiently robust regularities* in inhabitants' behaviour to benefit from" (Mozer, 1998). More recently, ANNs in buildings have been used as a means of short term future event prediction such as hourly cooling loads in buildings, with the aim of optimising the heating, ventilation and air conditioning system operation timing (Li, 2009). There is wide support for the use of ANNs' ability to solve such forecasting problems and the non-linear mapping ability of neural networks is widely accepted as a technology offering an alternative way to tackle ill-defined problems in building envelope automation (Kalogirou, 2001). The potential for such technology to comprehend human wants as inputs to its system nominates ANNs as a potential conduit for satisfactorily predicting when those wants are required.

The ability to adopt protocols and procedures enables human beings to operate effectively in spite of contrasting conditions one might experience throughout the day. Conversely, buildings as a means of providing a user-friendly, environmentally regulated environment do not operate with the same elegance because buildings are subjected to a wider range of internal and external conditions, and posses the additional handicap of being unable to relocate themselves to more favourable environments (Lee and Selkowitz, 1997).

In principle, the use of computational algorithms present themselves as a useful tool in aiding the ever progressing transition of building envelopes from static to dynamic entities. But prior to implementation of such an approach, the question arises as to the implications of such potential paradigmatic change in the built environment, and the subsequent upshots of a theoretical uptake in such building envelope technology. While internal occupant comfort underpins the research, a key concern of the authors was that of the environmental performance of the building. Would the side effects of mass façade automation *further increase* the operational energy use of buildings? Or perhaps have effects on the urban landscape aesthetic and become criticised in the same vein as other positive initiatives such as wind turbines?

2 Method

The method is split into two parts. The *Building Envelope Design* explains the physical systems design and presents the data collected that provided the input data to the ANN. The second part discloses the steps taken to *optimise the ANN* and presents its optimal network architecture. The flow of data from part one to part two is shown in Fig. 1.

2.1 Building envelope design

The experiment and collection of input data was set up in a $3m^3$ room oriented towards South-West. The system operates using 4 blades resting on 4 pivot points, constituting a louver system. Using one servo on one of the blades pivot points, rotational movement is translated into linear movement with which all other blades respond and turn from zero to ninety degrees in tandem. Four lux sensors were used when collecting data; two placed in the internal space and two in the external space. The averages of the lux readings allowed for a more accurate estimation of the amount of ambient light both inside and out. The kinetic movement of the system was actuated using Arduino – an open source software/hardware controller platform. The data visualisation and collection was carried out using the Processing platform (version 2.09b). The graphic user interface (Fig. 2.) provides a form of visual feedback for the user, by which he or she can make future decisions to override the system. The functionality of the system is two-fold and consists of *two separate states* with which the system can be running. The system caters for environmental inputs in the form of lighting levels and user preferences by enabling blade override capabilities when desired. Control theory underpins the logic behind the environmental behaviour of the system, which aimed to maintain a steady level of 500 lux internally. The user override – in the form of a potentiometer – allowed the user to adjust the blade angle to fully open/ closed respectively.

The graphic user interface (GUI) gives the user information regarding the state of the shading system as well as both the internal and external environments. The *blade angle monitor* reports the status of the louvres at any given point as well as their current angle. The lighting monitor displays the proportion of light admitted into the space through a gradient RGB visual. The key information (lighting override level, blade override level, external light level, internal light level and average light level) is given to the user in the form of graphs on a thirty-minute time loop. A time loop was used in this instance to help inform the user of the system and the environments most recent activity as a form of feedback with which to make future decisions.

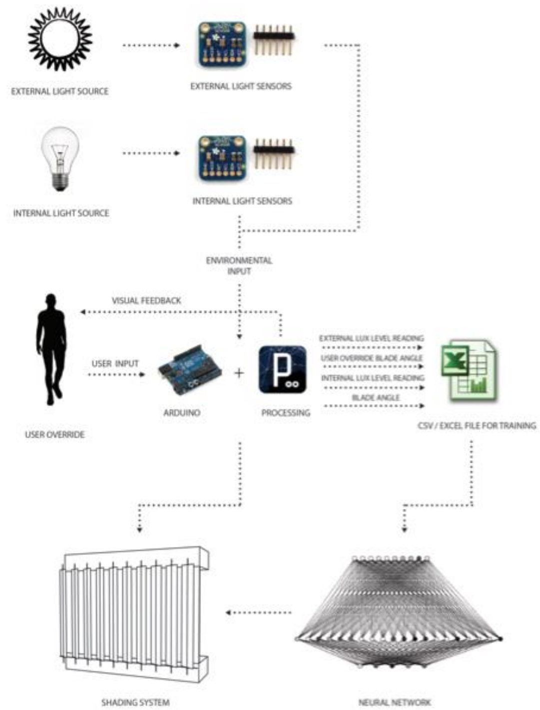


Figure 1: Data flow diagram of the dynamic shading system

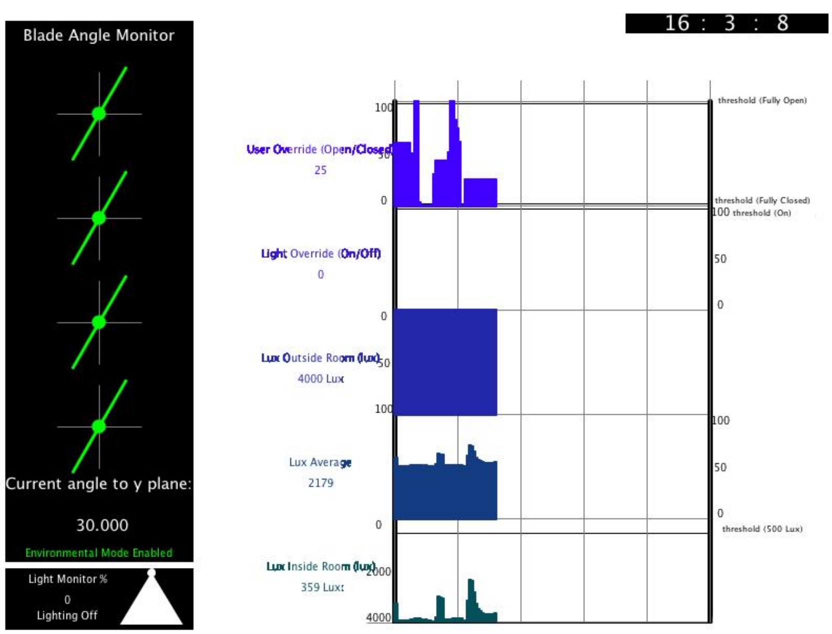


Figure 2: Louvre system scope of movement

2.1.1 System mode 1: User override

User Override Mode setting refers to any system movement acting on data received from the user. In this instance, the user is able to override the system at any point he or she deems necessary. Once overridden, the system discounts any environmental data and the impact it may have on the blade setting (i.e. control theory function temporary shut down) and acts entirely on the users' desired angle. In this study, the user has the ability to override the system to angles 0^o (closed full) and 90^o (open full).

2.1.2 System mode 2: Environmental

The Environmental Mode setting refers to any system movement acting on data received from the natural environment only. In this instance, the lux readers installed provide quasi-real time data regarding the internal and external lighting conditions. Based on the data read by the sensors (and on the understanding that the user has no desires to override the blade angle), the system evaluates the data chronologically and makes a decision on the blades position angle by *stepping towards* the desired lux level.

2.1.3 Control theory

A stepper control function was introduced to find the optimal blade angle based on constantly fluctuating environmental data. The step towards the desired lux level is a chronological calculation based on preceding information. When data is read in from the lux sensors, its *deviation* is calculated based on a comparison between the *internal lux level* and the *desired lux level*. The step that the angle should take is based on the inverse of the deviation multiplied by a *step proportion*. The current angle in addition to the recommended step gives the new angle. In this instance the step proportion is set to 0.1 (10%) so as not to overshoot the desired blade angle. This loop is running as long as the environmental mode is enabled. This allows the system to adjust the blade angle so as to converge on the desired internal lux level.

2.1.4 Output data

The system collected data over the course of one working week in an architecture studio in the Bartlett School of Architecture, University College London (Sunday 28th July to Friday 2nd August 2013). Resident architects were encouraged to use the system when they felt necessary to aid the provision of real-life output data with which to train the ANN. Readings taken at each minute throughout the course of the day have the corresponding values associated: internal lux reading, external lux reading, lux average, blade override, blade output. The results collected show a fair consistency between the days. The internal lux level in Fig. 3 sits regularly around the 500 lux level irrespective of the more external dynamic fluctuations displayed. Where the internal lux level rises or falls from this benchmark figure generally indicates the use of the override function imposed by the user (although in some instances, the lux level drops or rises due to anomalies such as exceedingly high daylight or extremely overcast skies). With each point during the day there is a blade angle associated. The blade angles recorded from the system give a resultant angle to the nearest degree (Actual – blue line). Each degree has been rounded to the nearest 10 degrees (Rounded – black line). The difference between the actual blade angle and its rounded equivalent was seen to be negligible and in-keeping with the discrepancies seen in the internal lux level variance maintainance. The data recorded between the hours of 9am and 5pm (a typical UK working day) is used for training and subsequent testing. The hours between 5pm and 9am have not been included in network training.

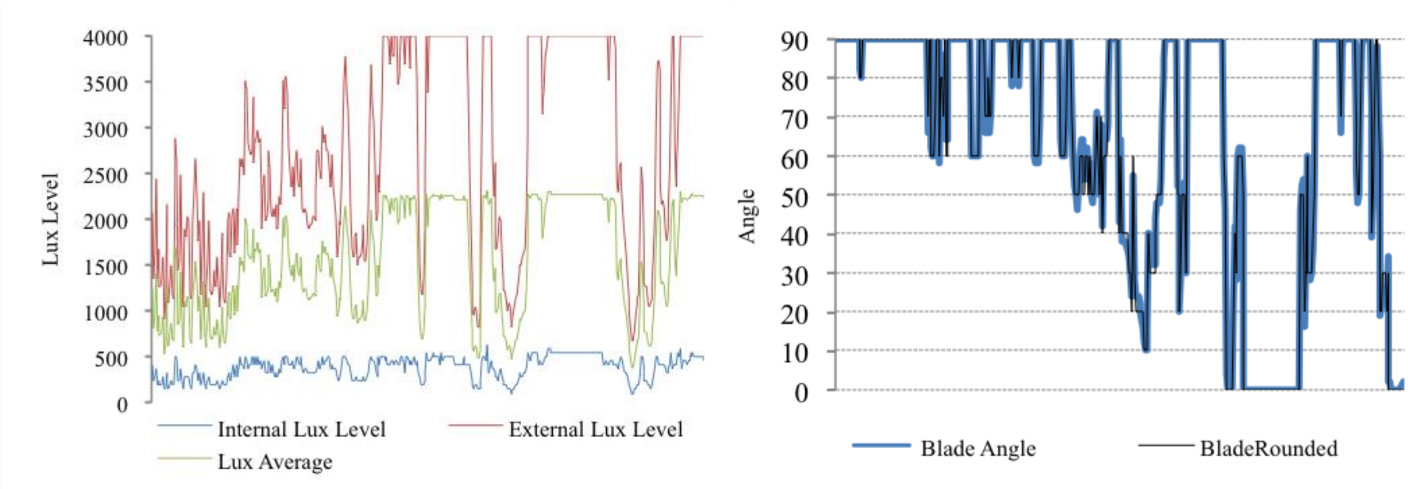


*Figure 3 and 4***:** *Lux level data and User override data recorded using the dynamic system*

2.2 Façade back propagation optimisation

The artificial neural network (ANN) approach is a generic technique - developed from the areas of artificial intelligence and cognitive science - for mapping non-linear relationships between inputs and outputs *without knowing* the *details* of these relationships (Yang et al, 2003). ANNs, and in this case feed-forward neural networks with back propagation (also known as multi layer perceptrons - MLP), are parallel distributed processing models used to model the brain's learning process. The likeness is drawn because the brain receives inputs from the outside world via neurons, processes the inputs via further neurons and produces a response.

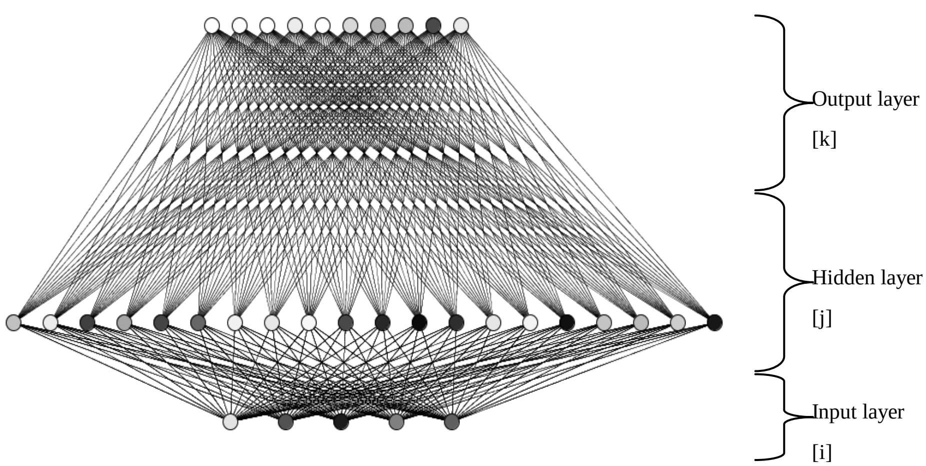


Figure 5: ANN architecture visualisation using Processing 2.09b

The network in this instance is a set of interconnected ‘neurons’ and consists of three (or more as demonstrated in this study) layers: an input layer, a hidden layer and an output layer. Information is fed into the input layer and through a series of weighted synapses; the information is passed forward through the hidden layer of the network through further connections, to the output layer. Sigmoidal function thresholds on the differing layers neurons determine whether the neuron ‘fires’ (feeds forward further information) or not. The theory behind the method of back propagation is that once the signals have been sent from input layer to output layer, the resulting answer is compared to the known actual answer and the weights between neurons in preceding layers are adjusted to step towards and accommodate the error. Each iteration involving the successful feeding forward of data (from input to output neurons) is known as a ‘training cycle’, with each complete set of training cycles constituting a ‘training epoch’.

The concept of learning via back propagation consists of input patterns of each input node (i) being fed-forward to the hidden layer (j) and output generated in the output layer (k – Fig. 5). Whilst training, the output values are compared to the target values for each epoch and if a difference between the two is apparent, the weighted connections adjusted and step towards the desired value, thus progressively decreasing the error rate. The resulting adjustment is propagated backwards from the upper layers to the lower layers, subsequently altering the weights across the entire network. As the weights are the obvious respondents across any length of training, they are a useful indicator as to how well the system is performing. The training data used across all of the experiments is the same five days data collected. The data is collected every half second, however in this study minute-by-minute data has been used, constituting 4218 lines of sample data. The data used has been taken from between the times of 9am – 5pm. In this instance, the aim of the experiments is to establish a credible network formation based on the training data, which will enable efficient learning to be able to cope with *unique* data. The data is split in two parts - training set and testing set - the first uses 90% of the data set and the latter utilises the remaining 10%. The network is run for 3000 epochs in every training case and 300 while conducting final testing based on the optimised network configuration.

2.2.1 ANN architecture optimisation

The model learning is initiated with the setting of affecting factors in the form of input variables. The influencing factors are internal light level, external light level, the variance rate between internal and external light level and user blade override. The minimum and maximum values for the inputs (as seen in Table. 1) are normalised between 0 and 1.

*Table 1**:** Maximum and minimum values for input neurons*

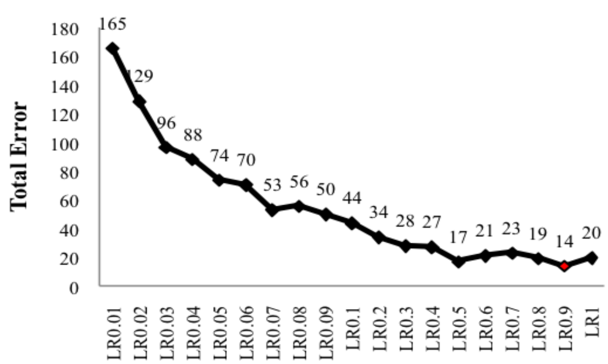
Input (X_i)	X_{min}	X_{max}
$Lux_{internal}$	*44*	*1842*
$Lux_{external}$	*246*	*2921*
$Lux_{mediated}$	*449*	*4000*
User Override	*0*	*90*

3 Training scenarios

The training scenarios are a series of experiments based on altering the ANN configuration to assess the differences in error rate, with the aim of improving prediction accuracy and performance when tested. All experiments have been conducted five times, with the averages taken for each. Learning the data collected from the shading system optimises the network architecture. Each variable factor has been progressively varied in turn until the best value with the smallest total error over the training series is discovered. Once discovered, this variable will become fixed and the following experiment will commence, adopting this fixed value. This process will continue until all floating variables have been fixed; constituting the optimal network configuration.

3.1 Learning rate variation results

In determining the optimal learning rate, other aspects of the network needed to be fixed to allow for consistency when comparing results. The fixed factors are as follows: input layer neurons - 4 (internal lux level, average lux level, external lux level, user override), hidden layers – 1, hidden layer neurons – 6, output layer neurons – 10. The testing period was halted at a learning rate of 1 because it is near asymptotic. Learning rate 0.9 exhibited a maximum error figure of 0.078 and a minimum error figure of 0.0033 (at random training iteration 2213 – Fig. 6.).



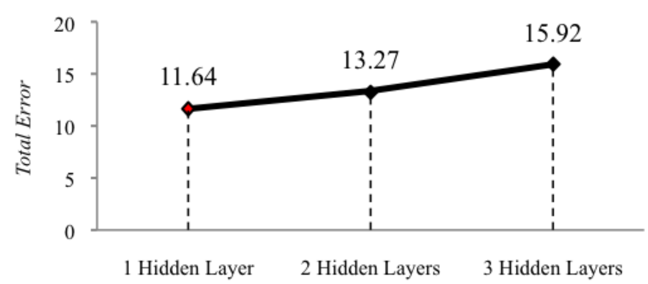


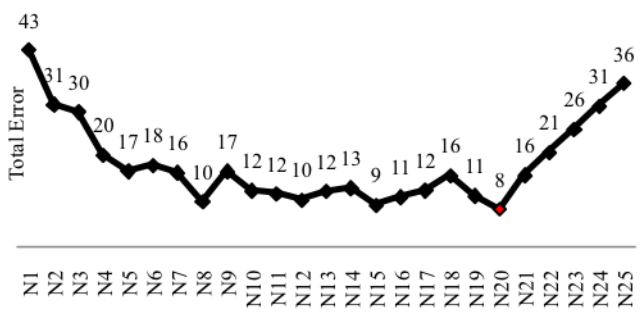
Figure 6 and 7: Patterns of error according to varying learning rate and Patterns of error according to varying hidden layer (3000 epochs)

3.2 Hidden layer variation results

In order to determine the optimum number of hidden layers, other factors were fixed as follows: 0.9 learning rate 4 input layer neurons, 6 hidden layer neurons per layer and 10 output neurons. The number of hidden layers was altered in three phases from 1 to 2 to 3. The total error according to the differing number of hidden layers is linear in fashion and the results can be seen in Fig. 7. The total error value between hidden layers 1 and 2 is relatively small, with 1 hidden layer boasting the optimal efficiency. The difference between the minimum and maximum value (1 hidden layer being the minimum and 3 hidden layers being the maximum respectively) is approximately 13%.

3.3 Hidden neuron variation results

The difference between the maximum and minimum total error rates is vast. Between 1 and 12 neurons a steady decline in the total error rate is apparent, save for neuron 8. Within the single hidden layer configuration, 20 hidden neurons proved to yield the lowest overall error rate with a total of 8.25 over 3000 training epochs. Beyond 20 neurons the error rate rises steeply, offering no improvement on the 20-hidden layer neuron formation. Probing into the two highest performing hidden neuron results graphs, clear distinctions can be seen that are not initially directly visible based on figure 15. The comparison shows that over the course of the 3000 training data sets, sample 20 converges to a far more stable error rate than sample 15 (Fig. 9.).



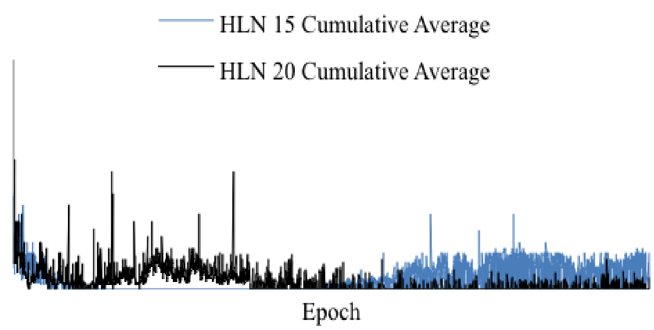


Figure 8 and 9: Patterns of error according to varying hidden neuron number and A comparison of the lowest scoring error rates (3000 epochs)

3.4 Optimal values for ANN architecture

The optimal values of the floating variable learning factors have been fixed through variation and response analysis. The optimised values for to determine the correct louver angle upon recall is summarised in Table 2.

Table 2: Optimised values to be used in louver ANN architecture

Variable	*Optimum Value*
Learning Rate	*0.9*
Number of Hidden Layers	*1*
Number of Hidden Neurons	*20*

4 Evaluating the optimised model

The values of each learning factor have been determined with the intention of reducing the overall errors in the network to the minimum value possible. Theoretically, a lower value ascertained while learning should minimise the errors in louvre angle prediction when tested. The neural networks demonstrated ability to learn must be assessed to determine whether it can regulate the correct blade angle with precision. The performance of the network has been assessed through the comparison of the result given through network recollection (*response*) to the output learning data gathered from the physical shading system (*actual*). Testing the system has been done using the following deduced ANN configuration: 4 input neurons, 1 hidden layer, 20 hidden neurons, 10 output neurons and 0.9 learning rate. Overall, the network averaged a blade error of 4.3^{o} per epoch suggesting modest prediction accuracy. Over 70% of the tested sample was correctly recalled by the newly trained neural network (71.3% - 214/300- Fig. 10). Such a large percentage further illustrates the success of the delineation of the variables' in previous experiments. Approximately one fifth (15.6%) resulted in a ten-degree error swing, 8.6% of this was undershooting by ten degrees with the remainder overshooting by ten degrees. The remaining 13% resulted in a twenty-degree error swing, 6.25% of this subtotal was undershooting by twenty degrees with the remaining 6.75% overshooting. The small errors displayed are a direct result of the readings taken while stepping towards the desired lux level at the time of data collection. It also explains the reason why the error in network recall never exceeded 20 degrees. This data overlapping can be deemed as the cause for any difference in blade angle. The reason the amount of incorrect recall rates seem lower at the extremities (i.e. 0 degrees and 90 degrees) is due to the difference in user override function (i.e. 100/0 = -1/+1) tipping any seemingly similar results in terms of lux level into distinction from one another.

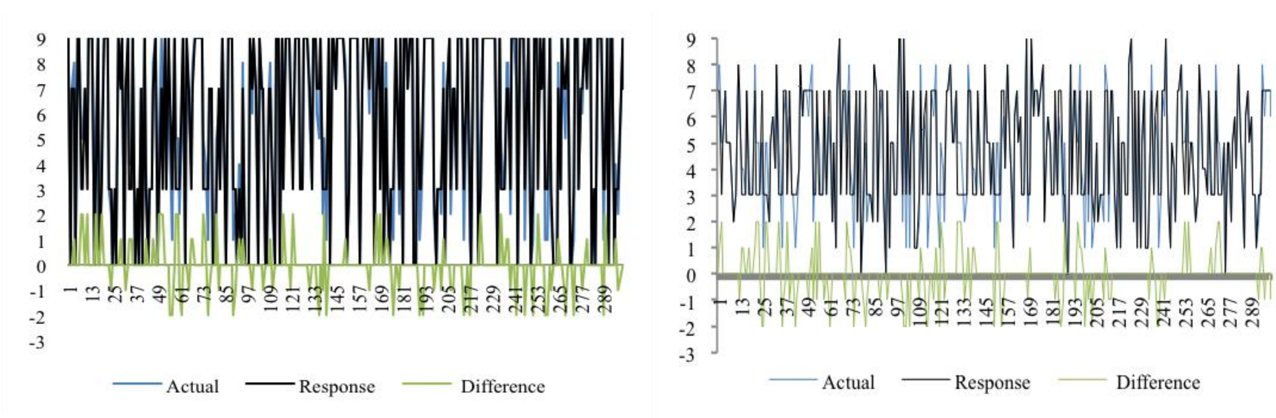


Figure 10 and 11: Trained accuracy and Tested accuracy based on user override function (300 epochs)

5 Testing the model seperately

To confirm the suspected theory arising as a result from the previous test, a final experiment was conducted. The previously mixed environmental and user override data has now been split into two separate training categories respectively. The first test was concerned primarily with the user override recall prediction accuracy. The second looked at the environmental input recall prediction accuracy. By isolating the two modes it allows for a deeper understanding of which part of the physical system was contributing to the eventual errors in recall. There were zero testing inaccuracies when recalling user-overridden preferences to set the blade angle fully open or fully closed. The optimised network produced a 0% error rate when tested randomly over 300 overridden epochs. Fig. 11 highlights the recall accuracy of the network based on the blade angle when in environmental mode. In this instance the recall prediction accuracy was at 70.5% (constituting an error rate of 29.5% -212/300 correctly recalled). In a similar vein to the previously amalgamated experiment, the recall inaccuracy never falls below 20^0, corroborating the theory discussed previously relating to the physical systems stepper function and subsequent data recording while the stepper function was engaged.

6 Conclusions

In this paper, a method consisting of a series of experiments has been presented in an attempt to compile a supervised artificial neural network configuration to enable the successful recall of the shading systems blade angles based on environmental and user inputs.

The research involved the creation of dynamic, adaptive façade and to understand how such a system, once trained, would perform autonomously. The experiments conducted allowed for the convergence of differing variables within the ANN to be ascertained in a bid to minimise the error in the weightings between adjoining layers in the network. The minimisation of error translated into what would be the optimal system based on the fixed inputs and outputs. What has successfully been achieved is the proof of concept that underpinned the subsequent aim of the research. This study was related to whether an adaptive façade could be trained to handle multiple inputs from environmental and human origin and translate such inputs simultaneously to achieve an adaptive architectural entity. In the pursuit of global stability within the system, the series of learning experiments informed the network architecture configuration prior to the assessment of its recall ability when tested. The training results appeared amicable and showed a clear demonstration of the benefits of the optimised neural network configuration.

One underlying drawback was the appearance of duplicate or overlapping data within the training set (as a result of the stepper function while in environmental mode), which subsequently led to adverse effects on the networks recall capacity. While an average recall error of less than 5^o over the 300 testing sets could be considered a successful demonstration of a systems ability to learn based on multiple inputs, there is room to improve these results in future.

Specific questions arising from the research are as follows:

1) To what degree can time improve the recall rate of the neural network?
2) To what degree does sufficiently robust user regularity improve the recall rate of the neural network?
3) To what degree would the user override function be a feasible input beyond the fully open/ fully closed configuration and what impact would an expansion of user override ability affect future recall success?

Such questions have emerged from the results of the work to date because they still remain almost wholly unanswered. The scientific contribution of the work was focussed on network performance and the questions listed above have arisen as a consequence of the results of the analysis. The questions outlined seem the next feasible step in building upon the current knowledge achieved within the scope of this research.

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Revisiting Client Roles and Capabilities in Construction Procurement

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Abstract

The need to improve performance of procurement in construction has resulted in several structural changes and re-arrangements for the acquisition of the client's development scheme. Much of these changes have focused on the contribution and roles played by parties other than the client to the delivery of projects. The role of the client during these changes has evolved from one of a passive fund provider to an increasingly active participant and hands-on management in some of the procurement arrangements. However, there is little evidence that these evolving roles have been met with a commensurate progress in project delivery performance for client organisations. There is evidence that lack of progress is hindering project performance. Simultaneously, research has so far given less attention to the changes in client's roles over time. This does not only call for a clarification of contribution the client makes in delivery of projects, but also highlights the need to re-visit the client roles under different procurement systems, and at different project phases, including pre-construction, construction and operational.

This paper presents a review of common procurement arrangements in the construction industry and the changing roles of the client's organisation. The paper also explores the client's role in each of these arrangements to establish what capabilities enable effective project delivery and performance. The identification of the capabilities is achieved by mapping client roles against procurement arrangements. The analysis of mapping exercise shows that the client has two types of capabilities for the delivery of every project: a primary capability required by all clients; and secondary one that is specific to a particular procurement case. The primary capability could serve as the minimum threshold for self-evaluation by client organisations.

Key words: Revisiting, Client Roles, Capabilities, Construction, Procurement.

1 Introduction

Recent effort in improving procurement performance has resulted in several changes in the client and the procurement systems. However, much of these changes have focused on the contribution and roles played by parties other than the client to the delivery of projects. For example there is growing direction of outsourcing some of the public client's activities to the private sector by adopting integrated procurement systems (Al-Jibouri & Ogink 2009).

The role of the client during these changes has evolved from one of a passive fund provider to an increasingly active participant and hands-on management in some of the procurement arrangements. However, there is little evidence that these evolving roles have been met with a commensurate progress in project delivery performance for client organisations. There is evidence that lack of progress is hindering project performance. Even though some improvement took place the construction industry, it has not been continuous and it has been mainly focusing on price rather than value (Smyth, 2010).

The increase direction toward integrated procurement systems to improve procurement performance requires close collaboration between all involved parties mainly the client, designer and contractor. Both the designers and the contractors' roles have received greater attention than those of the client in the delivery of the construction projects. Furthermore, research has so far given less attention to the changes in client's roles over time. This highlights the need to re-visit the client roles under different procurement systems, and at different project phases, including pre-construction, construction and operational.

This paper presents a review of common procurement arrangements in the construction industry and the changing roles of the client's organisation. The paper also explores the client's role in each of these arrangements to establish what capabilities enable effective project delivery and performance. In working toward this objective, a detailed review has been conducted to establish the role of the client throughout the procurement life cycle. The following sections of this paper provide an overview of the common procurement, research method, finding and discussion and finally a conclusion.

2 Procurement

It is estimated that the infrastructure investment required to sustain the population growth until 2020 is about USD 5 trillion per year (World Economic Forum 2013). With the increasing value and complexity of construction projects, several procurement arrangement has been developed to aid the public clients in selecting design, construction, management, operation and financial services procurement packages (Kumaraswamy & Dissanayaka 1998). According to (Masterman 2002) selecting the most appropriate procurement system is one of the critical success factors in construction industry. Simultaneously, they clarified that the inefficiency of client management is a key parameter affecting the project performance. Masterman (2002) highlighted that client's organisation characteristics and culture is a key factor in developing a sound procurement strategy.

The physical construction procurement highly depends on the efficiency and quality of information provided by the public client during the tendering stage. Laryea (2011) argued that the information provided by the client is not always clear and adequate. According to Watermeyer (2011) improving the construction phase performance starts at the design stage. However, both the public clients and designers facing difficulties in preventing design errors (Lopez et al. 2010).

Public Client is a major procurer and has the ability to influence the market and stimulate innovation (Knutsson & Thomasson 2013). The management of the project requirements and design are two main tasks that influence all subsequent procurement activates. However due to public client limited resources some of these activities are outsourced to consultancy firms and with several changes in the procurement systems project design, management, operation and even financing has been transferred to the private sector.

The procurement of a development scheme commences with the identification of needs and completes when the agreed product or/and services are delivered (Watermeyer 2011). The client establishes a set of relationship with different organisations during the life cycle of the procurement process. The client plays a key role in bringing various parties together at different stages of the project by selecting one the common procurement arrangement. In general, there are four main procurement arrangements clients use in delivering construction projects (Tookey et al., 2001; Masterman, 2002; Morledge & Smith 2013) which are: Separated, Integrated, Management and Public Private Partnership.

There are further sub-systems under each of these procurement routes and appropriate packaging of different services is crucial in achieving efficiency in construction project (Kumaraswamy & Dissanayaka 1998). Figure 1 illustrates the main procurement arrangements and subsystems.

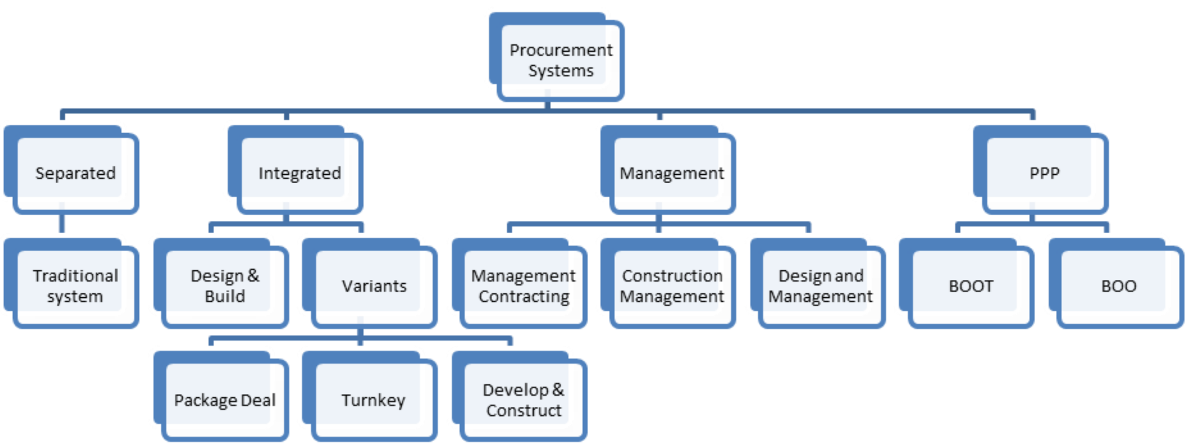

Figure 1: Main procurement arrangements and subsystems

2.1 Separated procurement

The separated procurement system is the traditional contracting method that separates the responsibility of the design from the construction. The client in the separate procurement approach involves in four main phases: design development, construction tender, construction delivery and finally operation and maintenance. The client appoints independent consultants to design and prepare the construction tender document and then supervise the contractor work. The client normally procured professional consultancy services to plan, develop scope of work, assess alternative solutions, develop the design, produce construction documents, and confirm implementation of the design during construction (Watermeyer 2012). Based on Yu, Ann; Shen (2013) research this phase of the project creates the foundation for a successful relationship between the client and the construction industry. Furthermore, innovation at the design stages is considered as critical source of creation and greatly influence competitiveness of the construction package proposals (Salter and Gann, 2003).

Both the client and the consultants work together in specifying the scope of the project before inviting construction contractors (Morledge et al. 2006). It very critical that they insure the design is well developed as rectifying design errors during the course of construction affect the project progress and require great attention from the client team (Love et al. 2013) . The relationship between parties in the separated procurement system is illustrated in figure 1.

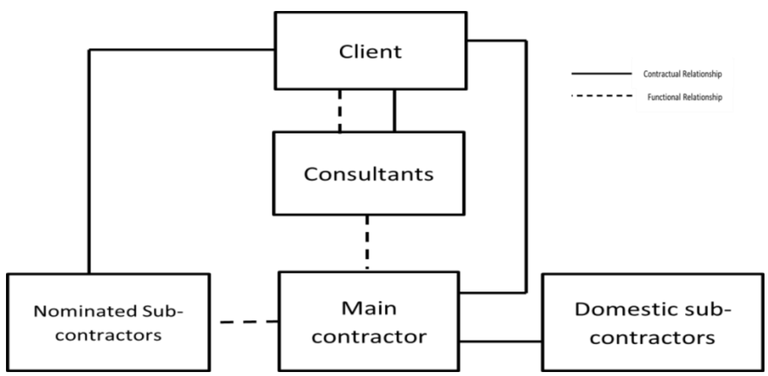

Figure 2: Relationship between parties in separated procurement system

2.2 Integrated procurement system

Integrated procurement system combines both of the project design and construction in one package. According to Masterman (2002) and Tookey et al. (2001), the responsibility of these two basic elements lies solely with the contractor. Therefore, selecting appropriate contractor by the client has significant impact on the project performance (El-abbasy et al. 2013). Design and build, management oriented, and Public Private Partnership are the most common form of this system, explained in the following sections.

2.2.1 Design and build

Following the client decision to adopt the design and build route the procurement process consists mainly: identification of client's requirements, obtaining tenders, tenders evaluation, and project implementation (Masterman 2002). It is very critical that the client provides the tenderers with sufficient and comprehensive information its requirements to achieve clarity and avoid misunderstanding (Masterman 2002). When working toward professional design, the client normally appoints a design consultant to prepare concept design , and compile the design and construction tender document of the project (Walker & Rowlinson 2008). The prospective contractor mainly depends on the information provided in the tender document to estimate the project cost and developing the project detail design. Following the contract award the contractor takes the key role in both the design and construction (Walker & Rowlinson 2008). Figure 3 illustrates the relationship between parties in the design and Build procurement system.

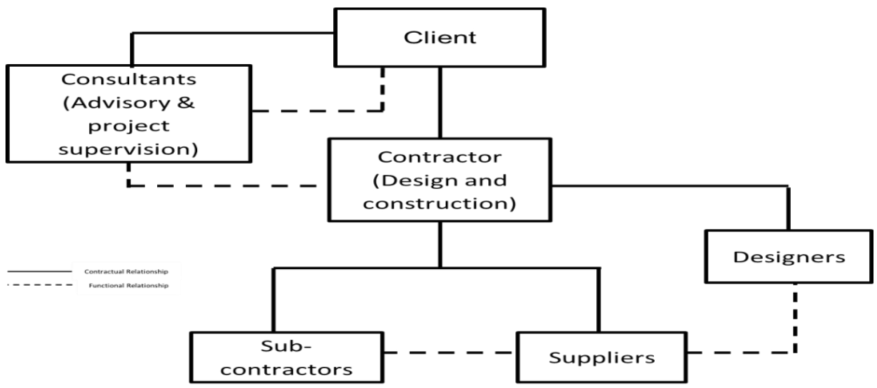

Figure 3: Relationship between parties in design and build procurement

Clients normally adopt Design and build procurement route to expedite the project execution especially at the pre-contract stage. Furthermore, the client has many options to expedite the process at this stage, for example tendering the project by providing the construction tenderers the requirements and performance level without design documents (Kumaraswamy et al., 2000; Masterman, 2002).

2.2.2 Management oriented procurement

Management oriented procurement system is distinguished by elevating the contractor to the early stages of the project to provide advisory and management services under the client directions. These procurement systems include management contracting, construction management and design and manage explained in the following sections (Masterman, 2002).

2.2.3 Management contracting

Management contracting involves the client selecting a contractor at the early stage of the project based on brief description, time scale and estimated cost of the of the project (Masterman 2002). Client agreement with the management contracting party may include providing services during the design phase of the project and construction phase. The management contracting agreement could be only for design stage and the contractor is paid the agreed fees, or continuous with construction phase and thus the management contractor becomes liable for completing the project on the agreed date (Masterman, 2002). However, all construction work should be carried out by sub-contracting the construction packages to trade sub-contractors that are not related to the management contactor, thus avoiding conflict of interest between the client and the managing contractor. Furthermore, all trade sub-contractors are jointly evaluated and selected by the client, consultants and the management contractor. It is worth noting that the management contractor bear the full responsibility if he appoints the work packages sub-contracts directly (Gan, 2011).

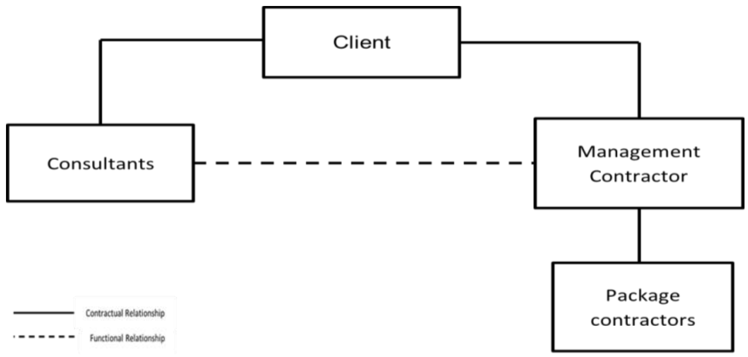

Figure 4: The client relationship with other parties in management contracting

2.2.4 Construction management

Construction management procurement system is generally similar to management contracting except that the trade contractors are appointed by the client directly, so the construction management contractor does not enters into any contractual relationship with these contractors. Accordingly, the client got involved with multidisciplinary contractors who impose additional management and administration activities. Splitting the project work into small packages increase competition and the project become more manageable (Masterman 2002). Figure 5 shows the project network and the relationship between parties in the case of construction management procurement system.

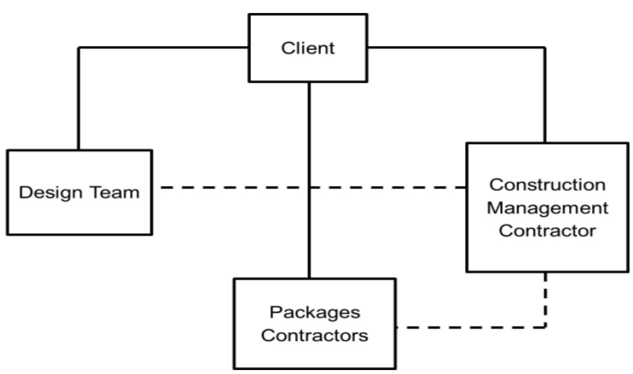

Figure 5: The client relationship with other parties in construction management

2.2.5 Design and manage

In Design and manage procurement, the client appoint one organisation for both design and construction, where the client contact is only with this organisation. The client can appoint either a consultant or a contractor to provide the consultancy and management services, and the package contractors carry out the actual construction work. These package contractors' enter into direct contracts with the client in case a consultant is providing the design and management (Consultant-led), and as sub-contractors when a contractor (Contractor-led) is in the design and manage position (Masterman 2002).

2.3 Public Private Partnership (PPP) procurement system

PPP is a procurement method used to develop facilities by transferring the financing, design, construction and operation to the private sector for a long term concession (Robinson & Scott 2009). This procurement system is mainly focusing in delivering the services rather than building asset and utilising the private finance rather than the public fund. In recent years, PPP has been selected for delivering infrastructure projects such as power generation, water supply, wastewater treatment, hospitals and schools. The contract in PPP is mostly based on performance level where the private investor is paid for the service delivered with limited risk on the public sector (Grimsey & Lewis 2005).

There are more than one form of contractual relationship between the client and the private sector, for example: Build Own and Operate (BOO) and Build Own Operate and Transfer (BOOT). In both examples the client or the end users pay the private sector service charges periodically to cover the cost of procuring and operating the facilities. With the BOOT procurement option the facilities are transferred to the client by the end of the concession period and in the case of BOO option the private sector is required to remove the facilities by the end of the concession period and keep the site in an acceptable condition (Walker & Rowlinson 2008). The contractual duration (Concession period) normally range between 20 to 30 years, however, the client may specify concession beyond this range. Figure 6 illustrates the relationship between parties in the PPP procurement system.

Based on Akintoye et al. (2003) and Robinson & Scott (2009) study; many public clients are on the learning curve and should acquire sufficient capabilities to achieve value for money . Furthermore, all stakeholders believe that PPP could be further improved by better understanding of risk allocation, standardisation and skills development (Akintoye et al. 2003; Robinson & Scott 2009).

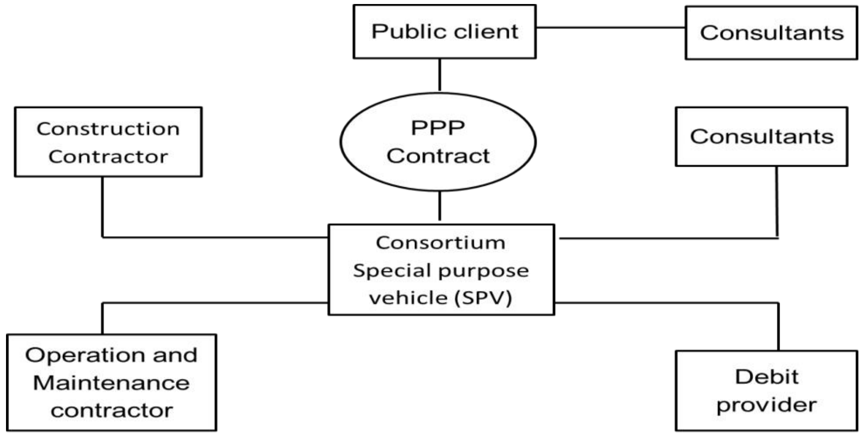

Figure 6: The relationship between parties in the PPP procurement system

3 Research method

The research was conducted through several phases including: literature review, data collection, data analysis, findings, discussion and conclusion. In the literature review, a wide range of sources relevant to the procurement systems and the client role were obtained mainly from journal, proceedings and books published during the period between 2000 and 2013. A comprehensive list of the procurement activities was extracted mainly from BSi (2011), RIBA work plan (RIBA 2013), Project Procurement lifecycle the integrated process (OGC 2013) and ECI client best practice guide (2013). Then the abstracts of the relevant papers were read through to filter the most related sources. A total of 250 journal's papers were found to be relevant to the role of the client in the construction procurement. Subsequently, random sample of 80 papers was selected and the review focused on these papers as the source for establishing the primary roles of the client in the procurements system. The research emphasised on the importance of client role in attaining effective construction procurement. The client role in each of the selected sources was tabulated, and the number of sources presenting the same role of the client was added for each of the procurement activities. The higher the number of sources the more important a particular role has within the client organisation. Therefore, the roles were then ranked in descending order, based on the number of sources. The classification of the roles and analysis of the ranking suggest two types of capabilities which enable the clients to exercise their roles effectively. They are named, primary and a secondary capabilities. The finding highlights some of the critical roles that provide the client's organisation with the minimum capabilities required for different procurement systems.

4 Finding and discussion

The review of the role of the client and the procurement systems show that most of the published sources studies between 2000 and 2013 were not specific to any procurement arrangement, with the exception of some studies directed toward Public Private Partnership. The finding of selected resources review and the ranking strategy applied in this paper presents some of the critical roles where client is expected to perform throughout the procurement life cycle. As can be seen in table 1 the review identified 18 general roles within the procurement life cycle, 12 roles of the client were stressed in between 3 to 11 sources. Therefore, given adequate attention these 12 roles establish a good base for the development of the client organisation capabilities.

Table 1: A literature synthesis of client role in construction procurement

No.	*Roles of the client*		*Critical tasks within the client role*		
	Role description	*Aggregate number of sources*	*Task Description*	*Aggregate number of sources*	
				General	*PPP*
1	*procurement strategy*	*11*	*Procurement route selection*	*6*	
			Bases of selected procurement route	*5*	
			Basis of procurement packages	*3*	
2	*project Initiation*	*10*	*Identify need of consultancy services*	*7*	*4*
			Set out objectives and outcome	*6*	
			Review feedback from previous projects	*3*	
			Value Management		*5*
3	*procurement method*	*9*	*Identify source of funding*	*5*	
			Contractor selection method	*8*	
			Consultants selection method	*5*	
			Pricing basis and payment options	*5*	
			Procurement management	*3*	
4	*Project Brief*	*8*	*All are two or less sources*		
5	*Business case*	*7*	*Agreeing the project objective with the stakeholders*	*3*	
6	*Risk management*	*7*	*Risk allocation*		*4*
			Monitoring and reporting risk		*3*
7	*Tendering and award*	*6*	*Award criteria*	*4*	
			Weightage for award criteria	*3*	
			Set /price ratio	*3*	
			Set quality scoring	*3*	
			Set price scoring		
8	*Performance Management*	*6*	*Performance assessment*		*3*
9	*Change control*	*4*	*Requirement management*	*7*	*3*
10	*Prequalification*	*3*	*All are two or less sources*		
11	*cost management*	*2*			
12	*operation and maintenance*	*2*			
13	*program development*	*1*			
14	*Design*	*0*	*Design management*	*3*	
15	*Construction management*	*0*	*All are two or less sources*		
16	*Completion*	*0*			
17	*Evaluation of post occupancy*	*0*			
18	*Information coordination*	*0*			

Based the ranking presented in table 1, nine roles have been ranked above the average number of sources (76/18) that attributed these roles to the client organisation. Each of these roles was addressed in between 4 to 11 sources during the period from 2000 and 2013. Further analysis of the roles show that six out of them are clearly related to the pre-contract stage, and the other three are a continue management and assessment roles which could run throughout the procurement life cycle. These findings highlights the client organisation that a good performance in construction procurement can be achieved by combining the effective participation at the pre-contact stages of the procurement and continuous and assessment and management of the procurement activities. The findings also stress some key tasks within the primary roles of the client, which direct the client organisation with the need of specialized capabilities in order fulfil its roles in an effective and professional working way.

The client was addressed to much less extent in the roles ranked between 10 and 18, these nine roles comes at different stage of the procurement life cycle for example prequalification is at the pre-award stage, where construction and operation at the post contract phase. Also, most of the nine roles highly depend on the selected procurement method and the level of integration between design, construction and operation or even funding. Thus, the client organisation may outsource these roles other parties how has better capabilities for the acquisition of the client scheme.

Accordingly, the roles of the client are classified in to two types: primary roles and secondary roles. The primary roles are the required by all clients irrespective of the selected procurement systems. This discussion shows that the client organisation has nine primary roles:

a. Development of the procurement strategy: This role several activities such as establishing the basis of selecting any procurement route, confirm the project objectives, undertake market engagement, identify responsibilities, and identify constrains.
b. Procurement initiation: this role covers the earliest stage of the procurement life cycle and expected to cove many activities, for example: the main project objectives, outcomes, consultancy needs, review previous projects feedback, and identify roles and responsibilities within the client organisations.
c. The development of the project brief: provide comprehensive information about the project which may include but not limited to scope, objectives, outcomes, quality expectations, deliverables, constrains, time frame, and project special features.
d. Selection of the procurement method: the finding table provides some of the key tasks within this role and these tasks establish the minimum capabilities for the client organisation.
e. Development Business case: this role reconfirms the tasks covered at the initiation phase after close coordination with the project stakeholders and evaluation of options for meeting the established objectives and outcomes.
f. Risk management: establishing clear understating of risks associated with project delivery and risk allocation are two crucial tasks among other within this role.
g. Tendering and award is one of very sensitive role especially the tender evaluation strategy and award criteria.

h. Performance management: this continuous process within the client organisation, and the project, the consultants and the contractor performance. The effectiveness performance management depends on the set performance strategy and the objectives of the client.
i. Change control: ensuring the procurement control is a challenging role with multidiscipline tasks technical, financial, legal, health, safety, and environment. Client effective contribution in requirement management has been frequently addressed in the reviewed sources which need greater attention from the client organisation.

After highlighting some of the tasks under the client primary roles, it worth noting that the secondary roles may vary based on the selected procurement strategy. Therefore, outsourcing all or some of these sources could be more viable option for the client organisation.

5 Conclusion

The finding of this paper shows that the primary roles of the client organisation are irrelevant of the procurement systems. The review concluded that the client has nine primary roles, namely development of the procurement strategy, project initiation, selection of the procurement method, development of the project brief, development of business case, risk management, performance management and tendering and award and change control. Additionally, there are nine secondary roles which depend on the procurement strategy. It is postulated thathese secondary roles may be outsourced to other parties without significant impact on the performance of procurement. The relationship between (primary and secondary) client roles and performance is the subject of further investigation.

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An Overview of Standard Contractual Forms Modifications in the Construction Industry - The Middle East

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Abstract

Despite the fact that there exist several construction forms of contract that aimed at standardizing the contractual clauses in relation to the construction industry, the adoption of the same was being subject to major modifications and alteration endangering the overall spirit and consistency of the contractual forms. Knowing that the middle East region is and will be subject to major construction projects during the upcoming years, it is of major importance to consider that well figured contractual clauses would play major role in simplifying part of the complexity associated with the construction environment. The problem is that the project parties would be focusing on the contractual aspects governing the project rather than technical and execution issues which would eventually flag hindrance in the project original schedule and certainly an escalation to the project original budget notwithstanding the project works atmosphere. Furthermore, and if the contractual clauses were not drafted clearly, contracts negotiation and signature would be a time consuming challenge and would take considerable time from the total originally allocated. During project execution, the problem may become worse if the contractual terms and conditions were not clear enough i.e. the contracting parties do not have a clear understanding of what they have agreed upon, accordingly, any claim may be considered as a fertile ground for contractual disputes.

The above issues represent a challenge to any project manager whose aim is to finish his project within the given time frame and allocated budget constraints. Hence, it would be of great importance to have the conditions of contracts responsibly drafted. The same would assist in alleviating disputes that do relate to contractual terms and would support the contracting parties to jointly read from the same book. This paper focuses on Standard construction contracts current practices in the Middle East with their corresponding conditions. The final section of this paper highlights the major modifications being witnessed to the Standard contractual clauses.

Keywords: Standard contractual forms, Middle East

1 Introduction

The General Conditions of Contract are of major importance since the same do play a main regulatory role at the various project interfaces during project execution which mandates a particular attention and proper tuning during project award through its corresponding Particular Conditions of Contract.

Particular Conditions needs to be introduced, as per FIDIC Fourth Edition reprint 2011, for the following reasons:

1. Where the General Conditions of Contract requires further information to be included in the Particular Conditions without which the conditions are not complete.
2. Where the General Conditions of Contract requires supplementary information to be included in the Particular Conditions without which the conditions would still be complete.
3. Where the locality and circumstances of the scope of works necessitate additional clauses to the General Conditions of Contract.
4. Where the law of the country in which the works to be executed necessitates introducing modifications to the General Conditions of Contract.

If the particular contractual clauses were not drafted responsibly, or falsely tuned, Contracts, even those with Standardized general conditions, negotiation and signature would be a time consuming challenge and would take considerable time from the total originally allocated (Tatarestaghi, 2011).

During project execution, the problem may become worse if the contractual terms and conditions were not clear enough i.e. the contracting parties do not have a clear understanding of what they have agreed upon, accordingly, any claim may be considered as a fertile ground for contractual disputes (Murdoch and Hughes, 2008). In 2006, Fenn et al developed and published a summary of the studies of the sources of disputes (Fenn et al., 2006). His study showed that disputes do relate to contract interpretation, misunderstandings, extension of time, variation to scope, payment, administration, contract terms…. Etc. For instance:

- Lee (1994), noted that unfair contract clauses, vague definition of contract documents in terms of performance period, payment, variations do contribute to disputes from contract problem.
- Jones (1994), highlighted that inadequate contract drafting is a factor that would contribute to disputes.
- Lo (2002), noted that differences in contract interpretation between project parties would lead to construction conflict.
- Yan (2002), marked that contractual factors do form one of the sources of dispute.

Within the Middle East region, the situation is not different, Al-Hammad, (1993), noted that there exists “interface problems” in the relationship of a main contractor and his subcontractor. The problems do relate mainly to contract progress payment, lack of construction quality work, execution errors, and delay in shop drawings and/or sample material approval, which do mandate clear contractual responsibly to deal with the same and avoid problem escalation.

The above issues represent a challenge to any project manager whose aim is to finish his project within the given time frame and allocated budget constraints. Hence, it would be of great importance to have the particular conditions properly drafted. The same would alleviate the disputes that do relate to contractual terms and would support the contracting parties to jointly read from the same book.

The Aim of this paper is to evaluate the mostly being modified Standard Form of Construction Contract clauses in the Middle East Area. Accordingly, the paper is structured as follows: firstly, the literature review is presented by providing an overview of the Construction Industry in the Middle East Region and a review of the Construction Contracts Standard Forms with a highlight on the importance of General Conditions and Standard Forms. Secondly**,** the research method used for the paper is explained. Finally the Research findings are presented with the way forward.

2 Literature review

2.1 Overview of the construction industry in the middle east region

The Middle East region connects the continents of Africa, Asia, and Europe. The definition of the countries forming the Middle East is not well defined to the extent that not everyone agrees as to what countries can be labeled "Middle Eastern". The countries that are normally referred to being middle Easterns are: Bahrain, Cyprus, Iran, Iraq, Israel, Jordan, Kuwait, Lebanon, Oman, Qatar, Saudi Arabia KSA, Syria, the United Arab Emirates, and Yemen (Gunderson 2003).

Comprising some of the spectacular skyscrapers to artificial floating island homes, state of the art large retail malls, major residential and commercial developments, the construction industry continues to remain at the top of Middle Eastern countries agenda in their quest to create an alternative to the predominantly oil based economy. During the third quarter of 2011, the value of construction contracts awarded reached USD 36.78 billion awarded in the second quarter of the same year (Ventures Middle East, 2011).

To identify the distribution of construction projects by countries, Figure 1 indicates Projects by Country and Status of Construction.

From a different perspective, within the Middle East region, the construction market in Saudi Arabia comprises the largest construction market with multibillion dollar projects under way and many more being still in the planning stage by the private and public sectors, (Mohammed Al-Nagadi, 2011), which is in line with Figure 1.

During 2011, the Saudi Arabia's construction sector indicated a double digit growth of 11.6% in 2011 if compared to 7.8% in 2010, (Bank Audi Saradar, 2012), reflecting a positive increasing trend in the construction market which implies additional use of construction contracts and imposes additional challenges to the contractual forms. A major key driver in Saudi Arabia's construction industry is the shortage of supply and escalating demand in the housing market. In March 2011, King Abdullah released a plan to build 500,000 affordable homes within the Kingdom worth US$ 66.7 billion (Bank Audi Saradar, 2012).

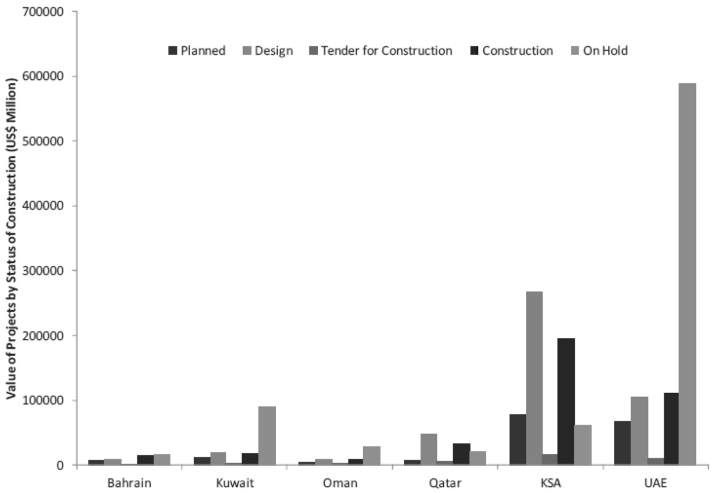

Figure 1: Projects by Country and Status of Construction (US$ Million) September 2012 (Ventures Middle East, 2012)

Another new dimension added to Saudi Arabia construction projects is the concept of economic cities with currently four are being constructed (King Abdullah Economic City, Jazan Economic City, Prince Abdul Aziz Bin Musaed Economic City, Knowledge Economic City being) with a value of around USD 50 Billion, and two More under the design and planning stage (North Economic City, Easter Province Economic City) (Saad Al Adhami, 2011).

2.2 Construction disputes observation

According to EC Harris 2013, an International Built Asset Consultancy, the construction disputes in the Middle East are more than double the global average, the same was attributed to the a failure to properly administer the contract, failure to understand and/ or comply with the parties own contractual obligations, its contractual which indicate additional urgency to further investigate the Conditions of Contracts being used (EC Harris, 2013).

2.3 What is "Standard General Conditions of Contract"?

Within the construction industry many parties are involved in projects. Those parties do mainly include the Client and the Contractor, in addition to the Project Manager, Project Consultant(s), Subcontractor(s) and Suppliers. In order to progress the proper project construction delivery on time, budget and quality (Project Management Institute, 2008) those parties need to be working in a certain close regulated manner to ensure the processes, and procedures are adhered to within the construction industry. In this regard, Contracts needs to be customized, agreed, and signed to formalize parties' relationships.

A Contract is “An agreement between two or more parties creating obligations that are enforceable or otherwise recognizable at Law” (Garner, 1995, p. 215). There are various types of construction contract. The choice of contract type depends on the project procurement methods designed to serve the project objectives and the existing constraints such as different ways of handling risk transfer, pricing, responsibility for performance, complexity, and cost certainty.

A prerequisite requirement for the signature and execution of a contract, amongst other things, is the general conditions that all the parties to the contract need to agree upon ((Tatarestaghi, 2011). “The General Conditions of Contract are general terms on which a corporation procures its resources or, contracts with other corporations” (Pathak, 2010, p. 52).

Accordingly, the General Conditions of Contracts are niched in the contracts between the owner and the general contractor, the owner and the designer, the owner and the supervisor, the owner and the professional construction manager, and between the general contractor and the subcontractors depending on the project stakeholders and the situation at hand (Sutt, 2011).

The contractual relationship is formed by the arrangement of a contract. The contract defines for the construction parties the baseline of understanding of the offer, acceptance, and consideration agreed upon for a project. Overall, general conditions of contract include provisions pertaining to many issues, particularly: defining roles, rights, responsibility, accountability, and authorities that are needed to be able to execute the agreed upon works “Experience has taught us that responsibilities without authorities are a dangerous situation in which to find oneself, and also that with authority there is associated responsibility” (Clark, 1993, p. 7).

General Conditions of Contract in construction are being standardized by several international bodies through Standard Forms of Contract which are considered to be readymade terms and conditions to be used when making a contract (Kwakye, 1997).

2.4 Why the “Standard General Conditions of Contract” use do worth investigation?

The General Conditions of Contract are as significant to the management and progress of construction projects and the profitability of the construction industry, as are accurate schedules, reliable equipment, and quality materials. Accordingly, adequately configured contractual clauses would play major role in simplifying part of the complexity associated with the construction environment (Cushman and Cook, 1995) this is one of the reasons behind the effort in establishing Standards General Conditions of Contract.

The main ambuscade is that the project parties would be focusing on the contractual aspects governing the project rather than technical and execution issues which would eventually flag hindrance in the project original schedule and certainly an escalation to the project original budget, being the contracted value, notwithstanding the project works atmosphere (Cornick et al., 1999) in the absence of clear Conditions of Contract. Therefore, Conditions of Contract are critical criteria that must be determined ahead of any purchase negotiation (Ross, 2003) due to its effect on the project progress parameters. Standard General Conditions of Contract (Standard Form of Contract) in construction are being introduced with the major advantage of establishing the same understanding of conditions between actors in a project hence reducing valuable time spent on understanding the Conditions during individual negotiations. The advantages Standard Form of Contract are not limited to the above; in fact other advantages do exist (Shnookal, 2010):

1. Since Employers, Engineers and Contractors most probably have used such contractual form, this means that they are familiar with their rights and obligations that are enclosed in the said form of contract. Accordingly, efficiency in contract administration is greatly improved. The importance of the same is highly obvious in international contracting where communication is relatively difficult and there is high probability of misunderstandings.
2. Since the Contractors are familiar with the Standard form in terms of risk allocation, the cost of tendering (on contractors) is normally reduced as Contractors understand that there is no hidden risk which may be the case when exploring terms that they are not familiar with. The cost of the same shall be reverted back to the Employers once a contract is entered.
3. "Standard forms do present an impartial starting point from which the parties can negotiate from" (Shnookal, 2010); the parties are familiar with the Standard form, the cost of negotiating the contract conditions is reduced since potential areas of disagreements within the terms are reduced keeping the Standard forms as benchmarks.
4. It is likely that the tender price be less for Standard forms since Contractors do not have to add the price of unforeseen risks that they are not familiar with or do not usually need to assume.

2.5 Construction Contracts Standard Forms

As previously discussed, Standard form contracts are pre-prepared documents where all the legal terms were previously set. There exist several International Standard forms of Contracts for construction. The Standard Form of Contract families under investigation shall include:

1. The American Institute of Architects (AIA)
2. Fédération Internationale des Ingénieurs-Conseils (FIDIC)
3. The Joint Contracts Tribunal (JCT)
4. Institution of Civil Engineers (ICE)
5. The New Engineering Contract (NEC)
6. Institution of Engineering and Technology (IET)
7. The Association of Consultant Architects (ACA)
8. BE Collaborative Contract
9. ConsensusDOCS Contracts
10. International Chamber of Commerce (ICC)

3 Research methodology

Saunders (2009) defined Methodology to be “the theory of how research should be undertaken”. Yin (2003) noted that having well designed rigorous methodology “is the logical sequence that connects the empirical data to a study’s initial research questions and, ultimately to its conclusions”. Accordingly, the research methodology is divided into phases whereby the conclusions achieved from the former phase are inputted to the upcoming phase until the research aim is finally attained.

The research methodology design of this paper can be summarized into the following four Phases:

Phase I: Review via desk research the existing families of international Standard forms of Contracts that do exist internationally in the construction industry

Phase II: Review and Identify which contract family is the mostly being used in the Middle East Area. This is done through the survey approach which addresses major contractors, major design consultants, legal consultants, and project management services providers

Phase III: Review and identify which Contractual Form of the Contract Family identified under Phase II is the mostly being used. This is also done through surveys approach and surveys addressing major contractors, major design consultants, legal consultants, and project management services providers

Phase IV: Examine and investigate the various particular conditions clauses being introduced and identify the ones that are largely subject to modifications endangering the overall spirit of the original Standard Contract Form. This shall be done through detailed analysis aiming at highlighting the contractual clauses that are subject to large modifications through the corresponding particular conditions. The same is done by ranking all contractual clauses modifications on a scale ranging from One to Three.

- One: being not modified and do not need further analysis.
- Two: represent minor modification to the Standard Contractual Form: those modifications that do not change the intent of the contractual clause. In fact those modifications that are needed for completeness, clarity, and do reflect project circumstances.
- Three: represents the contractual clauses that are majorly modified: those modifications that change the contractual clause intent such as full clause deletion, new clause introduction, partial clause deletion…etc.

Semi structured interview shall then be conducted to identify the reasons governing the modifications under Three and Two when applicable.

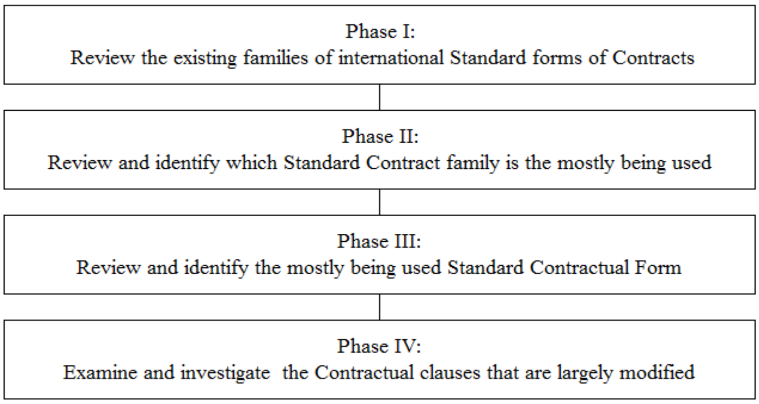

Figure 2: Research Phases Sequence

It is of the essence to note that in the absence of literature clearly identifying the mostly being used Standard Construction Contractual Form in the Middle East, the first three phases are of importance since we would like to focus our investigation, in this study, on the mostly being used Standard Contractual Form to insure wide spread benefit of this study outcome.

3.1 Data collection techniques

This research considers surveys for Phase I, II, and III. Phase IV shall be based on the data obtained and on semi-structured interviews with key industry players. Surveys were addressed to Contract Administrators, Chief Executive Officers, Lawyers, Quantity Surveyors and Project Mangers. This research focuses on the major players in the construction industry within the Middle East region. This is mainly considered because they do represent all points of view within any construction project. Concerning the sample size to be considered, this research covered the three by far largest Middle Eastern contractors, the two by far most spreading engineering consultancy firms, one of the largest project management consultancy services company, and one of the largest dispute and conflict resolution legal firm in the Middle East. The above seven organizations do have a weighing presence within the construction industry in the Middle East and the data obtained from them is expected to be representative and reflects the industry conditions and suits this research objectives.

Table 1: Data Collection Details

	Contract Administrator	*Chief Executive Officer*	*Lawyer*	*Quantity Surveyor*	*Project Manager*
Organization 1	*X*				
Organization 2				*X*	
Organization 3		*X*			
Organization 4	*X*				
Organization 5			*X*		
Organization 6					*X*
Organization 7	*X*				

3.2 Data analysis techniques

Phase I, II and III are quantitatively analyzed and ranked through the use of spread sheets- excel software. Phase IV of this research considers ranking the modifications introduced to the Standardized Contractual Conditions into three levels through Modifications Indicators Ranking "MIR", depending on the degree of modifications assessed; One being not modified and three highly modified. Accordingly, each modification was first analyzed from a qualitative point of view and given a certain MIR which would transform qualitative data to quantitative data to be inputted to spread sheets for overall ranking. When the said ranking is set, semi structured interview shall take place; the outcome of which shall be considered for quantitative content analysis. It is of the essence to keep in mind that some modifications may be proper and others may be improper both would require thorough investigation. Brief description of Phase IV initial findings is found in the upcoming sections.

4 Research findings

4.1 Phase I: Review of the existing families of international Standard forms of contracts

Despite the fact that a desk research has been conducted to review and identify the existing families of international Standard forms of Construction Contract, the considered issued surveys addressed the issue of completeness of the reviewed families. The survey results for Phase I did not reveal any additional family of Standard form of contract that is normally being adopted within the Middle East region. Accordingly the earlier Ten identified families of Standard contract in the literature review section shall further be considered for investigation.

4.2 Phase II: Review and Identify which Standard contract family is the mostly being used in the Middle East Area

The prepared surveys were issued to the survey participants. The obtained data was then entered into a spread sheet for averaging. The results of the same indicated that the mostly being adopted family of Standard forms of Contract is "Fédération Internationale Des Ingénieurs-Conseils" in French which is commonly known by FIDIC being The International Federation of Consulting Engineers, (Bunni, 2005), with more than 50% adoption against the other families. The findings can be summarized in Table 2 below.

4.3 Phase III: Review and Identify the mostly being used Standard Contractual Form within that contract family in the Middle East region

Now that Phase II provided and indication about the mostly being adopted Standard contract family which is the FIDIC range of contracts, Phase III focuses on the FIDIC Standard Contract Forms in terms of adoption.

FIDIC was founded in 1913 by three countries. The founding member countries of the FIDIC were Belgium, France and Switzerland. FIDIC is known for producing Standard forms of contract for civil engineering construction, and mechanical and electrical plant. The suite of FIDIC contracts are well known by their colors, for instance: Conditions of Contract for Construction ("Red Book"), Conditions of Contract for Plant and Design-Build ("Yellow Book"), Conditions of Contract for EPC/Turnkey Projects ("Silver Book"), Short Form of Contract ("Green Book") …..etc. The suite of contracts presented by FIDIC in 1987 were replaced in 1999 (fidic.org). It is worth noting that there are important changes between those issued in 1987 and the 1999.

The result of the survey conducted to identify the mostly being used FIDIC Standard Contract From is found in Table 3.

Table 2: Average percent adoption of Standard Contract Families in the Middle East region

	Standard Contract Family	***Average Percent (%) Adoption***	***Organization 1***	***Organization 2***	***Organization 3***	***Organization 4***	***Organization 5***	***Organization 6***	***Organization 7***
1	*The American Institute of Architects (AIA)*	**18%**	*12%*	*15%*	*11%*	*35%*	*22%*	*15%*	*16%*
2	*Fédération Internationale des Ingénieurs-Conseils (FIDIC)*	**52%**	*45%*	*60%*	*72%*	*41%*	*38%*	*51%*	*57%*
3	*The Joint Contracts Tribunal (JCT)*	**12%**	*13%*	*14%*	*10%*	*6%*	*16%*	*13%*	*12%*
4	*Institution of Civil Engineers (ICE)*	**2%**	*3%*	*4%*	*0%*	*0%*	*4%*	*3%*	*0%*
5	*The New Engineering (Contract NEC)*	**8%**	*20%*	*0%*	*2%*	*10%*	*8%*	*1%*	*15%*
6	*Institution of Engineering and Technology (IET)*	**0%**	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*
7	*The Association of Consultant Architects (ACA)*	**0%**	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*
8	*BE Collaborative Contracts*	**4%**	*5%*	*2%*	*2%*	*6%*	*7%*	*6%*	*0%*
9	*ConsensusDOCS Contracts*	**3%**	*2%*	*5%*	*3%*	*2%*	*5%*	*4%*	*0%*
10	*International Chamber of Commerce (ICC)*	**1%**	*0%*	*0%*	*0%*	*0%*	*0%*	*7%*	*0%*
	Total	**100%**	*100%*	*100%*	*100%*	*100%*	*100%*	*100%*	*100%*

The survey indicate that the mostly being used Standard contract form is the Conditions of Contract for Works of Civil Engineering Construction (Red Book 4th) with 28% then comes the Conditions of Contract for Construction, for Building and Engineering Works, Designed by the Employer (Red Book 1999) with 24% adoption. Accordingly, the upcoming sections of this paper will be focusing on the Conditions of Contract for Works of Civil Engineering Construction (Red Book 4th).

Table 3: Average percent adoption of FIDIC Standard Contract Forms in the Middle East region

	Standard Contract Form	*Avg (%)*	*Organization 1*	*Organization 2*	*Organization 3*	*Organization 4*	*Organization 5*	*Organization 6*	*Organization 7*
1	*Conditions of Contract for Electrical and Mechanical Works including erection on site (Yellow Book)* *First Edition 1963* *Third Edition 1987*	0	0	0	0	0	0	0	0
2	*Conditions of Contract for Works of Civil Engineering Construction (Red Book 4th)* *First Edition 1957* *Fourth Edition 1987* *Reprinted 1988 with editorial amendments* *Reprinted 1992 with further amendments* *Supplement to the 1992 Red Book published in 1996 and 2011*	28	15	42	23	20	34	37	25
3	*Conditional of Contract for Design-Build and Turnkey (Orange Book)* *First Edition 1995*	4	4	5	3	4	4	4	4
4	*Conditions of Sub-contract for Works of Civil Engineering Construction* *First Edition 1994*	3	0	1	3	5	3	4	5
5	*Short Form of Contract (Green Book)* *First Edition 1999*	1	0	0	0	0	4	3	0
6	*Conditions of Contract for Construction, for Building and Engineering Works, Designed by the Employer (Red Book 1999)* *First Edition 1999*	24	30	20	31	32	16	18	21
7	*Conditions of Contract for Plant and Design-Build for Electrical and Mechanical Plant, and for Building and Engineering Works, Designed by the Contractor* *(Yellow Book)* *First Edition 1999*	12	15	11	14	8	7	16	13

8	*Conditions of Contract for EPC Turnkey Projects (Silver Book)* *First Edition 1999*	6	12	0	3	8	7	0	12
9	*Form of Contract for Dredging & Reclamation Works (Blue Book)* *First Edition 2006.*	2	2	1	3	3	2	2	1
10	*Conditions of Contract for Construction: The Harmonised Multilateral Development Banks Form of Contract (Pink Book)* *First Edition 2005* *Third Edition 2010*	2	2	1	2	2	5	1	1
11	*Conditions of Contract for Design, Build and Operate Projects (Gold Book)* *First Edition 2008*	5	5	5	4	5	6	5	5
12	*Conditions of Subcontract for Construction (compatible with the 1999 Red Book)* *First Edition 2011*	13	15	14	14	13	12	10	13
	Total	% 100	100	100	100	100	100	100	100

4.4 Phase IV: Examine and investigate the contractual clauses that are largely modified

In this phase, the particular conditions of contract for the Conditions of Contract for Works of Civil Engineering Construction (Red Book 4th) were collected, analyzed and ranked into three categories the following chart represent the initial finding concerning the extent of modifications. It is of the essence to note that Figure 3 considers only the modifications of the original clauses found in the Standard Contractual Form and does not include any consideration of the additional Clauses introduced.

The major modifications were associated with the Clauses addressing Contractor's General Responsibilities, Claims Under Performance Security, Sufficiency of Tender, Programme to be Submitted, Cash Flow Estimate to be Submitted, Liquidated Damages for Delay, Variations, Measurement, Settlement of Disputes, Default of Employer, Cost and rate of Exchange.

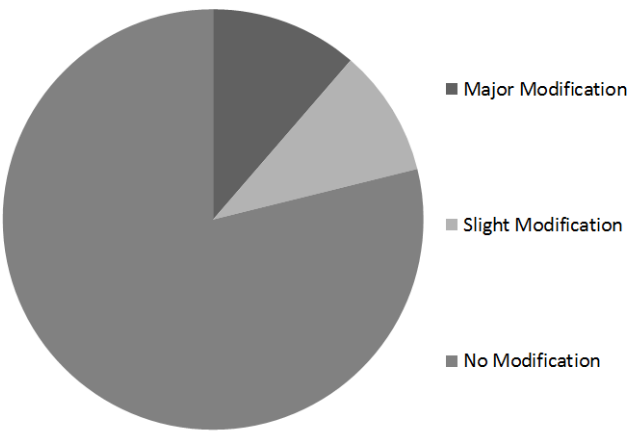

Figure 3: Initial finding concerning the extent of modifications

5 Way forward

The findings under Phase IV need to be further analyzed, Phase V, in a way to understand the reasons behind introducing the said modifications and the effect these modifications had on the project. Accordingly, recommendation in relation to the modifications would be drawn and formalized. Phase V considers semi structured interviews in addition to literature review to be able to achieve a sound recommendation.

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Quantity Surveying Role and Environmental Influences in Saint Lucia

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Abstract

Professional Quantity surveyors (PQSs) play a vital role in the construction industry in terms of managing and controlling costs of projects, which has been documented in many studies in the construction field. The environmental influences or forces from the constantly changing construction business environment have caused PQSs to adapt and evolve their role over time in order to survive and prosper. The study aims to evaluate the changing role of the PQSs in construction business environment and the environmental influences impacting on their role and business performance. The descriptive research method was used in the study, which involved the mixed methods approach for the primary data collection. Firstly, interviews of the experienced PQSs, which provided the qualitative data for analysis. Questionnaire was the next approach used which provides the qualitative data. This approach involved the widespread survey of the PQSs registered with the Institute of Surveyors Saint Lucia (ISSL), for which an overall response rate of 76.5% was obtained.

The findings of the research revealed the following: The PQSs in Saint Lucia confirmed that the quantity surveying (QS) profession and their roles are changing but albeit at a slow pace; PQSs are still deeply rooted in the traditional roles, with the quantification and costing of construction works and project financial control and reporting were perceived as the two most important roles; The evolved roles have been moderately accepted; and Future (growth areas) directions of the QS practice were perceived to be largely in the emerging roles, in particular Building Information Modelling (BIM) management and Whole Life Costing (WLC) Assessment. They considered the internal environmental influences to have the greatest impact on their role and practice. The study concluded that PQSs in Saint Lucia perceived that they are using mainly their traditional core competencies and some non-traditional competencies to respond to the demands of the rapidly changing business environment. The findings of the research provide an important contribution towards filling the significant gap in existing knowledge in the construction industry and have implications on service expansion and development and strategy development of the PQSs in Saint Lucia in the future.

Keywords: construction industry, quantity surveying role, business environment, environmental influences, Saint Lucia.

1 Introduction

The construction business environment in Saint Lucia is becoming increasingly competitive and dynamic as a result of the impact of the economic recession, the changes in client requirements and political forces. These environmental influences (i.e. forces and events impacting on their future) have changed the role of PQSs in Saint Lucia although at a slow pace. They therefore need to constantly scan and proactively monitor the key influences in their environment in order to discern new directions, adapt changes in their professional practice and remain relevant in the industry as suggested by Frei and Mbachu (2009).

The overall aim of the research paper is to evaluate the impact of the environmental influences in the construction industry towards quantity surveying role in Saint Lucia. The objectives of the paper are to: (1) Evaluate the changing role of PQSs in the construction industry in St. Lucia; and (2) Identify and evaluate the environmental influences and their effects on the role of PQSs and the QS profession in Saint Lucia.

This study therefore provides invaluable knowledge to the construction practitioners, researchers and other key stakeholders in better understanding the role of PQSs in a rapidly changing business environment for their strategic planning and decision making. The extensive literature review in the field of QS reveals that there has been a significant amount of studies on the role of PQSs and QS practices. However, there is a paucity of research in the field of QS in Saint Lucia. This paper seeks to fill some of the gaps in the literature and is presented as follows: the literature review; followed by the research methodology, which briefly described some limitations; the analysis and the discussions of the results; and conclusions are drawn from the results.

2 Literature review

2.1 Role of the professional Quantity Surveyors

The primary role of a PQS is to manage the costs relating to building projects during their life cycles (Seeley, 1997). According to RICS (2014), PQSs are the cost managers (engineers) of construction and work in all sectors of the construction industry worldwide.

Table 2.1: Competencies required by Quantity Surveyors for RICS APC

Competency	*Attribute*
Mandatory	*Conduct rules, ethics and professional practice; Client care; Communication and negotiation; Health and safety; Accounting principles and procedures; Business planning; Conflict avoidance, management and dispute resolution procedures; Data management; Sustainability; Team working.*
Core	*Design economics and cost planning; Contract practice; Construction technology and environmental services; Procurement and tendering; Project financial control and reporting; Quantification and costing of construction works.*
Optional	*BIM management; Capital allowances; Commercial management of construction; Conflict avoidance, management and dispute resolution procedures; Contract*

	administration; Corporate recovery and insolvency; Due diligence; Insurance; Programming and planning; Project evaluation; Risk management; Sustainability.

Source: RICS (2014)

RICS (2014) has considered the role of the QS in terms of competencies and described "competencies" as the capabilities, behaviours, knowledge, skills and attitudes required to perform a specific function with competence. It has grouped the competencies required of the PQSs seeking assessment of professional competence (APC) into three distinct categories: mandatory or basic competencies, core competencies and optional competencies as shown in table 2.1 above. In this study, the role of PQSs will be categorized as traditional and non-traditional (evolved and emerging) roles. The RICS core competencies are the traditional roles of PQSs, while the optional competencies encompass mainly the evolved roles and some emerging roles. It is very unlikely that all these optional competences will be performed by any one PQS.

2.1.1 Traditional role of the professional Quantity Surveyors

The traditional role involves the original and core professional services for which the quantity surveyor existed and the QS profession was established. The traditional roles are described as a measure and value system (Ashworth, 2010) and are the core competencies identified by the RICS in table 2.1 above. Empirical studies within the industry (Smith, 2004; Perera and Pearson, 2011) suggest that the traditional role (core competencies) will continue to be highly important in the future. It is recognized that over past few decades, PQSs have ventured and diversified into services or roles beyond the traditional boundaries of cost management. (Haron and Abdullah, 2006). The emergence of the non traditional roles was as a consequence of the changes in key environmental influences, which include, inter alia, changes in client needs, market, industry and QS profession (RICS, 1991); developments of ICT (Cartlidge, 2002; Smith, 2004; the education system received by them over time (Badu and Amoah, 2004); and research and its dissemination as well as the trends in sustainability (Ashworth, Hogg and Higgs, 2013);

2.1.2 Evolved and emerging roles of the PQSs

The evolved roles entail the additional non-traditional professional services that have been evolved (Frei and Mbachu, 2009) and gradually accepted over time by PQSs. Most of the evolved competencies shown in table 4.2 are emanated from the RICS optional competencies in table 2.1 above. According to Fanous (2012), the emerging roles in QS are areas which are being, or have recently been introduced into the QS profession and include Whole-life Costing (WLC) Assessments, Sustainability, and BIM management. Furthermore, strategic management and leadership competency is also currently emerging and enables PQSs to focus on the overall management and the strategic direction of their practice to achieve sustainable value creation and to assume strategic leadership roles in construction projects.

In order to meet the clients' requirements in the 21st century, the PQS should possess a blend of three pillars of QS competencies: technical expertise, management and strategy competencies, in addition to the mandatory competencies. It is notable that management oriented competencies as well as the development of soft skills (Leveson, 1996; Nkado, 2000) and strategy competencies will be the key business imperatives for the PQS responsiveness to the clients' needs and their ultimate future business success. The PQS future role requires a deeper understanding of the strategic aspects of context relevant competencies. Examples include, inter alia, strategic cost management, strategic project management and strategic risk management.

2.2 The QS in a changing business environment

PQSs need to continuously adapt to and influence the changing environment factors or influences emanating from their environment in order to operate successfully by conducting some form of environmental scan or analysis (EA) (Wetherly and Otter, 2011). The EA will allow them to identify, evaluate and understand the strategic environmental influences to gain a greater understanding of their strategic position in the marketplace and accordingly they will have to build strategic resilience, i.e. acquiring adaptive competencies in order to adjust their service offerings and strategies. Furthermore, AE preordains a level of strategic thinking (Langford and Male, 2001) and strategy formulation (Wheelen and Hunger, 2012). Lansley (1987) emphasises the importance for construction firms to undertake some form AE. Without continually scanning the environment in which they operate, PQSs will be at the risk of strategic drift (Johnson and Scholes, 2002), where their competencies, services and strategies will be out of alignment with the changes in the environment and can lead to performance downturn and ultimately the demise of their practices.

2.2.1 External Environment analysis

In assessing the external environment, a QS practice can apply PESTEL analysis to identity and explore the macro environment influences that are likely to impact on its reputation, services and business performance and the industry it operates in as follows:

- **Political environment:** These factors include political stability, change of government, changes in its policies and legislative programme and government spending on research (Johnson and Scholes, 2002). The Government of St. Lucia introduced 15% VAT in 2012, which has in part caused inflation to increase (GOSL, 2013).
- **Economic Environment:** The economic influences include, inter alia, changes in interest rates, exchange rates, inflation rates, business cycles, GDP and demand, unemployment, disposable income and availability of credit (David, 2011). The global financial crises have caused a downturn in the global construction sector and the economy (Frei, 2010). St. Lucia experienced a downturn in the economic and construction sector in 2012 (GOSL, 2013).
- **Social environment:** the socio-cultural influences include the changes in population demographics make-up and spread, and changes in income distribution, lifestyle and attitude of individuals (Johnson and Scholes, 2002) and culture and its effects on the organization.
- **Technology environment:** The technological forces include new technologies, the pace of technological change and government spending on R&D in industry (Johnson and Scholes,

2002). Relevant literature (Smith, 2004; Oladapo, 2006) highlight the importance of the use of IT and ICT to improve the quality of professional services.

- **Environmental (green) factors:** include attitude of an organization towards pollution control; environmental protection laws; and energy consumption (Johnson and Scholes, 2002) and more specifically the PQSs attitude towards sustainability (Ashworth et al., 2013). Now governments and other key stakeholders in industry are placing greater emphasis on green factors in particular environmental sustainability which requires PQSs to broaden their role and knowledge base (RICS, 2009a) in areas such as energy assessments.
- **Legal environment:** This is characterized by changes in rules and regulations in the global construction industry. For example, RICS, (2009b) has developed a suite of New Rules of Measurement (NRM)) for measuring building works to reflect changes in the environment.
- **The industry competitive environment:** PQSs can assess the sources of competition in the industry by using the Porter's five forces framework: competitive rivalry, threat to entry, threat of substitute products, bargaining power of clients, bargaining power of suppliers to determine the profit potential of the industry and its sub-markets (Johnson and Scholes, 2002).

2.2.2 Internal environment analysis

Scanning and analyzing the internal environment involves an assessment of the strategy capability (competencies and resources) of the organization with tools such as internal organization analysis and value chain analysis (Wheelen and Hunger, 2012). Barney (1991) who advocated resource (capability) based view stressed the importance the internal analysis and the resultants internal forces as fundamental sources of gaining competitive advantage and improving performance.

The SWOT analysis will bring together the key strategic issues arising from the external and external environmental analyses and setting the agenda for an organization's business, service and strategy development (Johnson and Scholes, 2002). This analysis gives a more holistic assessment of the business environment.

3 Research methodology

3.1 Research method and design

The descriptive research method was employed in this research, where mixed methods (quantitative and qualitative) approach was utilized for the primary data collection and analysis (Krishnaswamy and Satyaprasad, 2010; Creswell, 2009). The qualitative approach was the predominant, which took the form of semi-structured interviews with the PQSs to obtain significant insight into the subject matters. Meanwhile, the quantitative approach involved a widespread questionnaire survey conducted amongst PQSs registered with the Institute of

Surveyors (St. Lucia) (ISSL). The extensive literature review was undertaken to generate the secondary data for the study.

Questionnaire and the interviews were designed, pilot tested and administered. The interview questions address, inter alia, the key roles and the business environment of the PQS identified in the literature. The survey questionnaire was structured similarly to that of the semi-structures interviews, thereby facilitating triangulation of the findings (Fellows and Lui, 2008) and respondents were required to rate their perceived importance or impact on a 5-point Likert scale.

3.2 Data collection and analysis

Thematic analysis was used to identify and analyze the common patterns (or themes) within the qualitative data set (Braun and Clarke, 2006) from the interviews, which were recorded and transcribed. The responses from the questionnaire were tabulated and analyzed based on descriptive statistics of mean scores using Microsoft Office Excel to draw conclusions.

3.3 Research population and sampling

The initial target population of survey was obtained from the list of 44 registered PQSs published on the website of ISSL. As result of this relatively small population size, a total population sampling technique was adopted (Krishnaswamy and Satyaprasad, 2010) in this study. Meanwhile, 10 members were excluded from the sample survey. The questionnaires were distributed by email or hand to the balance of 34 full members, out of which 26 were returned fully completed. The interviews were conducted with a selective sample of 11 PQSs. Respondents from the interviews also participated in the questionnaire survey to ensure validity and reliability of the analysis. The table 3.3 below shows the population and sample sizes and the response rate for the questionnaire survey. The response rate of 76.47% is adequate and higher than many cited works on construction industry by leading authors (Frei and Mbachu, 2009; Nkoda, 2000).

Table 3.3: Population & sample sizes and Response Rate of questionnaire

Initial survey population size	*44*
Exclusions (overseas or could not be contacted and technicians)	*10*
Final sample size	*34*
Questionnaire administered by researcher	*19*
Self administered by respondents and emailed	*7*
Total number of responses	*26*
Overall response rate	*76.47%*

3.4 Research limitations

Time and resources were the limitations of the research study. Furthermore, the investigation was limited to the views expressed by QS practitioners in Saint Lucia and the population sample was size. However, due to the validity of the study, extensive literature review, the management of the research design and process, and minimization of research biases; researchers and practitioners can using these finding to generalized beyond Saint Lucia.

4 Analysis and discussion of results

4.1 Interview discussion findings

4.1.1 The roles of the PQSs in the construction industry

Generally, the respondents agreed that the role of the PQS has changed slightly to embrace some evolved competencies as result of the changes in clients' requirements and the political and economic environments. One of the respondent suggested that "the traditional role will remain whilst the role of PQSs are changing slowly to adapt to customers and market changes" The unanimous consensus amongst respondents is that the traditional role of the PQS has and will continue to dominate in the future in Saint Lucia. Another respondent perceived that "we are stuck to the traditional paper based measurement approach and this will continue in the near future." This view suggests that PQSs in Saint Lucia are focusing on the core competencies which largely define their functional role.

The respondents were generally of view that the evolved role has been moderately accepted and incorporated in the QS role in Saint Lucia. Valuation, contract administration and construction project management were common amongst most respondents. All the respondents unanimously agreed that currently the emerging role of QS is very low in acceptance and is slightly likely to be accepted in the future. The general perception was that WLC assessment will become important in the future.

4.1.2 The key environmental influences that impact on the PQSs role and practice

The respondents were generally well aware of and understand the key environmental influences that affect their role and professional practices. The economic and political forces were cited as having the most profound impact on the QS profession. Most of them claimed that the global economic recession has led to a reduction in the demand for construction activities and may reduce the demand for their services in the future. This is in corresponds with the views of Frei (2010) noting that the global financial crisis is having devastating effects the construction industry and the PQS operating in it.

According to most respondents, technological forces have not really impacted on their role and business practice due to their micro practices (less than 10 employees) , lack of financial capacity to invest in ICT in construction and associated training and their attitude to use ICT in their practice. However, they believe that ICT will become important to the QS profession sometime in the future.

There were mixed views from the respondents regarding the socio-cultural forces. They identified a numbers of key social-cultural that have impacted on the QS profession including professional culture of individualism, unethical practices in the area of valuation and the complacent attitude of PQSs towards quality of service and work. Many respondents cited the professionalism, client’s satisfaction and high quality of QS services are the three important pillars required to build the reputation of QS profession. Furthermore, most respondents suggested that there is a growing recognition of the QS profession and this will positively impact on their practice in the future. This view differs from that of Smith (2004).

The majority of respondents suggested that both the green and legal forces have not impacted significantly on the QS profession as a result of the inertia or reluctance of government and the QS profession to adopt new regulations in the industry. This view is a divergence to that of RICS (2009a; 2009b) and Ashworth et al. (2013).

Many respondents cited competition amongst QS practitioners, client bargaining power and changing needs, provision of services at very low fees and other construction professionals competing for traditional QS work are some of the key competitive forces that have impacted on QS practice. However, most of them are of the belief that the competition is not very intensive but may intensify if the economic recession continues in the immediate future. In the interview discussions, the most respondents agreed that internal organization forces if they are properly deployed will contribute to competitive advantage and improve their performance. This finding confirms with Barney (1991) resource based view.

4.2 Questionnaire survey results

4.2.1 Roles of PQS in the construction industry

The 21 roles listed in the questionnaire were identified in the literature review including six roles were traditional, ten were evolved and five were emerging. Most of them emanated from the RICS (2014) and Fanous (2012). The table 4.2 below shows the perceived ranking of current and future roles of the PQSs along with the potential future growth.

Table 4.2: Relative importance of the Competencies of PQs with likely future growth

Where 1= Not important, 2= Of little important, 3=Moderately important, 4=Very important and 5 = Extremely important

		Mean	***Rank***	***Mean***	***Rank***	***%***
a	***Traditional role (average score)***	***4.31***	***1***	***4.63***	***1***	***7.4%***
1	*Quantification and costing of construction works*	*4.81*	*1*	*4.77*	*1*	*(0.8)%*
2	*Project financial control and reporting*	*4.46*	*2*	*4.73*	*2*	*6.0%*
3	*Procurement and tendering*	*4.35*	*3*	*4.58*	*5*	*5.3%*
4	*Contract practice*	*4.12*	*4*	*4.62*	*4*	*12.1%*
5	*Cost planning*	*4.08*	*5*	*4.65*	*3*	*14.2%*
6	*Construction technology and environmental services*	*4.08*	*5*	*4.46*	*6*	*9.4%*
b	***Evolved Role (average score)***	***3.31***	***2***	***3.95***	***2***	***19.3%***
1	*Valuation (property, rental, etc)*	*4.42*	*1*	*4.38*	*3*	*(0.9)%*
2	*Contract administration*	*3.65*	*2*	*4.42*	*2*	*21.1%*
3	*Consultancy services*	*3.65*	*2*	*4.27*	*4*	*16.8%*
4	*Project Management*	*3.54*	*4*	*4.46*	*1*	*26.1%*
5	*Insurance*	*3.54*	*4*	*3.96*	*6*	*12.0%*
6	*Facilities management*	*2.54*	*6*	*3.00*	*10*	*18.2%*
7	*Risk management*	*3.27*	*7*	*4.04*	*5*	*23.5%*
8	*Management and Dispute Resolution procedures*	*3.04*	*8*	*3.81*	*7*	*25.3%*
9	*Development/investment Appraisal*	*3.04*	*8*	*3.81*	*7*	*25.3%*
10	*Research Methodologies and Techniques*	*2.42*	*10*	*3.38*	*9*	*39.7%*
c	***Emerging Role (average score)***	***2.37***	***3***	***3.37***	***3***	***42.2%***
1	*Whole Life Costing Assessment*	*2.54*	*1*	*3.65*	*1*	*43.9%*
2	*Strategic Management and Leadership*	*2.54*	*1*	*3.58*	*2*	*40.9%*
3	*value management studies*	*2.50*	*3*	*3.27*	*4*	*30.8%*
4	*Sustainability*	*2.42*	*4*	*3.42*	*3*	*41.3%*
5	*BIM Management*	*1.85*	*5*	*2.92*	*5*	*58.3%*

Current practice

In overall terms, the findings showed that the three most important of all roles performed by PQSs (in descending order of mean scores) were quantification and costing of construction works; project financial control and reporting; and valuation. The three least important undertaken roles are BIM management, sustainability, and research methodologies/techniques.

The research results indicated that currently the PQSs have ranked the traditional roles (average score of 4.31) as the most important. Quantification and costing of construction works, project financial control and reporting, and procurement and tendering were ranked the three most important tradition roles performed by QS in descending order of importance. This was followed by the evolved roles, being moderately important (mean value of 3.31) by the PQSs, with valuation (4.42), contract administration (3.65) and consultancy services (3.65) were ranked as the three most important roles. PQSs have attached the lowest rankings to the emerging roles (average score of 2.37). The two highest ranking emerging competencies were (in order of mean scores): WLC assessment and strategic management studies, which are perceived by the practitioners to continue in the future. The survey respondents ranked BIM management competency as the lowest overall both now and in the future, which generally resonates more with developing countries. These results in overall terms are in line with the interview analysis.

Future Expectations and directions

The study results indicated that PQSs perceived that all the 21 roles will grow in importance in the future except for quantification and costing of construction works and valuation showing negative growth, which were already very important to the QS practice. It is also notable that respondents rated all the competencies above midpoint (3.00) with the exception of BIM management. The three most important of the 21 roles ranked by PQSs were quantification and costing of construction, project financial control and reporting, and cost planning. It should be noted that cost planning as a traditional role was perceived to move up the rank in the future from the lowest ranked role to being ranked the third highest and was the highest potential growth area (14.4%), will enable PQSs to place greater appreciation of the clients requirements for early cost advice and involvement in the process. The importance of cost planning was also noted by Dada and Jagboro (2012).

The PQSs are predicting that the traditional roles will grow in importance to become close to extremely important (mean score of 4.63) in the future. This is followed by the evolved, which will be near to very important (mean score of 3.95) and then the emerging roles, which will become moderately important (mean score of 3.37) in the future.

On average, the emerging roles were predicted to experience significant growth of 42.2% in the future. Meanwhile, the evolved roles were forecasted to growth in importance by 19.3%. Of these evolved roles, project management was perceived to grow in importance by 26.1%, being ranked the highest. This outcome concurs with the findings of Nkado (2000). The perceived importance of the traditional roles was forecasted to growth by 7.4%, being rated the lowest overall. The three key areas of high growth in descending order are BIM management, forecasting 58.3% growth; WLC assessment, forecasting 43.9% growth; and sustainability, forecasting 41.3% growth. This may suggest that the QS practices are planning to expand and diversifying their service offerings in future.

Overall PQSs in Saint Lucia are of the view that the traditional roles will continue to dominate in the future, which is similar with the findings of Perera and Pearson (2011). At the same time the non-traditional (evolved and emerging) roles were predicted to grow in future importance to add value to the clients.

4.2.2 Environmental Analysis and influences

The respondents' views on the environmental analyses lied between moderately important (3) to very important (4). They indicated that internal organization analysis (4.04) and SWOT analysis (4.04) were perceived as very important to their practice. These are followed by the macroeconomic (3.77) and the industry competitive (3.69) analyses that were close to very important for their practice.

The research findings showed that key environmental influences that have impacted on the respondents practices in descending order if importance as follows: Internal organization factors (4.19); Economic factors (4.15); political factors (3.77), industry competitive forces (3.58), social factors (3.50), technology factors (3.31), legal factors (2.92) and environmental green factors (2.42). It can be seen that the internal organizational factors were viewed to have the highest (positive) impact on their future practices. This may indicate that they are placing great emphasis on the internal capabilities and competencies of the practice in order to meet the client's needs and achieve competitive advantage. This is consistent with the Resource Based View advocated by Barney (1991) as mentioned in the interview discussions above.

The economic factors were ranked as having the next highest influence on their practice. This finding is similar with the views of Frei (2010) and expressed by the respondents in interview phase of the study. This signifies that the role of PQS in construction cost management has become even more critical in this recessionary time in order to meet the client's needs as noted by Smith (2004). The green factors are perceived to have the lowest impact on the QS practices, which may suggest that the PQSs have placed least emphasis on environmental sustainability issues in discharging their role which represents a divergence from the views of RICS (2009a).

5 Conclusions

In summary, the research has critically evaluated the roles of PQSs in Saint Lucia in the context of the changing business environment. The results concluded that the "technical" `traditional core competencies were ranked as the most important competencies by the PQSs and will continue to dominate the profession in the future in Saint Lucia. To take advantage of the traditional roles or core competencies, PQSs indicated that they should place greater emphasis on the analysis of the influences within the internal organization environment in order to gain competitive advantage and improve their business performance.

The evolved roles have become moderately accepted in the QS practice. Evaluation, consultancy services and contract administration were perceived as the most important evolved roles of the PQS. Research methodologies and techniques competency is the least important to the QS practice. With regards to the emerging role, PQSs perceived them to be the least accepted role in their practice. It is recognized that WLC Assessment and strategic management and leadership competencies are emerging and perceived to grow in the future. BIM management is the least important emerging role of the PQS, currently and in the future.

The study revealed that the internal organizational factors will have the most likely impact on the QS practice in the future. This suggested that PQSs recognized the importance of matching their competencies and other capabilities to the changes in the business environment to gain competitive advantage and their improve business performance. Furthermore, PQSs' perception of the analysis of the business environment lies between moderately important (3) to extremely important (5). The internal organizational analysis and SWOT were perceived by PQSs to be the most important. However it was also confirmed by most PQSs in the interview discussions that they do not have a formal systematic way of carrying out the analyses of the business environment. From the forgoing, PQSs will continue to play a strategic role in the construction industry in the future by using a combination of their technical and management competencies. Finally, the findings of this study will have implications for PQSs in relation to service and strategy development in the future and the avoidance of strategic drift.

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Organizational Effectiveness of Building Project Organisations and Greenfields to Develop

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Abstract

The purpose of this paper is to explore and categorise the different approaches used to determine organizational effectiveness of construction project organizations. First, the conceptualization of organizational effectiveness is reviewed. This resulted in three main approaches that are used to categorise the approaches used within construction literature. Then, based on a structured literature search in scopus, the main approaches applied within construction industry based research are categorised and potential areas for further development have been determined. It has been found that the use of the multiple constituencies approach to organizational effectiveness is very limited within construction literature, while it may deepen our understanding on the determinants of construction project success.

Keywords: Effectiveness, Performance, Construction project organization.

1. Introduction

Organizational effectiveness or performance is the ultimate dependent variable in much organization and management research (Cameron & Whetten, 1983; March & Sutton, 1997). Discovering the independent variables that define effective and ineffective organizations is the major challenge for organizational evaluation (Cameron & Whetten, 1983). The conceptualization of organizational effectiveness has been very broad the last century resulting in three major approaches: goal-attainment approach, system(-resource) approach and multiple/strategic-constituencies approach (Carton, 2004; Glunk & Wilderom, 1996; Henri, 2003).

In the construction industry the same challenges are present when measuring the effectiveness of building project organizations. For instance, there are many recent articles that have taken on the more classical goal-attainment approach (Hale, Shrestha, Gibson, & Migliaccio, 2009; Raisbeck, Duffield, & Xu, 2010).

The purpose of this paper is to explore the different approaches used within literature concerning the construction industry. Based on a structured literature search in Scopus the main approaches applied within the industry are categorised and potential areas for further research are determined.

2. Overview of effectiveness constructs and models

As stated by (Cameron, 1986; Carton, 2004) and many other researchers, organizational effectiveness is a problem-driven and multi-dimensional construct. Constructs, by definition, have no objective referent. They are mental abstractions used by individuals to interpret their own reality (Cameron, 1986). This means that the criteria used to measure organizational effectiveness are based on the values and preferences of the individuals that participate in a research project. The search for the definition of organizational effectiveness is therefore infinite. However, several approaches have been developed to capture this construct the last few decades. Carton (2004) analysed eight different approaches and concluded that three primary constructs remained. These approaches are summarised in the following table (Table 1).

Table 1: The three primary approaches to capture the construct of organizational effectiveness (derived from: Carton, 2004, pp. 62-66)

Approach	*Conceptualization of the organization*	*Focus*	*References*
Goal attainment	*Organization as a rational set of arrangements oriented towards achieving goals*	*exclusively on the ends: achievement of goals, objectives, targets, etc.*	*(Etzioni, 1960)*
System resource	*Organization as an open system (input, transformation, output).*	*While not neglecting the importance of the ends, emphasizes the means* *needed for the achievement of specific ends in terms of inputs, acquisition of resources and processes*	*(Yuchtman & Seashore, 1967)*
Multiple/Strategic-constituencies	*Organization as internal and external constituencies that negotiate a complex set of constraints, goals and referents.*	*This model broadens the scope of the goal attainment and system resource models by adding the expectations of the various powerful (internal and external) interest groups that gravitate around the organization (owners, employees, customers, suppliers, creditors, community and government)*	*(Connolly, Conlon, & Deutsch, 1980)*

The different models will be further explained in the following paragraphs.

2.1 Goal attainment models

This approach relies on the vision of organizations as a set of rational set of agreements oriented toward the achievement of goals (Goodman & Pennings, 1977). These goals are mainly set by management. Effectiveness is measured in terms of accomplishment of outcomes (Etzioni, 1960). This approach rejects the premise that an organizational effectiveness construct can be universally defined or measured in terms of a static set of measures (Carton, 2004).

Since the 1960's, there is and has been a lot of criticism on the goal attainment approach. Ward, Curtis, and Chapman (1991) pointed out several weaknesses in using the goal approach for the evaluation of construction projects. One of them is the setting of objectives on an appropriate level. Apparent success in terms of meeting or exceeding an objective may just reflect an easily achieved objective (Ward, et al., 1991). Comparing PPP or D/B delivery methods with traditional methods based on the achievement of goals can also run into other fundamental problem: in a traditional setting the project goals are mainly defined unilaterally by the client or the clients representative, in a PPP or D/B setting the goals are often defined by the client and the main contractor together. Also, the performance can be affected by the external context. The application of the fairly new Design and Build contracts could, for example, have resulted in the assignment of more experienced project managers on the client as the contractors side. Other limitations of this approach are given by (Ghorpade, 1970). He states that multiple and even incompatible and implicit goals exist in organisations. Focussing on official or formal goals is misleading, for these goals are mostly incomplete or nothing more than window-dressing (Glunk & Wilderom, 1996). They can also vary over time and also in the degree in which they are being taken seriously by key members or stakeholders of the organisation (Tsui, 1990).

2.2 System (resource) models

This approach takes a system perspective. It stresses input, resources and processes over output variables. As stated in table 1, a system resource approach, while not neglecting the importance of the ends, emphasizes the means needed for the achievement of specific ends in terms of inputs, acquisition of resources and processes (Henri, 2003). By doing this, it focuses not only on the output variables (dependent variables), but also predicting variables (independent variables) of organizational effectiveness. This approach appears to be most useful in those organizations in which output goals are difficult to measure precisely, and when accurate input measures are available. When output measures are available, it also makes it possible to relate input, resources and process to outputs.

According to Carton (2004), the systems approach implies that performance is multi-dimensional, and must be examined using a set of measures simultaneously, which are appropriate to the population and phenomenon of interest, to allow for comparison across organizations. As with the goal attainment approach, this approach criticized for not taking into account for differences between stakeholders perceptions' on performance (Carton, 2004).

2.3 Multiple constituencies models

A multiple constituencies model broadens the scope of the goal attainment and system resource models by adding the expectations of the various stakeholders (internal and external) that are somehow connected to the organization (owners, employees, customers, suppliers, creditors, community and government); (Cameron & Whetten, 1996; Henri, 2003). While several variants of this approach exist, the core of all variants is that an organization is effective to the extent that it satisfies the needs of various relevant organizational constituencies (Tsui, 1990).

According to Carton (2004), the key to using a multiple constituency approach is to determine what constituencies are present, what their view of effectiveness is, and the consequences of these assessments. From this evaluation, a set of performance criteria can be derived for each organization.

The two models previously described can both be seen from an constituency point of view. The goal attainment approach tends to reflect the perspective of owners and/or management. The system resource approach is more linked to important resources such as suppliers, subcontractors or personnel. The multiple constituencies model tries to integrate the multiple stakeholder viewpoints. This approach also inherits some of the problems of the earlier approaches, for instance the competing goals within an organization.

3. Models used within construction literature

To learn from other models that have been developed for the construction industry, a structured literature search was performed in Scopus on journal articles and reviews that were published since 2008.

3.1 Terminology used in structured search

In organisational and management studies, marketing, operations research, economics and other fields the word performance and effectiveness is widely used (Garvin, 1984; Neely, Gregory, & Platts, 1995). In these studies, semantically related terms to effectiveness such as performance, success(factors), efficiency, efficacy, satisfaction and quality are often employed. Some authors even use the terms interchangeably which contributes to a terminological confusion (Kanter & Brinkerhoff, 1981). What probably contributed to this confusion even more is that performance is an evolving concept (Pintea & Achim, 2010). For instance, at the beginning of the 20th century, following the machine analogy of organizations, the term ‘organizational effectiveness’ referred mainly to efficiency (i.e. technical efficiency). Changing conceptions of the organization also altered the notion of efficiency-as-effectiveness. Therefore, the structured search uses multiple synonyms to search for more or less the same aspects.

The keywords used in multiple searches are given in the following table.

Table 2: Aspects used in the Scopus and Web of science search

	Aspects *Combined with AND*				
Synonyms *Combined with OR*	*Aspect 1*	*Aspect 2*	*Aspect 3*	*Aspect 4*	*Aspect 5*
	Effectiveness	*Organi?ation**	*Compar**	*Indicator**	*Construction*
	Performance	*Project organi?ation*	*Benchmark**	*Measure**	*Building*
	Success	*Project delivery method**		*Metric*	
	Efficacy	*Project*		*Assess**	
	*? and * are wildcards used in the search*				

The search resulted in more than 184 hits in Scopus. Based on the title of the articles and the date of publication (2008 and later) the search was narrowed down. Thereafter, most relevant articles were selected based on the abstract and accessibility from the TU-Delft network and further analysed for this paper.

The models found are categorised in either goal-attainment models, system-resource models or multiple-constituencies models. From every model the main variables and scales are noted. The results are presented in the following paragraphs.

3.2 Goal attainment models

There are many articles that we found which present models that can be placed within the field of goal attainment models. (Raisbeck, et al., 2010) compared the performance of PPP with traditional procurement based on ratio scales on relative time and cost per stage and full construction period. (Hale, et al., 2009) compared Design/Build with Design/Bid/Build (traditional) delivery methods based on ratio scales on time and costs. (Minchin, Li, Issa, & Vargas, 2013) compares the performance of Design/Build and Design /Bid/Build delivery systems used by the Florida Department of Transportation. Based on ratio scales the cost estimate, award bid and final costs are compared. Duration was measured by looking at the original contract duration and final duration. Okunlola Ojo, Aina, and Yakeen Adeyemi (2011) compared 53 traditional contracts and 15 Design/Build projects. Time overruns, cost overruns are measured based on ratio scales. A 3 point Likert (ordinal) scale is used to measure satisfaction of the client with the standard of workmanship and specifications.

3.3 System resource models

Some articles that we found can be placed within the field of system resource models. Not surprisingly the main focus of these articles was on “project success factors”.

Eriksson and Westerberg (2011) developed an holistic procurement framework that examines how a broad range of procurement related factors (process) effects project performance criteria (output). Based on a literature review Eriksson and Westerberg (2011) identified the following process variables: level of integration between client and contractors in de design stage, type of tendering, focus on soft parameters in bid evaluation, (joint) subcontractor selection, type of payment (incentives related to performance criteria), collaborative tools and the use of performance evaluation. The output variables that were identified are: cost, time, quality, environmental impact, work environment and innovation. In this paper no scales on which to measure the different variables are discussed.

Scott-Young and Samson (2008) developed “a comprehensive model of theoretically grounded project team variables and to explore its explanatory power for three key project outcomes (cost, schedule, and operability) in capital projects executed in the process industries”. The resource and process variables contain cross-functional team, team experience, team continuity, co-location, virtual office setup, office designed for communication, project manager continuity, project manager incentives, problem solving, clear goals, senior management support, autonomous project structure and team potency. To measure these variables they used five item likert scale derived from other studies and team interviews. To measure output they measured cost, schedule and operability based on ratio scales.

Idoro (2012) compared Direct labour (DL) and Design/Bid/Build (DBB) delivery methods used in Nigeria. The objectives of his study “are to compare the levels of use of selected project plans, the levels of conception, design and construction planning and the outcome of projects procured by DL and DBB methods.” The resource and process variables focus on the use of 14 different project documents that represent different forms of planning, based on an binary scale (0=not prepared, 1=prepared). The output variables are % time-overrun/initial contract period and % cost-overrun/initial contract sum (ratio scales). Based on a 3 point likert scale the clients assessment of project duration, cost and quality is measured.

3.4 Multiple-constituencies models

Some articles that we found can be placed within the field of multiple constituencies models. They can be divided in two groups.

Doloi, Iyer, and Sawhney (2011) examined the effectiveness of prequalification criteria in contractor selection from a successful project delivery perspective. The resource and process variables used by Doloi are technical expertise, relevant work experience, turnover fluctuations and successful past projects, defects liability attitude, plant maintenance programs, work method statement, safety initiatives record, quality control and quality assurance programs. The output and outcome variables used by Doloi are, failure to comply with quality specifications, failure in on-time delivery, tender quality, tender timeliness, failure to perform safety requirements, past record of conflicts and disputes, on-time project delivery. All variables are measured on a 5 item Likert scale. Why one could see this model as a multiple constituencies model is that Doloi collected his data from senior management, project managers, contract administrators, head contractors, consultants and designers (97 responses in total). However, as many other studies do, all the different viewpoints are added together instead of viewing them separately. Examples of other studies which apply this same approach are Yeung, Chan, and Chan (2009) and Toor and Ogunlana (2010).

A study that does not aggregate all the different viewpoints has been performed by Lehtiranta, Kärnä, Junnonen, and Julin (2012). She used 580 evaluation reports representing 214 construction projects to evaluate the extent to which construction project participants' perception of each other's performance reflects on the owner's perception of project. The feedback question sets that are used in this research, i.e. the performance factors to be evaluated, are designed individually for each feedback flow. The variables are measured based on a five-point Likert scale. The variables are categorized in 5 main categories: project management, collaborative working, staff and skills, environment and safety, and finishing and handover. The main conclusion of this research is that "correlations were found between several relationships and the clients' view of project success suggests that multidirectional performance measurement within vertical and horizontal relationships would provide a useful source of information for deepening our understanding on the determinants of construction project success."

4. Conclusions and framework to develop

Based on the structured literature search it must be concluded that most research in the construction industry falls behind compared to general research on organizational effectiveness. Most models still applied within the industry can be dated back to the 1960s'; models that have been criticized ever since.

Furthermore, the findings of Lehtiranta, et al. (2012) show that the expectations of the various stakeholders should be accounted for and analyzed separately to deepen our understanding on the determinants of construction project success. This integrative perspective is provided by the multiple-constituencies approach to organizational effectiveness (Conolly, Colon, & Deutsch, 1980). This approach should be developed further for measuring the effectiveness of construction project organizations.

To do this, the three main approaches from the previous paragraph are combined into an input-process-output-outcome-context framework. In this framework the system resource approach is captured in the input, process and context measures. The goal attainment approach is captured in the output, and the multiple constituencies approach is captured in the outcomes for the different stakeholders (inside and outside the project organization).

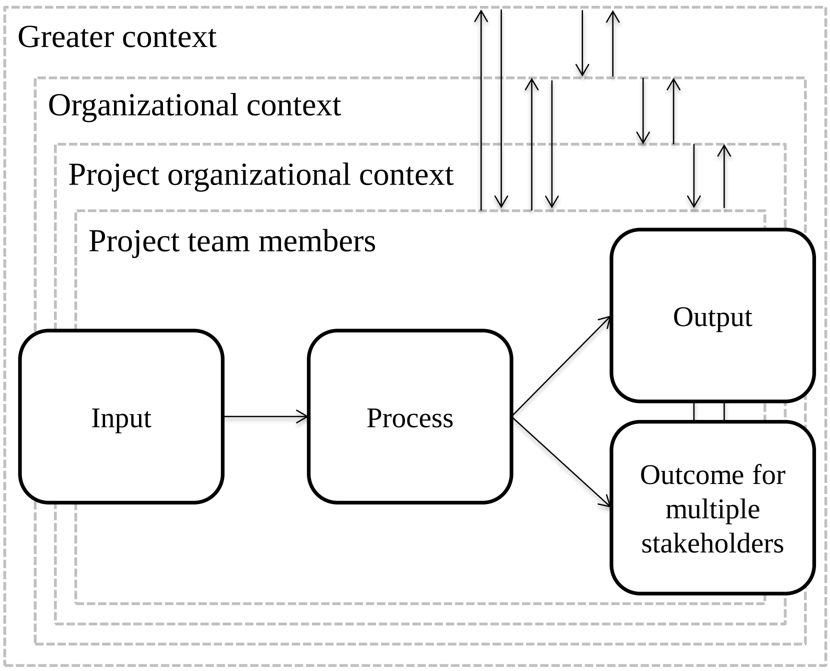

Figure 1: the IPOOC framework (own figure) for measuring construction project organization effectiveness

In general, input exists of items that go into the organisation, such as knowledge, human resources, technologies and materials. These inputs make it possible for the project organization to delivery output and outcomes. Processes represent several activities within the project organization which transform input into output. Output is mainly defined by the projects official goals in regard of time, quality, costs and even sustainability. Outcomes relate to the perception that critical internal and external stakeholders have concerning the project.

A similar framework that is commonly used in other research on (organizational) effectiveness is the input-process-output(-outcome) (I-P-O) (Mathieu, Maynard, Rapp, & Gilson, 2008). The reason why context is added to this framework is that construction project organizations have to operate in different contexts. Not only the context of the one organization, but also the context of different organizations and the greater context of the project surrounding. These different contexts can have a great influence on the project organization on multiple levels.

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Coping with Extreme Weather: Strategies of Construction SMEs

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Abstract

Weather extremes have created a considerable impact on Small and Medium-sized Enterprises (SMEs) in the UK during the recent years, especially on SMEs in the construction sector. Evidence in relation to the recent weather extremes have demonstrated that SMEs are some of the worst impacted by the Extreme Weather Events (EWEs) and have confirmed them as a highly vulnerable section of the UK economy to the impact of extreme weather. This is of particular importance to the construction industry, as an overarching majority of construction companies are SMEs who account for the majority of employment and income generation within the industry. Whilst construction has been perceived as a sector significantly vulnerable to the impacts of EWEs, there is scant evidence of how construction SMEs respond to such events and cope with their impact. Based on the evidence emerged from case studies of construction SMEs, current coping strategies of construction SMEs were identified. Some of the strategies identified were focused at organisational level whereas others were focused at project level. Further, some of the strategies were general risk management / business continuity strategies whereas others have been specifically developed to address the risk of EWEs. Accordingly, coping strategies can be broadly categorised based on their focus; i.e. those focused at project or organisational level, and based on the risks that they seek to address; i.e. business / continuity risks in general or EWE risk specifically. By overlapping these two aspects; their focus and risks that they seek to address, four categories of coping strategies can be devised. There are; general risk management strategies focused at business level, general risk management strategies focused at project level, EWE specific strategies focused at business level, and EWE specific strategies focused at project level. It is proposed that for a construction SME to effectively cope with the impact of EWEs and develop their resilience against EWEs a rich mix of these coping strategies are required to suite the particular requirements of the business.

Keywords: Construction, Coping strategies, Extreme Weather, Resilience, SMEs

1. Introduction

A range of Extreme Weather Events (EWEs) such as flooding, heavy snowfall, extreme temperatures, and heavy rainfall have affected the UK in the recent years, creating significant economic damages. It is projected that such weather extremes will further increase in number and severity in the future, especially due to climate change impacts (Stern, 2007). As an industry, construction is vulnerable to the impacts of EWEs due to its inherent nature of most of the activities being carried out in the open environment. In fact, the industry is perceived as a sector highly vulnerable to EWE impacts (Mills, 2003, Crichton, 2006, McWilliams, 2009). In addition to direct physical impacts of EWEs, construction can be affected by the indirect effects on the construction sector and those associated with it. Whilst direct effects include disruption to site works as a consequence of the EWE itself (e.g. the site might be flooded); indirect effects include disruption to site works as a consequence of the secondary effects of an extreme weather event (e.g. due to disruptions to deliveries and utility supplies through the supply chain) (Metcalf et al., 2009). Although construction industry SMEs have been aware for many years of the direct affects that weather extremes could have on their operations, and are likely to have developed project programming strategies to deal with such eventualities, there is less evidence to suggest that they are prepared for extreme weather events as a consequence of climate change or have considered in detail the indirect impacts to their operations of disruptions to their supply chain (Berkhout et al., 2004). Therefore, recent weather extremes in the UK seem to have created a noticeable impact on the sector; especially on construction SMEs (Wedawatta et al., 2010b, Wedawatta et al., 2011b). Whilst SMEs are considered as highly vulnerable to external disruptions such as EWEs (Crichton, 2006, Wedawatta et al., 2014), this is specially so in an industry like construction, where their activities are significantly weather dependent (Wedawatta et al., 2010a). For instance, a survey of businesses operating in the Cumbria region found that a majority of businesses that have ceased business following extreme weather events in 2009 and 2010 were found to be construction SMEs (Wiseman and Parry, 2011). 74% of businesses that have ceased trading were from construction, all of whom falling into the category of SMEs. Harty et al (2007) through a review of construction future studies identify EWEs as a specific issue that would be of importance to the construction industry in future.

From a construction SME perspective, their resilience to EWEs is likely to be focused around their projects, which is the core of their practice. This was observed by Hertin et al (2003), where it was noted that construction organisations were mainly concerned about the impact of weather events on construction processes and how weather extremes can affect their ability to deliver the projects within the cost and time constraints. Therefore, whilst the focus is mainly on construction SMEs at the organisational level, how construction SMEs respond to EWEs on their construction projects is also investigated in this study. However, evidence that identifies construction SMEs as being in the majority of businesses who ceased to function following EWEs that affected the Cumbrian region in 2009 – 2010, suggests that organisational level response to EWEs is also important (Wiseman and Parry, 2011). This suggests that EWEs have critically affected the business continuity of construction SMEs, necessitating responses to EWEs focusing both on construction projects (process) as well as their organisations, in order to enhance their long term survival amidst the increasing risk of EWEs. The purpose of this paper is to analyse how the UK construction SMEs are responding to the risk of

EWEs and discuss whether construction SMEs have been active in implementing coping strategies addressing these key business aspects.

2. Research method

Case study was adopted as the preferred research strategy to investigate the existing coping strategies of construction SMEs. Dul and Hak (2008) defined case study as “a study in which (a) one case (single case study) or a small number of cases (comparative case study) in their real life context are selected and (b) scores obtained from these case are analysed in a qualitative manner (2008, p4). Justification for adopting case study as the overarching strategy was discussed previously by the authors; see Wedawatta et al (2011a).

Accordingly, two in-depth case studies were developed to explore the context within which construction SME’s interpret and respond to EWEs. The first case study was a building contractor and the second a civil engineering contractor. SMEs studied were medium-sized businesses employing between 50 and 249 employees and are well established construction organisations that have been in business for several decades. These two cases were selected to obtain the perspectives of both building and civil engineering construction SMEs. In order to observe the perspective of construction projects, in each case, a construction project which had been affected by EWEs were studied to obtain an understanding of on-site issues related to EWEs. The projects studied were a residential development and a land remediation and earthworks project for the two case study SMEs respectively. Interviews were conducted with the head office senior management and site management.

3. Findings and discussion

3.1 Coping strategies of construction SMEs

Key coping strategies that the case study SMEs have put in place or existing strategies that have helped them to minimise the impacts of EWEs are identified in the table 1.

Table 1 –coping strategies of case study construction SMEs

Case study SME1	*Case study SME2*
• *Estimating and Bidding strategies (1.1)* *Considering EWE risk when making decisions on whether to bid for a project, and if so, on the prices quoted* • *Project planning (1.2)* *Minimising vulnerable site activities during the winter. Planning project activities making use of a*	• *Estimating and bidding strategies (2.1)* *Considering the risk when quoting for a project in terms of price and time quoted.* • *Diversifying business activities (2.2)* *Having a diverse range of business activities, being in a position to absorb the impacts of EWE disruptions in some of its projects.*

mixture of indoor and outdoor activities on their different projects at any given time, so that employees can be re-assigned to projects which are not affected by weather, if a particular project is affected for a long time period. • *Methods of construction (1.3)* *Addressing weather risks in methods of construction used.* • *Business continuity plan (1.4)* *Having a business continuity plan in place, outlining the roles and responsibilities of personnel, procedures to be followed during times of disruption such as during EWEs.* • *Employee selection and terms of labour employment (1.5)* *Changing the terms of employment for its direct labour force, allowing to temporarily lay off staff during periods of low construction activity. Selecting site staff locally.* • *Sub-contracting practices (1.6)* *Transferring the risk of disruption to sub-contractors by sub-contracting vulnerable trades.* • *Conditions of contract (1.7)* *Relief for time periods affected by EWEs obtained through the conditions of contract.* • *Health and safety procedures (1.8)* *Existing health and safety procedures in place that have to be adhered to in carrying out construction work on sites.*	• *Conditions of contract (2.3)* *Relief for time periods affected by EWEs and additional costs obtained through the conditions of contract.* • *Project planning (2.4)* *Minimising vulnerable work activities during winter months.* • *Employee selection (2.5)* *Employing locally and employing experienced and qualified professional staff across every section.* • *Frequent communications between head office and sites (2.6)* *Frequent meetings held on sites and in head office were identified as a risk management strategy, where any issues at the time are discussed and actions to be taken are planned in a timely manner.*

Both the SMEs have experienced a range of adverse impacts on their projects and thereby their businesses due to EWEs during the recent years prior to the study. It can be seen that following this range of adverse impacts in relation to the EWEs that affected the UK in recent years, case study SMEs have now put in place a diverse range of response measures. Whilst some of these measures were instigated prior to the EWEs (e.g. sub-contracting practices, terms of employment, etc), SMEs have also developed new measures (e.g. minimising vulnerable trades during winter, method of construction) in direct response to the EWE impacts experienced.

3.2 Discussion on coping strategies

Some of the strategies identified in the case study SMEs were focused at organisational level whereas others were focused at project level. Further, some of the strategies were general risk management / business continuity strategies whereas others have been specifically developed to address the risk of

EWEs. Accordingly, coping strategies identified in case study SMEs can be broadly categorised based on their focus; i.e. those focused at project or organisational level, and based on the risks that they seek to address; i.e. business / continuity risks in general or EWE risk specifically. This categorisation is depicted in Figure 1. The following sub-sections outline each of the categories identified above.

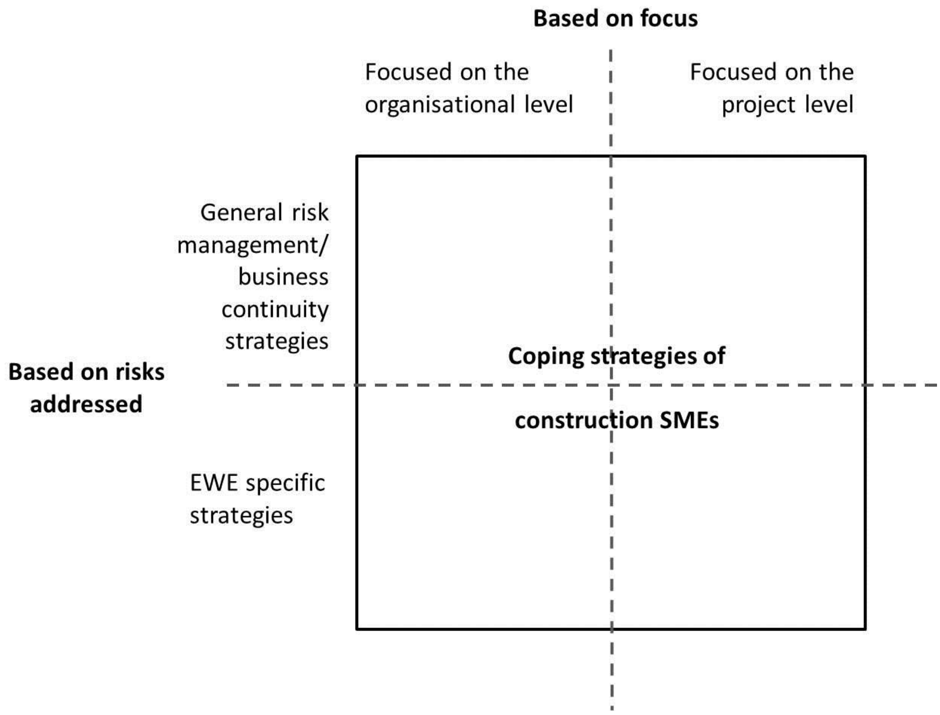

Figure 1 - Categorisation of coping strategies of construction SMEs (Wedawatta, 2013)

3.2.1 Categorisation based on risks addressed

General risk management / business continuity strategies

Some of the coping strategies that the construction SMEs have found useful were general risk management / business continuity strategies implemented within the businesses. Whilst these have not been implemented specifically to cover the risk of EWEs, having such strategies in place has enabled SMEs to prevent, withstand and recover from EWEs better. Strategies reported by SME1, such as sub-contracting practices, terms of labour employment and business continuity planning, as well as the strategies reported by SME2 such as business diversification and project meetings, are generic risk management strategies implemented to reduce risk, ensure business survival and commercial advantage. Therefore, it is evident that some of the general risk management / business continuity strategies implemented in construction SMEs could effectively contribute towards their resilience to EWEs.

EWE specific strategies

However, general risk management strategies alone, as discussed above, may not provide an adequate level of resilience against EWEs. Considering this, the case studies revealed that SMEs have extended general risk management strategies or implemented new strategies specifically addressing the risk of EWEs. In the case study SMEs, these included considering EWE risk in bidding, estimating, and project planning, and usage of conditions of contract for their advantage. Such EWE specific strategies seem to be essential in combination with general risk management strategies, if a construction SME is to achieve a good level of resilience to EWEs.

3.2.2 Categorisation based on unit of focus

Coping strategies at project level

Case study findings revealed that the focus of construction SMEs, in regard to EWEs, was mostly on the projects that they undertake. EWEs affecting their projects have created a significant impact on construction SMEs. Consequently, many of the coping strategies that have been implemented focused on construction projects. For instance project pricing, bidding and planning strategies, conditions of contract, sub-contracting practices, and methods of construction can be cited. Given the potential of EWEs to disrupt site activities for prolonged durations as well as intermittent disruptions that can also have a significant impact on construction SMEs, it is important that the risk is adequately addressed at project level.

Coping strategies at business level

Whilst a majority of the strategies found in case study SMEs were focused on construction projects, some of the strategies discussed were implemented at business level. For instance, business continuity planning and commercial strategies such as diversification can be identified. As was recognised by the case study SMEs, whilst their businesses were thought to be resilient to EWEs it was also recognised that a future EWE may have the potential to affect the activities of their businesses irrespective of the measures that are in place. Therefore, it is important that the risk is also addressed at business level to account for the resultant impact on the business as a whole and its continuity. Lack of coping strategies at the business level may, perhaps, be argued as a reason for construction SMEs reporting high business failure rates as a result of EWEs. Whilst the case study SMEs demonstrated such coping strategies at the wider business level, many of the smaller SMEs might not have such strategies in place.

3.2.3 Types of coping strategies in construction SMEs

Based on the analysis above, the coping strategies of construction SMEs can be subdivided in to four quadrants, based on their focus and the risks that they seek to address;

- General risk management strategies focused at business level

- General risk management strategies focused at project level
- EWE specific strategies focused at business level
- EWE specific strategies focused at project level

These are depicted in each of the quadrants in Figure 1. Coping strategies observed in case study construction SMEs seem to suggest that most of the strategies implemented by construction SMEs currently fall into the category of EWE specific strategies focused at project level, whilst less attention has been paid to the other three types of coping strategies (see Figure 2). In Figure 2, coping strategies implemented by the case study SMEs have been roughly placed on each quadrant, to best reflect the views expressed by the respondents. Whilst it is an approximate representation rather than a precise one, due to factors such as some coping strategies addressing more than one quadrant, it depicts the bias towards project level coping strategies by construction SMEs.

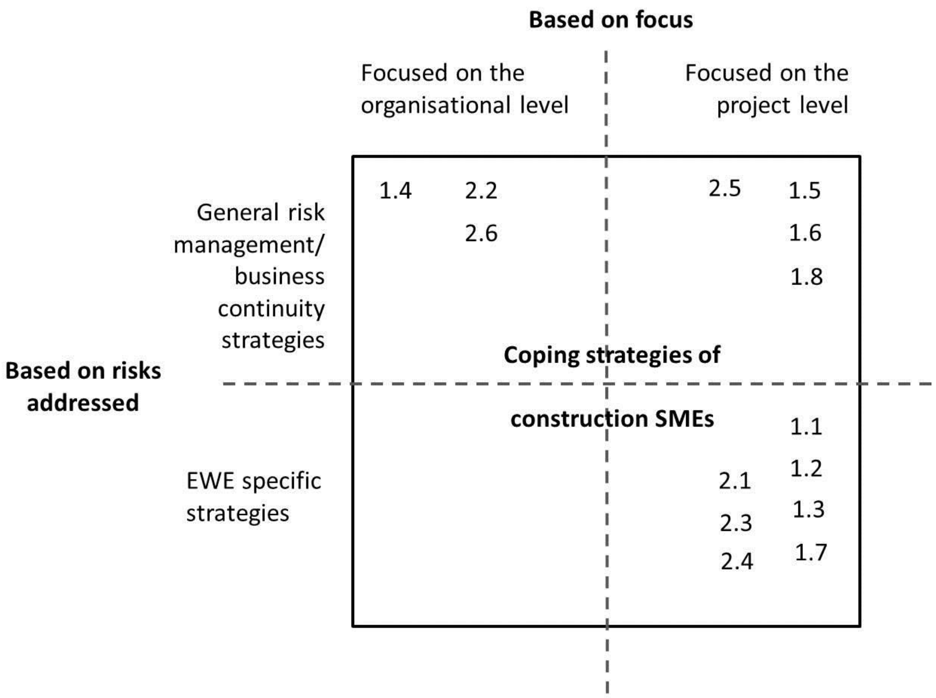

Figure 2 – Coping strategies of case study SMEs allocated to each quadrant

It can be argued that a resilient construction SME will demonstrate coping strategies falling into each of the quadrants, based on their requirements. It is important that a construction SME implements a suitable mix of strategies to achieve the required level of resilience. For example, EWE specific coping strategies at project level can minimise disruption to site activities. However, as noted by construction SMEs, site activities might still be disrupted by EWEs despite such measures being in place. Therefore, other types of coping strategies at business level are required to address the remaining risk and cope with the impact that disrupted site activities will have on the rest of their business. It may be argued that the lack of coping strategies to cover different types of risk, as identified above, is a reason leading to why EWEs have such a severe impact on construction SMEs and threaten their continuity. For instance, an exploratory survey conducted as a precursor to in-depth case studies showed lower percentages of construction SMEs with business continuity insurance and business continuity planning (Wedawatta et al., 2011b). Categorisation, identified above, presents a novel approach to presenting the coping strategies of construction SMEs, and suggests the importance of having a broad mix of coping strategies in place pertaining to each type of coping strategies identified.

4. Conclusion

Both case study SMEs considered EWEs to be a critical risk to their businesses. This was mainly due to significant adverse impacts experienced in relation to recent EWEs that have affected their businesses. As a result, the risk of EWEs has been addressed in a number of ways and the SMEs have sought to increase their resilience to EWEs. Case study SMEs therefore considered their businesses as adequately resilient to EWEs. Although the two case study SMEs considered their businesses as adequately resilient to EWEs, it was also recognised that future lengthy EWEs have the potential to create a significant impact on their businesses. Therefore, whilst the SMEs were confident of their ability to respond successfully to such an event with the help of measures that are currently in place and their resources and competencies, the need for further improving their resilience was recognised.

Categorisation adopted in the study identified four types of coping strategies for construction SMEs; general risk management strategies focused at business level, general risk management strategies focused at project level, EWE specific strategies focused at business level, and EWE specific strategies focused at project level. Findings of the case studies suggested that the case study SMEs have focused mostly on their projects and have implemented EWE specific strategies focused at project level the most. The risk does not seem to have been addressed adequately at the business level, accounting for any negative impacts that EWEs may have on a business if the projects get affected by EWEs. It is important that a construction SME implements a suitable mix of strategies to achieve the required level of resilience. It may be argued that the lack of coping strategies to cover different types of risk, as identified above, is a reason leading to why EWEs have a severe impact on construction SMEs and threaten their continuity.

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Determining Demand for Disaster Resilience Education through Capacity Analysis of European Public Authorities

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Abstract

Over the past decade, annual global fatalities from natural disasters have averaged 106,000 and the estimated average annual losses have been US$165bn. The long-term trend has seen both of these numbers rising. The built environment plays a key role - damage to it accounts for most of the economic losses and its failures often determine the level of fatalities whereas, it is the built environment to which people turn for safety and shelter when a disaster occurs and its continued functioning is essential for disaster response and recovery.

In order for higher education institutions to support disaster resilience efforts with capacity-building educational and research programmes, the priority areas for capacity development first need to be identified. To this end, the Academic Network for Disaster Resilience to Optimise educational Development (ANDROID) designed a survey of the capacity of European public administrations as part of an initiative to develop a roadmap for European education for societal disaster resilience.This paper reports the theoretical framework and initial findings from a Europe-wide survey of the capacity of public authorities and the implications for disaster resilience-related education in the built environment. There is evidence of considerable demand for disaster resilience education from public administrations. There is a need for further advocacy for disaster resilience awareness and education both in general and for built environment professionals in particular.

Keywords: Disaster Resilience, Education, Built Environment, ANDROID network

1. Introduction

1.1 The importance of disaster resilience education for built environment professionals

Over the past decade, annual global fatalities from natural disasters have averaged 106,000 and estimated average annual losses have been US$165bn. The long-term trend has seen both of these numbers rising. Whereas the majority of fatalities have typically been recorded in developing nations, most of the economic losses have occurred in developed countries. In 2011, global economic losses were dominated by the earthquake and tsunami in Japan which resulted in estimated losses of US$210bn. In 2012, 67% of total global losses occurred in the USA resulting from weather-related events, particularly hurricane Sandy, and, in the first half of 2013, flooding in Europe was the main source of global disaster-related losses. (Munich Re, 2012; 2013a; 2013b)

A number of factors contribute to the trend towards greater losses from disasters including the increasing concentration of people and assets in cities, the tendency for cities to be situated in low-lying coastal areas and on the banks of major rivers, the extension of supply networks and the increased dependence on all kinds of networks which mass urbanisation entails. Climate change predictions also suggest that both vulnerabilities of populations and the severity of disaster events are set to increase. (IPCC, 2013)

The built environment plays a key role. On the one hand, damage to it accounts for most of the economic losses and its failures often determine the level of fatalities. Indeed, in man-made disasters, the collapse or failure of buildings and infrastructure may be the mechanism by which the disaster occurs and, in acts of war and terrorism, it is often the built environment that is specifically targeted. On the other hand, it is the built environment which people turn to for safety and shelter when a disaster occurs and its continued functioning is essential for disaster response and recovery.

Similarly, the construction industry is central to achieving disaster resilience through the appropriate design and construction of buildings and infrastructure, for responding to disasters (dealing with damaged buildings and infrastructure and providing temporary services to affected communities) and in post-disaster reconstruction efforts.

Built environment professionals thus play an important part in disaster resilience and, therefore, the education of these professionals must allow for the incorporation of relevant disaster resilience-related courses and materials to enable them to successfully fulfil this role.

1.2 University education in support of disaster resilience

The United Nations International Strategy for Disaster Reduction acknowledges the central role of all levels of government in enhancing the disaster resilience of communities and emphasizes the need to foster better knowledge and understanding of the causes of disasters and to build and strengthen capacities through educational and training programmes. (UNISDR, 2009; UN General Assembly, 2013)

In order for higher education institutions to support these efforts with capacity-building educational and research programmes, it is essential that the priority areas for capacity development are identified. To this end, the Academic Network for Disaster Resilience to Optimise educational Development (ANDROID) designed a survey of the capacity of European public administrations at both national and local levels as part of an initiative to develop a roadmap for European education for societal disaster resilience.

1.3 Overview of this research

The survey attempted to capture opinions regarding the capacity constraints affecting public administrations at both national and local levels across Europe with the intention of relating these to the demand for disaster resilience education and identifying potential opportunities for educational provision.

This paper describes the theoretical framework which was derived as the basis for the survey, the implementation of the survey, the responses received and the survey findings in terms of both the implied demand for disaster resilience education and the capacity constraints reported to be affecting public administrations. Preliminary recommendations regarding education for built environment professionals are then drawn.

2. Identifying a common basis for capacity measurement

The ANDROID academic network boasts partners in 28 European countries and this was considered an appropriate starting point in defining the extent of the survey. The list of these countries may be seen in Table 1 (below).

To overcome the problems associated with the numerous (geographical, population, risk, etc.) differences between respondents' contexts in a Europe-wide survey, the fulfilment of the Hyogo Framework for Action (HFA) priority actions was adopted as a common baseline from which to measure capacity as all the survey countries have signed up to them. However, since these actions apply specifically to the national level, a corresponding set of local level actions which follow from the HFA priority actions were derived for the purpose of the survey. (UNISDR, 2005)

3. Deriving a conception of capacity for the survey

The first difficulty to overcome was that the term 'capacity' does not have a single, universally acceptable definition, yet the survey relied on a robust conception of capacity being formulated to allow the measurement of which aspects of capacity were constrained. (Honadle, 1981; Glickman and Servon, 1998; Hou *et al*., 2003; Christensen and Gazley, 2008)

A review of the literature suggested a conception where capacity is considered to be:

- fundamental to performance; (Ingraham, 2005)

- relative to a specific action to be performed; (Honadle, 2001; Eisinger, 2002; Hall, 2008)

- more than simply resources or inputs; (Armistead *et al*., 1995; Hall, 2008)

- less than actual performance since effective performance cannot be assumed to follow directly from adequate capacity (Armistead *et al*., 1995)

- multidimensional but with the added complexity that there is a high level of interaction and potentially replacement or compensation between capacity dimensions (e.g. internal knowledge and skills can be replaced by the necessary financial resources to outsource these) (Honadle, 2001; Christensen and Gazley, 2008; Hall, 2008; Norris *et al*., 2008)

- adaptive, dynamic and the basis of resilience. (Glickman and Servon, 1998; Norris *et al*., 2008)

For this survey, we were concerned with organisational capacity (i.e. the unit of analysis being the organisation rather than the individual, community, or society as a whole). (Christensen and Gazley, 2008; UNDP, 2011) In addition, consideration of time is problematic – despite some authors insisting that time is a dimension of capacity, it doesn't seem to fit as a distinct capacity dimension but it certainly is a major factor to consider in the context of performance. (Christensen and Gazley, 2008)

3.1 Modelling the capacity – function performance relationship

A basic operations management model of a transformation process from Armistead *et al*.(1995) was adapted to reflect the conception of capacity outlined above. As shown in Figure 1, capacity relates to both the inputs and the process of transforming them in order to achieve the action. Note that capacity by itself is insufficient to achieve performance of the specified action, since external and institutional factors affect capacity deployment and transformation as well as action selection and definition.

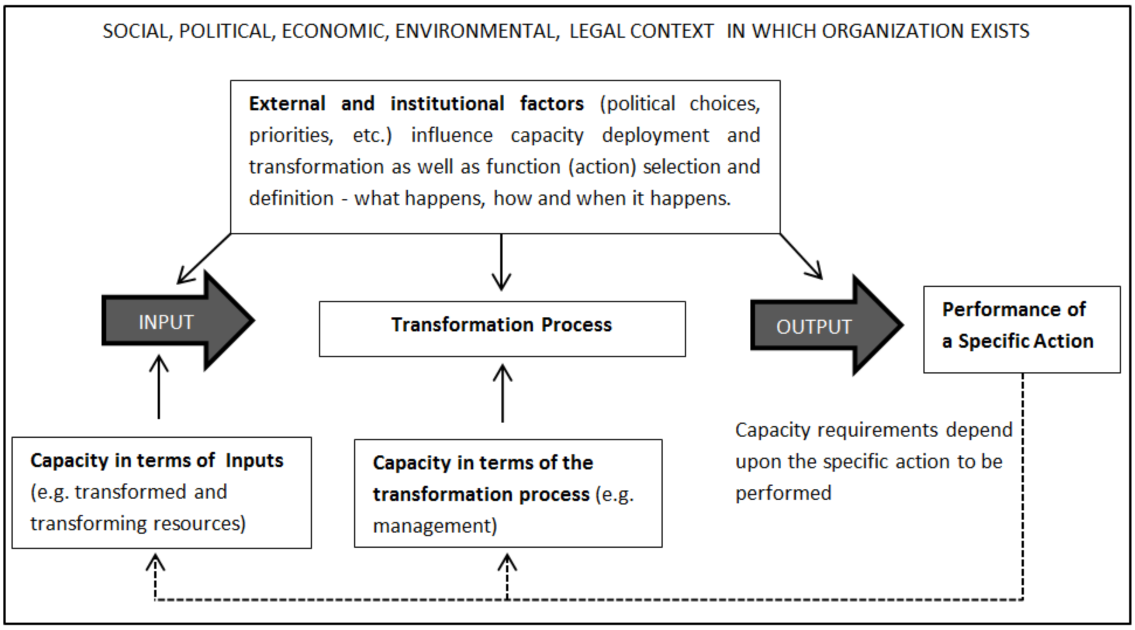

Figure 1: Capacity – Performance Model for a public organization with respect to a specified Action

3.2 Dimensions of capacity

In this conception, capacity is necessarily multi-dimensional not just in terms of relating to both the inputs and the transformation process but also relating to multiple input dimensions and process dimensions. In light of the literature, and in consideration of the intention to relate capacity constraints to educational interventions, the following capacity dimensions were identified as relevant:

- Human resources (availability) (Lusthaus *et al*., 1995; Christensen and Gazley, 2008; UNISDR, 2009)
- Human resources (knowledge and skills) (Lusthaus *et al*., 1995; Christensen and Gazley, 2008; UNISDR, 2009)
- Financial resources (Lusthaus *et al*., 1995; Christensen and Gazley, 2008)
- Management (Lusthaus *et al*., 1995; Hall, 2008; Gibbon *et al*., 2002)
- Leadership and direction (Lusthaus *et al*., 1995; Eisinger, 2002; Gibbon *et al*., 2002)
- Systems and infrastructure (Lusthaus *et al*., 1995; Christensen and Gazley, 2008; Norris *et al*., 2008)
- Linkages / relationships with external organizations / communities / society. (Lusthaus *et al*., 1995; Glickman and Servon, 1998; Eisinger, 2002; Gibbon *et al*., 2002)

4. Survey methodology

The survey tool was designed as an online questionnaire. This enabled the central and convenient collection of data from diverse response locations as well as the possibility for supporting multiple language interfaces while maintaining a single database for responses.

The survey consisted of two sets of questions - one set intended for respondents acting at the national level and relating to national level actions, the other set for the local level. Respondents were automatically directed to the appropriate question set based on their affiliations. The questioning logic proceeded as follows: for each of the identified (local or national level) actions it was first determined whether the action had already been successfully completed. If it had, then it indicated that no capacity constraint existed. If the action had not been achieved and it was additionally ascertained that this was a result of constrained capacity rather than something else (the 'external and institutional factors' referred to in Figure 1), then respondents were asked to rate the given list of capacity dimensions in terms of both their importance and the degree to which they were constrained thereby enabling a gap analysis to be carried out to determine which dimensions of capacity were affecting HFA implementation and allowing the priority areas for capacity development to be identified.

The data collection strategy relied on local partners of the ANDROID academic network in all 28 survey countries contacting public administrations and other organisations that were competent to comment on the situation regarding HFA implementation and associated capacity constraints at both local and national levels.

Due to the great diversity of disaster contexts across the survey countries coupled with the relatively low response rates expected from an online survey questionnaire format and, therefore, low predictability of which organisations would answer it, it was accepted during the survey design that a representative sample of local and national administrations across Europe could not be achieved. Rather, the intention was to maximize the number of responses to the survey and thus obtain an initial indication of the situation across Europe.

In addition, the dual measurement of relative importance and relative extent of constraint for each capacity dimension coupled with the multiple capacity dimensions, the multiple actions for both local and national levels and the inclusion of the possibility that non-performance of an action could reflect 'external and institutional factors' rather than capacity constraints all combined to give very granular data and a relatively lengthy questionnaire taking 15 - 20 minutes to complete. The effect of this was, for findings to be statistically significant, the number of responses would need to be high while the relative complexity of the survey indicated response rates were likely to be low. Indicating, in turn, that the relative effort required of local ANDROID partners in terms of finding potential respondents and encouraging them to respond would be high.

To facilitate the maximisation of response numbers, the survey questionnaire was made available in a number of major languages (English, German and Russian) as well as local languages (Turkish, Estonian) where the local ANDROID academic network partner deemed it desirable in order to improve response rates.

5. Responses

A total of 127 survey responses were received (considerably lower than intended). The distribution of these responses by country and level of engagement (national or local) with the HFA actions is shown in Table 1 below. The distribution of responses between countries was highly variable with more than half of total responses received coming from Sweden and 7 countries failing to provide any responses at all.

However, since most of the Swedish responses referred to the local level, this affected only the local analysis while the distribution of national level responses was relatively evenly spread between the countries.

Table 1: Survey Responses Received

Country	*National Level responses*	*Local Level responses*	*Country*	*National Level responses*	*Local Level responses*
Austria	*1*	*0*	*Lithuania*	*0*	*1*
Bulgaria	*0*	*0*	*Malta*	*0*	*0*
Croatia	*0*	*2*	*Norway*	*1*	*0*
Czech Republic	*4*	*0*	*Poland*	*1*	*0*
Cyprus	*1*	*0*	*Portugal*	*0*	*0*
Denmark	*0*	*1*	*Romania*	*0*	*0*
Estonia	*5*	*0*	*Slovenia*	*0*	*1*
Finland	*1*	*0*	*Spain*	*0*	*0*
France	*1*	*1*	*Sweden*	*6*	*61*
Germany	*3*	*4*	*Switzerland*	*3*	*5*
Greece	*0*	*0*	*The Netherlands*	*1*	*1*
Iceland	*4*	*2*	*Turkey*	*4*	*2*
Ireland	*0*	*0*	*United Kingdom*	*5*	*1*
Italy	*1*	*0*			
Latvia	*3*	*0*	*Totals*	*45*	*82*

6. Analysis of results

The survey respondents represented organisations with a total of 19,058 personnel working in the disaster resilience field. Of these people, only 13% reportedly held an educational qualification in a disaster resilience field.

A majority of the organisations (68%) were reported to be interested in their staff obtaining disaster resilience-related academic qualifications.

Out of the 127 survey respondents, 45 (35%) represented organisations engaged in disaster resilience at the national level. Of these, less than 20% reported that the national actions were successfully complete. There appears to be considerable deficiency in the implementation of (national) priority action 3 (Use knowledge, innovation and education to build a culture of safety and resilience at all levels) with only 3% of respondents agreeing that this action had been successfully completed. However, the majority of respondents indicated a state of 'moderately progressed'. Similarly, overall progress in terms of all the other HFA priority actions (at national level) were considered to be moderately progressed.

In terms of capacity constraints regarding the implementation of the HFA priority actions (at the national level), between 60% and 80% of respondents reported that their organisations did not face capacity constraints for implementing these actions but rather that non-completion or lack of progress in implementing the HFA priority actions was due to other factors.

Of the local level respondents, less than 20% reported that the local actions were successfully complete with the exception of Local Action 3: (Disaster risks are regularly and systematically managed (identified, assessed and monitored)) where 35% reported it to have been completed. Most of the 7 local actions were reported to be moderately progressed.

In terms of capacity constraints to local level implementation of the HFA priority actions, between 70% and 90% of respondents reported that their organisations did not face capacity constraints to implementing these actions. Thus, similarly to the national level results, only a small number of respondents answered the questions designed to identify the relative magnitude and importance of the specific dimensions of capacity which were considered to be constrained.

Those respondents who did report the existence of capacity constraints indicated that the financial resources dimension of capacity presented the greatest challenge to their organisations (at both local and national levels). This can be seen from Table 3 where the 'gap', a function of both the importance of a capacity dimension and the degree to which it is constrained, has been calculated for each capacity dimension at both national and local levels. While the choice of function (multiplication or addition) and scale is open to debate, a scale of 0 – 4 (where 4 = extreme importance / constraint; 3 = high importance / constraint; 2 = moderate importance / constraint; 1 = low importance / constraint and 0 = no importance / constraint) was selected for both importance and constraint criteria in this case and the gap was calculated as the product of importance x constraint. Thus, if the capacity dimension was either of no importance or not constrained, the gap would be calculated as 0 and the maximum gap value (for extreme importance and extreme constraint) would be 16.

It can be seen from these tables that the capacity dimension most directly reflecting the demand for disaster resilience education, staff knowledge and skills, is ranked as the fifth most pressing constraint facing national level organisations and the fourth for local level organisations. Since the choice of scale and method of calculation of the gap are open to interpretation and some of the differences in calculated gaps are small, it is more meaningful to consider these gaps in groups or tiers of significance. For both national and local levels, the financial resources dimension is clearly most significant and is the sole occupant of tier 1. For national level organisations, three distinct tiers are apparent with staff knowledge and skills in the second tier. For local level organisations, four tiers are apparent and staff knowledge and skills appear to be in the third of these.

Table 3 – Gap analysis of capacity constraints

	National Level					*Local Level*				
Capacity dimensions	*Importance*	*Constraint*	*Gap*	*Rank*	*Tier*	*Importance*	*Constraint*	*Gap*	*Rank*	*Tier*
Staff availability	*2,3*	*2,4*	*5,6*	*2*	*2*	*2,6*	*2,2*	*5,8*	*2*	*2*
Staff knowledge	*2,7*	*2,0*	*5,4*	*5*	*2*	*2,5*	*1,8*	*4,4*	*4*	*3*
Financial resources	*2,6*	*2,5*	*6,6*	*1*	*1*	*3,1*	*2,8*	*8,5*	*1*	*1*
Management and admin.	*2,3*	*2,1*	*4,9*	*7*	*3*	*2,2*	*1,6*	*3,5*	*8*	*4*
Strategic leadership	*2,6*	*2,1*	*5,5*	*4*	*2*	*2,3*	*1,5*	*3,6*	*7*	*4*
Systems and infrastructure	*2,4*	*2,0*	*4,8*	*8*	*3*	*2,4*	*1,9*	*4,4*	*3*	*3*
Linkages	*2,5*	*2,1*	*5,4*	*6*	*2*	*2,4*	*1,5*	*3,7*	*6*	*4*
Legal framework	*2,5*	*2,2*	*5,5*	*3*	*2*	*2,6*	*2,2*	*5,8*	*2*	*2*

7. Discussion

Although the number of responses was low (127 responses), the number of personnel represented (19,058) by the responding organisations is considerable and suggests that the total population of disaster resilience-related personnel across Europe is substantial. When further considered in light of the low percentage (13%) of these personnel who reportedly hold disaster resilience educational qualifications, it appears that there is high demand for educational programmes in this area. This impression is reinforced by the majority (68%) of respondents' organisations' reported interest in their staff obtaining disaster resilience-related academic qualifications.

While this high educational demand is measured for public administrations, these are likely to include substantial numbers of built environment professionals (for their town planning, architectural, building compliance, traffic, public works, etc. functions) and there is no reason to expect that their needs in terms of disaster resilience education would differ substantially from those of other public administrations' personnel. Rather, given the central role played in disaster preparedness and response by the construction industry, which in most countries is dominated by the private sector, the implication is that most of the disaster resilience educational demand for built environment professionals would exist in the private sector.

An unexpectedly high proportion of respondents (60% - 80% with respect to national level actions and 70% - 90% with respect to local level actions) indicated that non-completion of the actions was not due to constrained capacity. While this greatly reduced the data available for determining the relative impact of each of the capacity dimensions on performing the HFA actions, it lends some credence to the conception of capacity adopted for the survey in the sense that, only if an organisation is focused on performing a particular action, do the capacity constraints relative to that action become apparent. The reported progress of all the actions is generally low (given the 2015 deadline for implementation) and this serves to confirm that, in most cases, their performance is not seen as an organisational priority.

In interpreting the relative significance of the capacity dimensions from the responses which reported capacity to be constrained, it is important to refer back to the conception of capacity put forward in section 3 above. In this conception, capacity is considered multidimensional but with the added complexity that there is a high level of interaction and potentially replacement or compensation between capacity dimensions so that, for example, internal knowledge and skills can be replaced by the necessary financial resources to outsource them. With this in mind, it is no surprise that respondents reported the greatest gap with respect to the financial resources dimension, reflecting its great flexibility. Within their rankings, the capacity gaps in both human resource dimensions (staff availability and staff knowledge and skills) were shown as relatively significant and this once again indicates that education both in terms of raising awareness and interest in disaster resilience (and thus increasing the pool of staff available) and also in terms of direct disaster resilience knowledge and skills which can be applied to organisational performance of the HFA actions are seen as being in demand.

8. Conclusions and recommendations

Despite suffering from a low number of responses, the survey did determine that a substantial demand for disaster resilience-related education and associated qualifications exists in public administrations. It is anticipated that this holds true in terms of the demand among built environment professionals given their representation in public organisations. However, with consideration of the central role that the construction industry plays in disaster preparedness and response, more demand for disaster resilience-related education for built environment professionals would be likely to come from the private sector and this should be further investigated.

The survey also indicated that the performance of the HFA actions and, by extrapolation, disaster resilience was not given adequate priority within public administrations. This is worrying given the considerable effort and resources which have been expended and the large number of global and regional initiatives to drive forward the disaster resilience agenda in recent years. There is therefore a need for further advocacy for disaster resilience awareness and education both in general and for built environment professionals in particular.

9. Acknowledgement

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A Critical Review on Disaster Preparedness of the Emirati Energy Sector

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Abstract

All disasters are said to follow a cyclical pattern referred to as the disaster cycle. The cycle is an overall view of stages within a continual loop of prevention, mitigation, preparedness, response and recovery. Disaster preparedness is one of the stages of the disaster management cycle. Disaster preparedness is guided in a manner which adequately protects communities. It involves the identification of potential hazards and vulnerabilities through risk assessments, development of forecast and warning systems, modelling and training for a number of disaster scenarios of different hazards and at different magnitudes, development of insurance infrastructure and the growth of an intelligent community. The energy sector dominates in the UAE and consists of various assets - electricity, oil and natural gas that are geographically dispersed and connected by systems and networks. The protection of these systems and assets and within the energy sector especially, the safeguarding of oil and gas infrastructure from any and all internal and external threats should become top priority in the UAE. Threats to geopolitical and economic stability that need to be considered and prepared for include tectonic activity, climate change, nuclear energy, terrorism and war.

This paper discusses the current level of resilience in the Emirati energy sector and what can be done to improve it. The secondary data was taken from various academic and professional sources whilst the primary data, which constitutes 35 questionnaires with both qualitative and quantitative data, were collected on site at two electricity generating plants, one in Abu Dhabi and one in Dubai.

Keywords: Disaster, Preparedness, UAE, Energy Sector.

1. Introduction

In 2011, a total of 332 natural disasters were registered, killing a total of 30,773 people and causing 244.7 million victims worldwide (Guha-Sapir *et al* 2012). It is important that any potential disaster or threat of disaster is managed. Preventative management focuses strongly on disaster preparedness as it puts together the processes, action and steps that should occur in the event of an emergency, *before* such an emergency. Disaster preparedness, consequently, plays a significant role in disaster mitigation and strategic planning, and if done properly presents a significant reduction in the recovery period. It is also likely to result in welcome improvements to infrastructure, particularly critical infrastructure, such as that of electricity and energy.

The protection of these systems and assets and within the energy sector especially, the safeguarding of oil and gas infrastructure from any and all internal and external threats, should become the top priority of the UAE and other oil-providing nations against asymmetric threats (Bi, 2006). One important, if not the most important, issue to the long-security of a national or even a regional energy system is the failure of international supply, whether on technical or political grounds. Any resilient energy network requires cooperation and the shared interests of all involved to work towards protection from “shocks”. This is especially the case if long term resilience is regarded as a secure supply. Resilient critical infrastructure, based on Olinsky-Paul (2013) is defined by the author as that which has the self-sustaining ability to supply emergency electricity provision during outages where normal operations are absent or disrupted.

This paper explores the disaster preparedness of the Emirati energy sector, by specifically focussing on Abu Dhabi and Dubai.

2. Disaster management

The ultimate goal of disaster risk management is to break the disaster life cycle (Frumkin, 2010). All disasters are said to follow a cyclical pattern (refer to Figure 1) referred to as the disaster cycle (Hogan and Burstein, 2007). *The cycle is an overall view of stages within a continual loop* (Forsman, 2007) such as that described by Ciottone (2006) - prevention, mitigation, preparedness, response and recovery. The process of dividing the disaster process into various, albeit overlapping stages is a useful heuristic device driving better understanding (Levinson and Granot, 2002) from which a disaster management plan can be implemented.

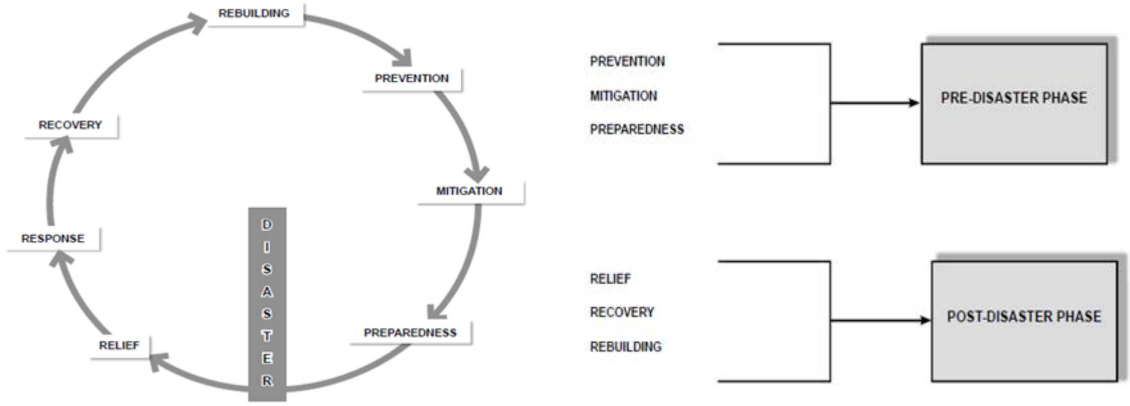


Figure 1: The Disaster Management Cycle and Phases Source: Miththapala (IUCN) 2008

Disaster preparedness is a step in the disaster cycle. It focuses on the pre-disaster phase and the in depth investigation on disaster mitigation and strategic planning in order to build resilience. Pre-disaster, when used in this paper, refers to the *extensive data collection, maintaining directories of resource, development of action plans, capacity building, training and community awareness activities* (Sundar and Sezhiyan, 2007) required to prevent, prepare and mitigate. Indeed, disaster preparedness is, according to Hays (2013a; 2013b) one of the "five pillars of resilience" (the others being protection, early warning, emergency response, recovery and reconstruction). In his definition, it involves the identification of potential hazards and vulnerabilities thorough risk assessments, development of forecast and warning systems, modelling and training for a number of disaster scenarios of different hazards and at different magnitudes, development of insurance infrastructure and the growth of an intelligent community. In this way, disaster preparedness and the other elements of this phase, are guided in a manner which adequately protects communities due to its comprehensive, multi-sector, community based and culturally sensitive approach (Ciottone, 2006). It also helps with strategic planning and resilience enhancement in such communities. Indeed, Jha and Stanton-Geddes (2013) propose education and communication, higher levels of preparedness and investments, better urban planning, coordination and development as the main tools with which to address the risks that a vulnerable community might face in the event of disaster. Following section describes disasters in the UAE.

3. Disasters in the UAE

The UAE is prone to various natural hazards including those atmospheric, geological and anthropogenic in origin. As development continues in the nation the country and its people become even more vulnerable to the effects of those hazards (Al Ghasyah *et al* 2010). Currently, there are limited, reliable national statistical data regarding disasters in the UAE. Information as to events is sporadic with the Dubai Emirate providing the best source of information (Saseendran, 2011).

Terrorism presents a key issue which could easily affect the geopolitical stability of the region, if not the entire globe (given the number of energy installations), global trade, economy and operations. There are also metrological and tectonic hazards to consider. For one, the Arabian Gulf is shallow, about 200 meters or less in most areas and as observed by Hafez and Halim (2007), the terrain is flat, with most of the oil installations either on the shore or in shallow water areas, major oil fields are either in the shallow area of the gulf or in the desert adjacent to the gulf shores. This makes them vulnerable to large tidal waves or sea storms. In February 2014, for example, Shamal winds helped contribute to unstable cool weather and strong offshore waves that led to shipping warnings. In land small dust storms were also reported (Kazmi 2014).

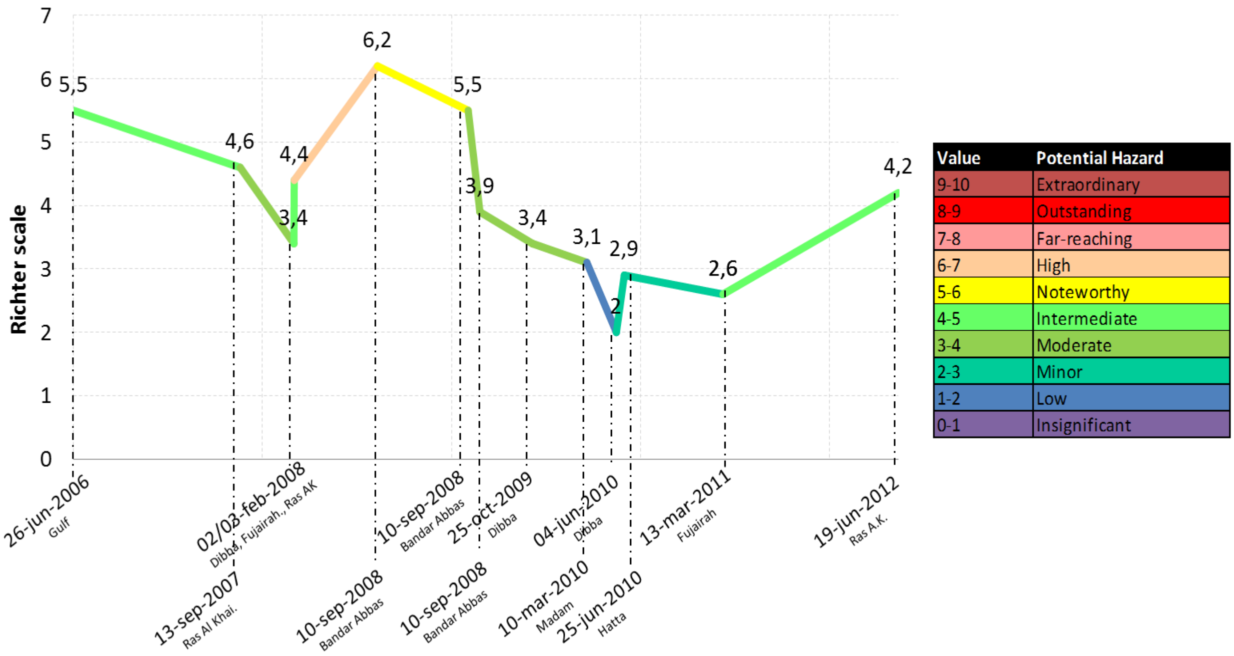


Figure 2: UAE Earthquakes experienced in the last 8 years: Magnitude and Place. Source: Authors, Data taken from Gulf News (2013c)

Tectonically, there are 25 seismogenic source zones in the Arabian Peninsula (Al-Amri, 2005) including the Zagros Thrust fault which readily generates earthquakes measuring 5 on the Richter Scale such as the Masafi Earthquake (magnitude ~5).Other potential threats come from the Hurmuz Straits, north of which is one of the most notoriously seismic active zones in the world (Shanableh *et al*, 2005). Figure 2 shows the tectonic activity experienced in the country since 2006. Most activity has been moderate or minor but there has been notable and even high.

Preparations for any impending disaster have been slow and in fact, due to the country's recent establishment, large scale disaster preparation has featured on a national scene at an appropriate scale only recently. Every year brings more encompassing disaster management legislation and initiatives (Al Ghanim, 2010). This is particularly important in the energy sector because of the four-fold nuclear reactor development at the coast of Barakah. The UAE must thus act in a proactive manner and must prepare adequately so that it remains resilient should any disaster event occur. Critical energy infrastructure plays a vital role in the UAE. Therefore, the preparedness of energy sector is very important. Next section describes the critical energy infrastructure in the UAE.

4. Critical energy infrastructure in the UAE

The energy sector dominates in the UAE and the gulf region generally. The Emirati economy is the second biggest regionally, after Saudi Arabia, and remains on course for five percent growth protection within the next four years –largely due to rising oil prices (Karach, 2011). Some OPEC nations and many non-OPEC nations have seen production decline, but the UAE has increased its total production of crude oil by approximately 31 *percent* and thus plays a highly significant role in global energy markets (EUAEW, 2011). The energy sector is therefore very much an economic powerhouse responsible for the positive development of the nation. Energy security and supply are must therefore be a priority for a country that has built its reputation as the region's most stable country, both politically and economically with attractive business opportunities that are not found elsewhere (Dalli and Wilcox, 2006). The new development of nuclear power at Braqa, 33 miles from the coast provides another prime reason for comprehensive strategic planning in the mitigation of disaster. The technological choice of Generation III ''APR1400'', which has enhanced safety features (Al Farra and Abu-Jijleh, 2012) is a good example of man-made prevention (as opposed to hazard preparation) but there is the need for further research into disaster management within the energy sector.

5. Methodology

The primary research of this study involved questionnaires consisting of both qualitative and quantitative style questions. In order to examine the disaster preparedness of the UAE energy sector. They were conducted in the official language of the UAE, Arabic. The location was at two electricity generating plants, one in Abu Dhabi and one in Dubai.

Forty questionnaires distributed and 35 were answered (20 Abu Dhabi and 15 Dubai) with 5 refusals. All were male and most aged between 30-40. The mean number of years employed at the Abu Dhabi plant was 4.5, a figure slightly higher than the years of experience in the current position at 4.4. In Dubai the mean of the years employed was lower 4.2 and likewise the years of experience in the current position was 3.8. Figure 3 shows the work area distribution of the respondents. All respondents belong to either the operational or technical area, who have the most direct contact with any threats in the field.

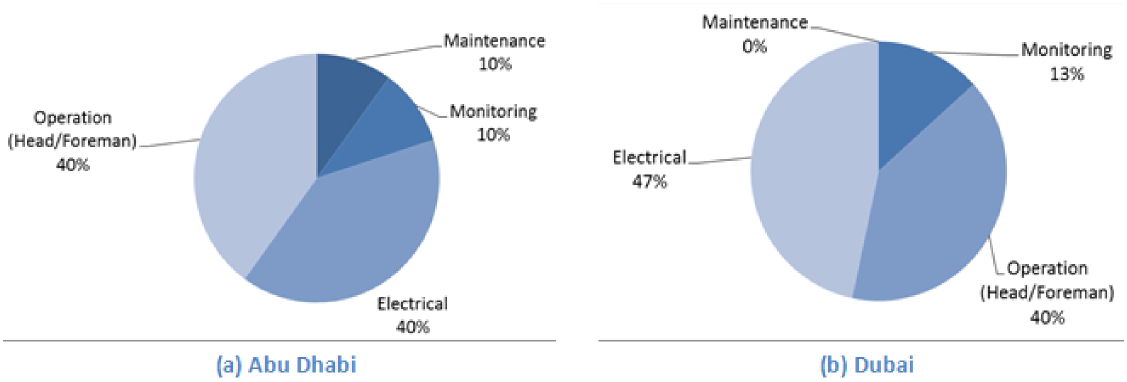


Figure 3: Work area distribution of the respondents (a) Abu Dhabi (b) Dubai

The questionnaires contained both qualitative and quantitative questions and most were multiple choice or structured in a matrix. In the latter the respondent was given a scale of 1 to 10 with which to make his choice. In addition, yes/no answer options were often used. In order to ensure a collective understanding of the questionnaire and the purpose behind it an information session and introduction by the researcher was given.

The questionnaire contained questions on the following topics:

- Preparation of the Emirati energy sector for natural and man-made hazards
- Perceived state of preparedness
- Barriers to be overcome to reduce vulnerability and increase preparedness

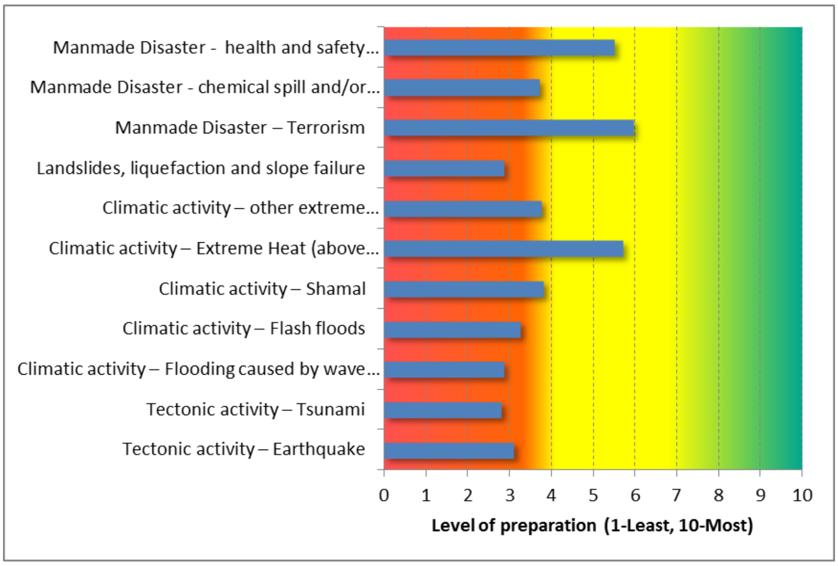
Steps in data analysis included: (i) editing and coding survey data, (ii) processing them in proper software, (iii) providing a descriptive statistical analysis for all the questions to generate insights. There are three basic measures of central tendency—mean, median and mode. In order to give some quantitative indication of the results, such as relative preparation for example, an index using the mean was constructed for each situation. Following section presents the findings from the questionnaires survey on preparedness of Emirati Energy Sector.

6. Results

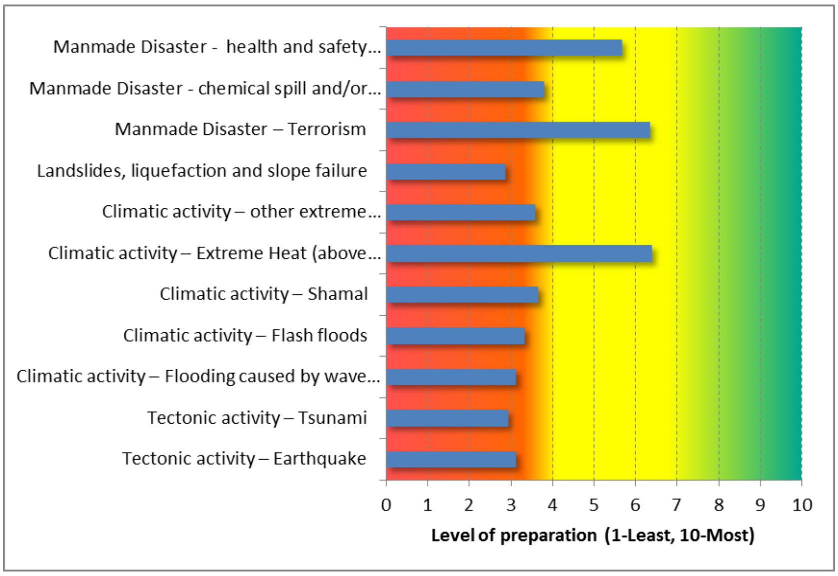
6.1 Preparation of the Emirati energy sector for natural and man-made hazards

The first question asked by the researcher included a list of hazards that people think the Emirati energy sector is best prepared for.

In terms of preparation both, Abu Dhabi and Dubai respondents believe that the sector is the most prepared against terrorism, extreme heat and health and safety related accidents. In general, the energy sector is ill-prepared when it comes to facing natural disaster. This is seen in the fact that in many cases the modal value is “3” whilst the mean value also lies in the 2-3 range. State of preparation rarely climbs above 5. It can be stated, based on the maximum values of Dubai that its workers feel more prepared for disaster than in Abu Dhabi (please refer to Figure 4a & 4b).



(a) Abu Dhabi



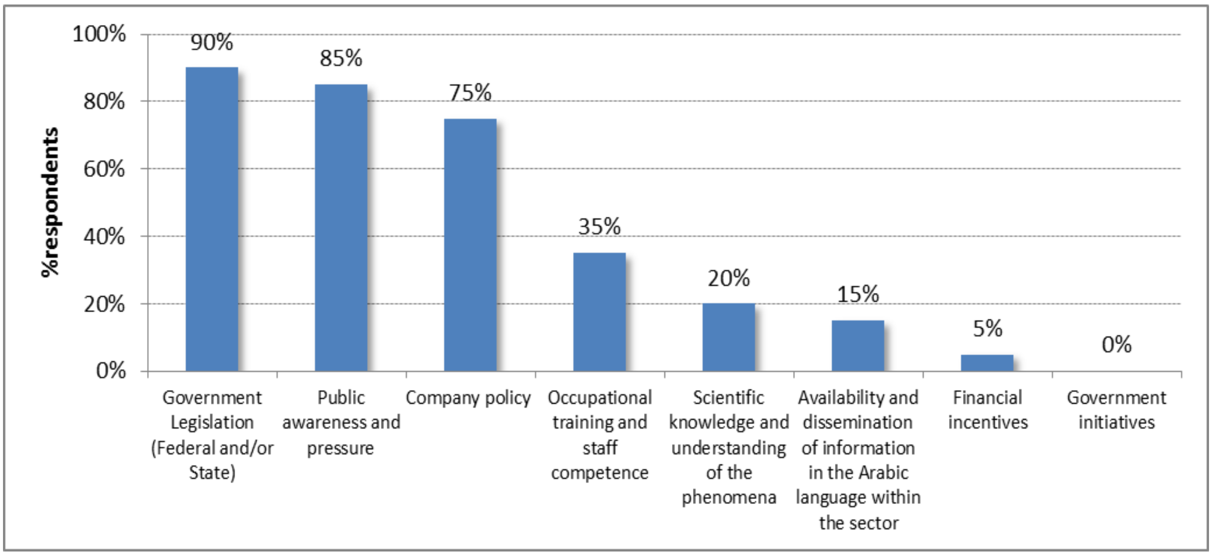
(b) Dubai

Figure 4: Level of preparation of the Emirati energy sector by hazard (a) Abu Dhabi (b) Dubai

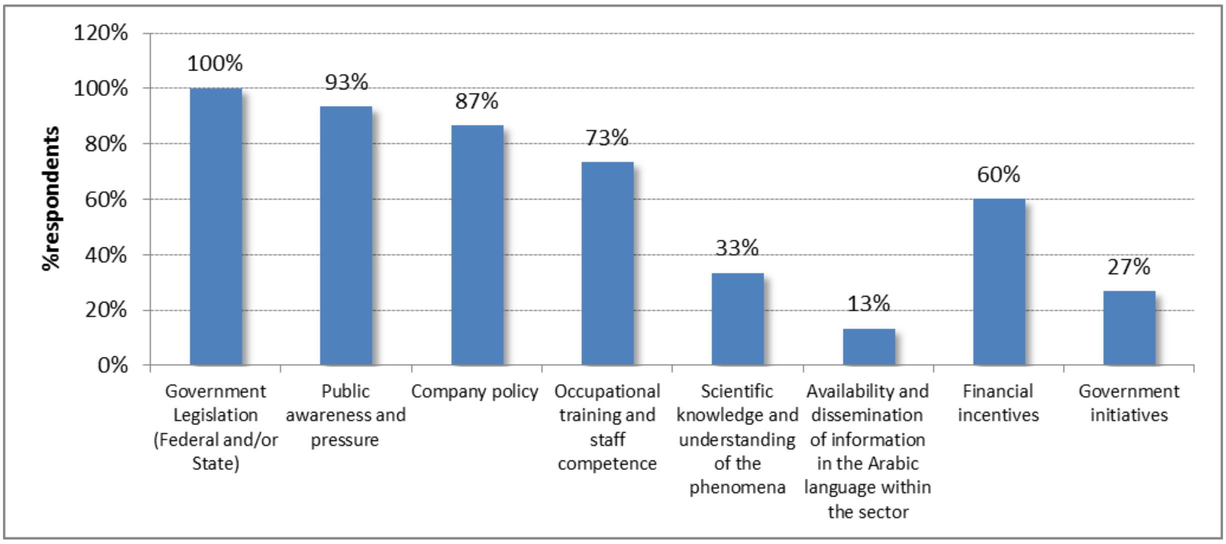
6.2 Perceived state of preparedness

Seeing as *10* represents the disaster that the energy sector is most prepared for and *1* the least, it follows that the UAE energy sector, is most vulnerable to those hazards that fall into the red, partly vulnerable if in yellow and not vulnerable if shaded green. Some 73% of the hazards listed fall below 4 (high vulnerability).

Respondents were asked to provide reasons as to why a given hazard scored highly (i.e. > 8). Although not all respondents scored any hazard greater than 7, given that the highest mode for Abu Dhabi is 6, they nevertheless attributed a number of reasons to the greater state of preparedness (refer to Figure 5) There is a strong degree of consistency between the two cities.



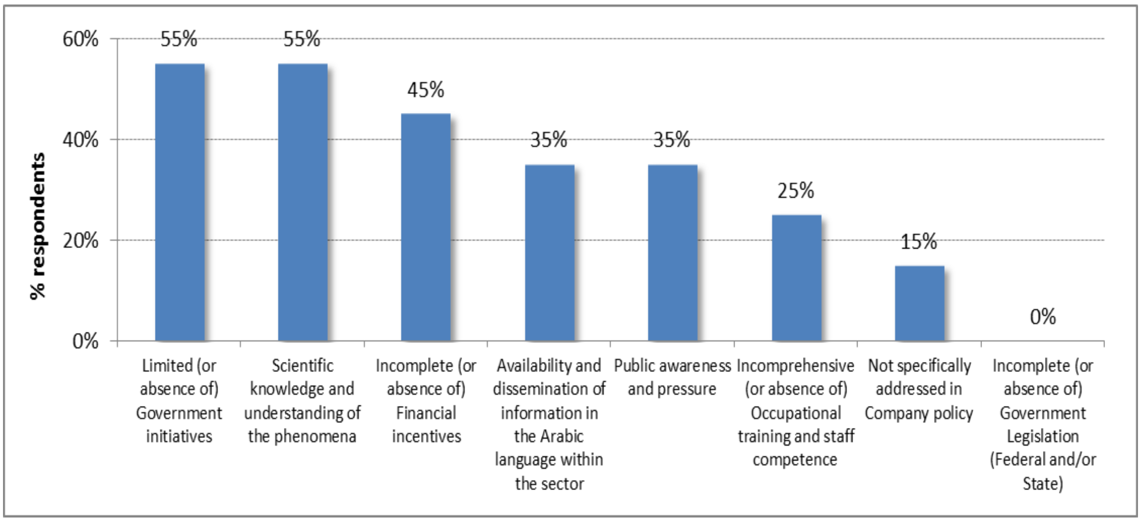
(a) Abu Dhabi



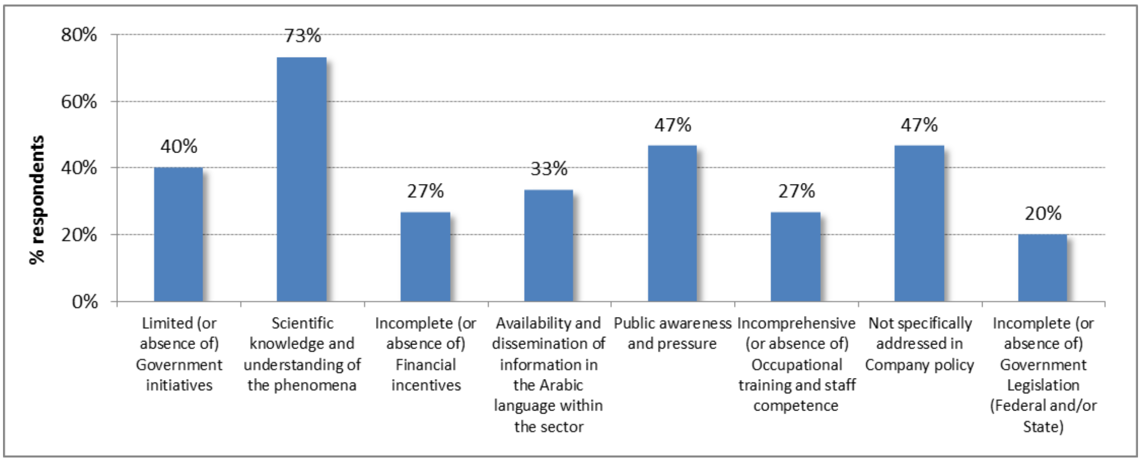
(b) Dubai

Figure 5: Greater state of preparedness of the Emirati energy sector (a) Abu Dhabi (b) Dubai

The reasons attributed to the lack of state of preparedness to disaster are shown in Figure 6. The answers between the two cities were distinct, except in the case of “scientific knowledge”.



(a) Abu Dhabi



(b) Dubai

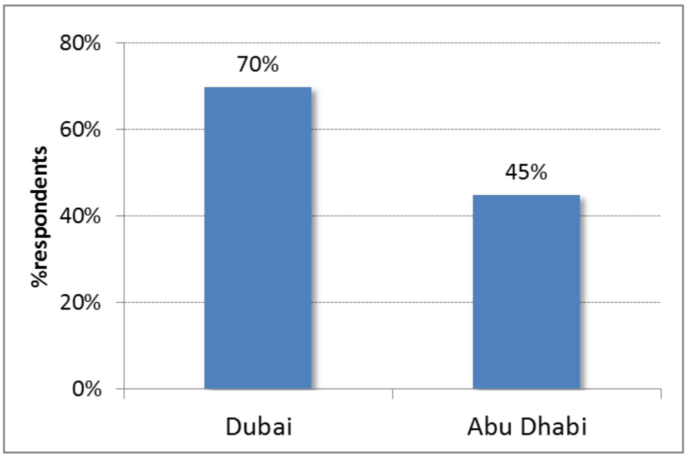
Figure 6: Lack state of preparedness of the Emirati energy sector (a) Abu Dhabi (b) Dubai

Figure 7 shows that both sets of respondents view Dubai as the most prepared Emirate state for natural disaster, indeed more in Abu Dhabi think Dubai is the best prepared than in Dubai itself. The following reasons are given Table 1:

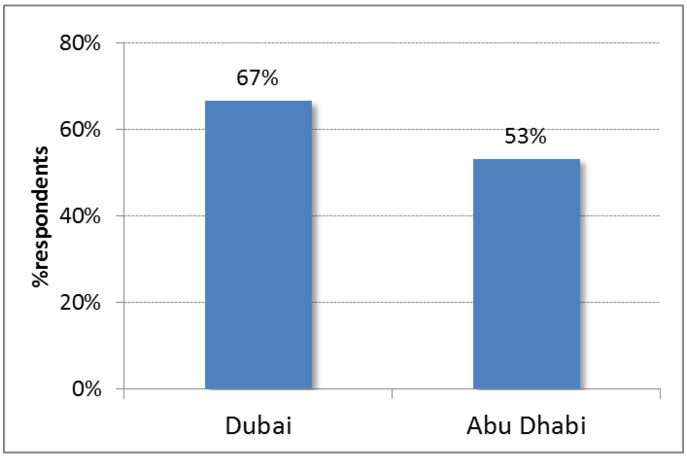
Table 1. Reasons given in each Emirate as to the better prepared state

Opinions	*Abu Dhabi*	*Dubai*
Better corporate policy for preparedness and response to disaster	*25%*	*7%*
Better planning standard for energy distribution and preparation against hazardous	*25%*	*33%*

Opinions	Abu Dhabi	Dubai
Being a more organized and discipline company	*20%*	*7%*
Human development e.g. through training, motivation and salary	*15%*	*33%*
Creation of a specialized area for the disaster management	*15%*	-
Being pioneers in the field by the innovation and better practices	*10%*	*27%*
More resources for equipment	-	*7%*



(a) Abu Dhabi



(b) Dubai

Figure 7. Well prepared Emirati states for hazards in the energy sector (a) Abu Dhabi (b) Dubai

When asked which Emirate is the worst prepared few people answered the question. Most who answered, stated Abu Dhabi, and attributed the limited preparation to human resources policies of the companies (training, development) and poor operation planning (refer to Figure 8). The absence of response may relate to social desirability bias. Social desirability, a problematic bias recognised as early as 1954 by Maccoby and Maccoby, is a social phenomenon which can be considered as the common courtesy and acceptability shown to strangers or acquaintances (or researchers) before they penetrate your circle of friends or enemies. It can occur in research due to issues of trust as respondents may not truly believe or understand what the researcher will really use the information for.

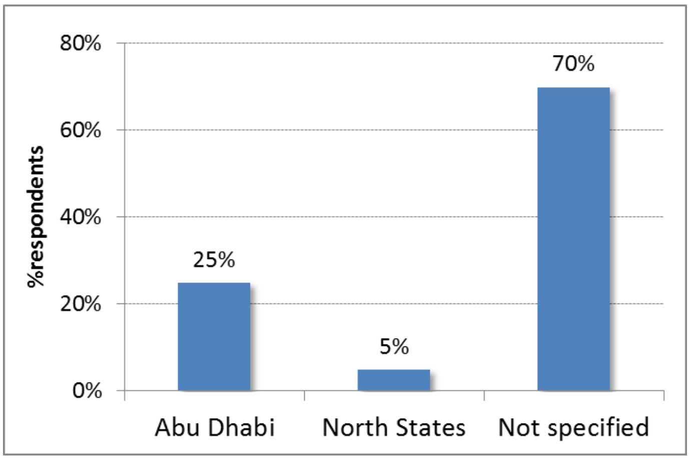


Figure 8. Ill prepared Emirati states for natural hazards in the energy sector by Abu Dhabi respondents

6.3 Barriers to be overcome to reduce vulnerability and increase preparedness

The main barriers (refer to Figure 9) identified by the questionnaire correspondents are:

- Disaster management training in the energy sector remains to be addressed (71% of the respondents)
- Staff competences, especially through education, to support the understanding of climate change and its related disasters (31%)

To complement the above, it is considered necessary to:

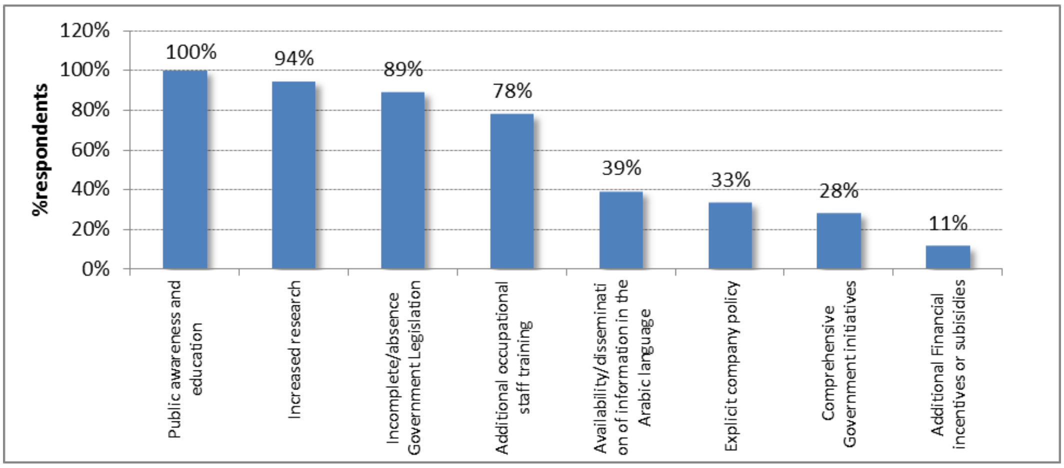
- Undertake verification simulations to assess the stage of personnel preparation, organisational structure in disaster response and resource capacity installed (31%)
- Develop a better planning stage for disaster preparation (26%)
- Achieve greater awareness, which means to give more priority to the issue (23%)
- Improve the human management policies in companies, such as safe work practices especially when it comes to time pressures (6%)
- Set more regulations in this line with sound disaster management practice (3%)

It is notable that the majority of responses were aimed at human resource improvement more so than other variables including technical or financial resources, policies or research.

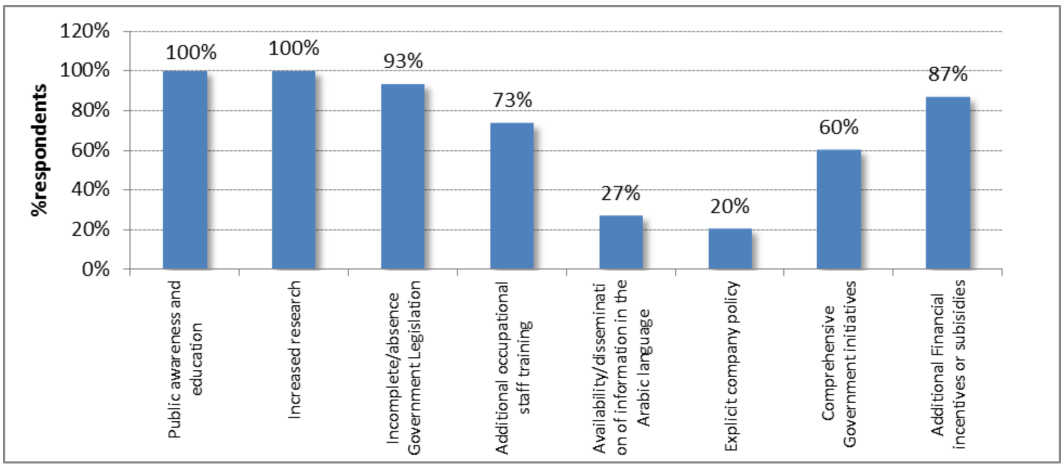
Considering the importance given to training by respondents, relevant courses should be designed to develop skills and awareness using effective and participatory methodologies. Such an approach could be an effective way to improve safety lead to prevention. Also, a revised training programme assures the effectiveness of training.

Finally, the authors looked at how to identify what is thought to enhance the resilience in the energy sector. The following were proposed by three-quarters of the respondents as a way to develop a sound disaster management plan for hazards affecting the energy sector:

- More public awareness and education
- Increased research
- More comprehensive government legislation
- Additional occupational staff training



(a) Abu Dhabi



(b) Dubai

Figure 9. Ways in which to enhance the resilience in the energy sector (a) Abu Dhabi (b) Dubai

7. Discussion

In terms of preparation respondents believe that the sector is best prepared against terrorism, extreme heat and health and safety related accidents. In general with the exception of terrorism at a mean of 6, limited error and a higher concentration to the right of the mean, respondents believe that the energy sector is ill-prepared when it comes to facing disaster. This is seen in the fact that in many cases the modal value is “3” whilst the mean value also lies in the 2-3 range. State of preparation rarely climbs above 5. It can be stated, based on the maximum values of Dubai that workers feel more prepared in the event of disaster than in Abu Dhabi.

Other key findings of the primary data are that the results obtained from the two sites are very similar. This may be due to the similarities in training received, the way management operates or even the education received by staff. Further research is required into this consideration, as it may well influence latent failures of the energy sector.

War and terrorism are seen as key threats to the Emirati sector. war, despite not having been specifically listed as a possible answer, was stated in the other category. In fact 50% of respondents said that “terrorism” was presented the greatest risk. This is, in some respects, unusual because of the lack of geopolitical instability in the country. There have been regional issues such as historical problems with Iran or the political climate in Arab regions following the Arab Spring. Climate change is also recognised as an issue.

The main barriers to resilience in the energy sector are said to be: Disaster management training in the energy sector remains to be addressed (71% of the respondents); Staff competences, especially through education, to support the understanding of climate change and its related disasters (31%)

The solutions put forward by the respondents to tackle such problems include programmes of public awareness and education, more stringent government legislation (at Federal and/or State level) and increased research to enhance scientific knowledge and understanding of the phenomena that influence the resilience and preparedness of the energy sector. Further research via in depth interviews is required to fully evaluate the effectiveness of such solutions.

Finally, the authors believe that this study should be extended across the entire energy sector to see whether the results of this case study can be validated: Such results could then form the basis of the UAE’s future energy sector strategies for the development of resilience in the face of both man-made and natural disasters.

8. Conclusion

Disaster preparedness is a key component of the disaster cycle which can build resilience into the energy sector. There is however various improvements that need to be made in the UAE to improve the energy sector’s performance. Dubai is said to be more resilient than Abu Dhabi to disaster. The sector is also said to be more resilient when it comes to manmade disasters and natural ones involving extreme heat. Employees of energy facilities do however state the need to increase the level of preparedness through public awareness and education, government legislation (at Federal and/or State level) and increased research to enhance scientific knowledge and understanding of the phenomena.

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Requirement of a Lifelong Social Security System for Operational Workforce of Construction Industry in Sri Lanka

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Abstract

Behaviors of Operational Workforce have been one of the challenges in the construction industry and construction sector is suffering from shortage of required human resources for its physical operations even though unemployment rate in Sri Lanka is about 4.2%. Despite all the other resources, management of Operational Workforce still determines the success or failure of construction projects. Operational workers represent a member of the working class who in generally performs manual labour and earns an hourly or output based remuneration. The main focus of this study was to explore what would happen to the industry, if it keeps neglecting the people who bring the desires of employers, blended with innovativeness of architects, strengthened by engineers, enumerated by quantity surveyors, documented by contract administrators into reality according to the sequence of planning engineers by builders and contractors, if no proper Operational Workforce is available. This paper is aimed towards identifying the barriers to attract workforce to construction industry and underline the steps to be taken for developing a responsible Operational Workforce.

Keywords: Operational Workforce, Construction Industry, Behavior, Retirement Benefits, Sri Lanka

1. Background

Construction is a project initiative industry. Project Management approach means having a temporary and systematic framework from inception to completion to procure ‘a unique product, service or a result which has defined start and end date’ (PMBOK, 2008). In the recent past many construction projects faced time and cost overruns due to unavailability of operational workforce. Many researchers identified scarcity of labour (Operational Workforce) as one of the key factors of project delays (Gaminiratne, 2004; Pathirage, 2008; Samarakoon, 2009 and Chandradasa & Ekanayake, 2011). Delay is one corner of the iron triangle as depicted in ***Figure 1***, i.e. time. Another corner is ‘quality’, which again has considerable impact from workmanship (Atkinson, 1999). Therefore, it is obvious that the third corner ‘cost’ is affected by the performance of operational workforce.

Figure 1: Iron Triangle

If cost overruns could be minimised and the salvaged finances could be reinvested to improve the operational workforce, then more productive and efficient workforce can be expected.

The Rethinking Construction report produced by Sir John Egan (Egan, 1998) to the Prime Minister of United Kingdom identified seven areas where attention should be given in the construction industry during the 21st century. Following recommendations were made therein by Sir John Egan:

A. Capital cost to be reduced by 10%

B. Construction time to be reduced by 10%

C. Predictability to be increased by 20%

D. Defects to be reduced by 20%

E. Accidents to be reduced by 20%

F. Productivity to be increased by 10%

G. Turnover and profits to be increased by 10%

Four of the seven significant areas identified through Sir Egan's report (B, D, E and F) have direct correlations to the behavior of the operational workforce in the construction industry. Thereby, this paper attempts to explore and identify barriers to attract construction operational workforce with the intention of addressing any perceived issues. In doing so, this research focuses on the Sri Lankan construction industry due to apparent behavioral challenges (Wijewickreme and Ekanayake, 2010). Next section defines and introduces operational workforce.

2. Operational workforce

General labour, skilled worker, physical production worker, blue collar worker, artesian, craftsperson, tradesman, operational level worker and the like are used to identify the Operational Workforce in construction industry. According to the findings of Equality and Human Rights Commission through their researches, 8% of the total workforce in UK or three million people are belongs to the construction sector (EHRC, 2010). Researches related to construction labour productivity are of at great interests to the academics and professional practitioners (Kadir, et al., 2005). Construction can be considered as a human driven industry. There are 300,000 firms working in construction industry as Small and Medium Scale Enterprises (SME) in UK itself. Sri Lankan Construction sector employs 8.2% of the total workforce or 682,000 people inclusive of Mining, Quarrying, Electricity, Gas and Water supply according to the reports produced by Central Bank of Sri Lanka (CBSL, 2012). There are over 2,000 registered contractors (ICTAD, 2013) in Sri Lanka as at present.

Construction is a male dominant industry. In USA, female contribution for construction sector is 4.3% (Swinney, 2005). The same is 3% in Sri Lankan context (Pathirage, 2008). Males generally enjoy responsibilities, which includes sourcing the requirements of their dependents. Majority of the Operational Workforce in construction industry of Sri Lanka is local migrants moved from villages to urban areas. They often work at remote locations and usually meet their dependents once a month. There are around 30 various trades directly related to construction activities excluding the trades of other major supportive trades such as; communication, mechatronics, electromechanical, building management and air conditioning. Having discussed operational workforce, next section briefs challenges within Sri Lankan industry context.

3. Challenges of operational workforce

Total unemployment in Sri Lanka is accounted around 4.2% (CBSL, 2012). According to the recent statistics, it appears that construction is not among the popular industries for the youths of Sri Lanka. Suitably educated but unemployed male population (up to GCE A/L) in Sri Lanka is about 4.7%, but it appears they are reluctant to join the construction industry (DCSL, 2012, p. 20; Table 5.4).

Youngsters prefer joining armed forces than construction industry after the school education even to scarify their lives at frontline operations and prepare the living path for their dependents even if they are not in existence. If lucky to survive, then they will become eligible for a lifelong pension scheme after completing 22 years of military services. If not their dependents will receive the benefit of the government pension scheme. Hence, military operatives are free from mental stress of their dependents as soon as he or she joined.

Physiological Contract (Chandradasa & Ekanayake, 2011) is a study that introduced an "Iceberg" model. According to the model, most of the human problems cannot be seen from the surface view. In many cases what is possible to see is "Work" and "Pay" only. Hidden part of the iceberg contains many other negative effects as depicted in ***Figure 2***, which may larger, heavier and danger to the construction industry and to the general society at large.

Figure 2: Iceberg model of physiological contracts (Businessballs, 2013)

A study carried out by Wijewickreme & Ekanayake (2010), identified a number of behavioral problems of Operational Workforce in Sri Lanka as illustrated in ***Table 1*** below.

Table 1: Ranking of Behavioral Problems of Operational Workforce

Rank	***Description***	***%***	***RII***
1	*High labour turnover*	*11.43%*	*0.63*
2	*Poor quality of workmanship*	*11.34%*	*0.62*
3	*Temporary or irregular attendance*	*11.29%*	*0.62*
4	*Lack of trade knowledge and skill*	*11.24%*	*0.62*
5	*Lack of cost concerns*	*10.34%*	*0.57*
6	*Irresponsibility & lack of reliability*	*10.29%*	*0.56*
7	*Unfair demanding of wages or rates*	*9.96%*	*0.55*
8	*Adamant behavior & lack of loyalty*	*9.58%*	*0.52*

9	*Reluctant to learning & training*	*9.20%*	*0.50*
10	*Carelessness & safety concerns*	*9.06%*	*0.50*
11	*Unethical sudden demanding*	*7.59%*	*0.42*

From the results, it was apparent that almost all the identified negative effects were giving considerable impact to the construction industry in relation to the requirements of managing the iron triangle (Atkinson, 1999). According to the recent growth of construction industry, demand for labour has risen while the supply seems to be insufficient. This situation is highlighted in the following statement.

> *"It is observed that the Labour Productivity has come down in almost all the sectors as a result of increased number of employees engaged, without a substantial or no increase in Value Addition. This may have been caused by the volatile nature of employment in the construction industry, where labour migration and shifting takes place, especially in the informal sector."* (Pathirage, 2008, p. 11)

Due to the insufficiency of labour, prices of labour have commenced increasing over the time, which ultimately increases the cost of overall construction. Labour costs itself captures almost 12% of total construction cost when it comes to infrastructure projects and the same becomes almost double or 20% to 25% when it comes to building projects depending on the quality and complexity of finishes according to the calculations based on Building Schedule of Rates (BSR) issued by ICTAD. Following statement explains the current status.

> *"The national working poverty incidence (13.7%) has been exceeded by the production industries of Agricultural, Construction and Mining workers who hold 21.1%, 18.1 % and 21.8% poor workers in respective categories when studying the poverty across the main industry categories of the workers occupied".* (Rasseedin, 2011a, p. 67).

It is said that tacit knowledge is much centered to the construction industry, developed through generations in Sri Lanka (Pathirage, 2007, p. 21) and at a risk of diluting it strengths whereas de Silva, et al., (2010) argued behavioral complications has become usual to the construction industry in Sri Lanka according to the recent studies. The situation is not necessarily limited to the construction industry, but there are many other industries which indicate similar negative effects as per the following statement.

> *"Conventional solutions for improving labour productivity concentrated on giving wage incentive to motivate the workers to work harder. But these alone are not expected to address, the root causes of low labour productivity, relating to health, worker attitudes, education, and the like".*(Rasseedin, 2011a, p. 93).

Victoroff (2005) argued that unavailability of a functioning social security system could lead to an increase in the criminal and terrorist activities due to lack of confidence because human nature has not changed. In Sri Lanka, a former Journalist of '*Agence France Presse'* (AFP) was murdered in February 2014 by a Paint bass that did pre charismas renovations to her residence (The Island, 2014).

This murder is an only a single example of many similar situations of burglary related murders by a casual operational workers of floating nature whom do not have any secured source of regular income.

4. Research methodology

The research was primarily based on inductive approach which moved from specific observations to a broader generalisations and theories. Research means different things to different people (Amaratunga, et al., 2002). Research is an organised process of combining and exploring range of approaches, strategies, techniques and procedures building towards the aim and objectives (Kumar, 2011). Researches are commencing from two types of approaches called deductive and inductive. When using the deductive approach, the researcher narrow downs a broad picture (more general) of an object towards a more specific focal point. Inductive researching is the opposite path of deductive approach (Saunders, et al., 2012).

This paper presents the results of a research that was carried out to find the barriers for attracting Operational Workforce in to the construction industry. A questionnaire was administered (Please refer to the copy of questionnaire at the end) among a sample of the Operational Workforce of the Sri Lankan construction industry, their immediate supervisors, project managers and directors of construction contractors. Following section provides more details on the questionnaire, analysis and its outcomes.

5. Questionnaire survey and research outcomes

A questionnaire was prepared with two-point perspective format (Wijewickreme & Ekanayake, 2010) to obtain different viewpoints of both Operational Workforce and their Managers on the same objectives. Managerial team was selected from directors, site managers and immediate supervisors through a structured cross section containing 55 members as given in ***Table 2***. The team representing the managerial perspective was requested to assess negative impacts of the Operational Workers from the management point of view according to a Degree of Importance from 1 to 7 Likert scale (Likert, 1932). Relative Importance Index (RII) (Enshassi, et al., 2012) was used to help further analysis. The questionnaire designed for management had two separate sections that assessed the negative behavioral affect they experienced from the operational workforce.

Table 2: Questionnaire Distribution

A.	*Company Directors*	*5*		*Managerial Team (Total 55)*
B.	*Site Managers*	*10*		
C.	*Middle Managers - Technical*	*40*		
D.	*Operational Workers*	*400*		
	Total	*455*		

All the questions in the questionnaire were based on the findings of pilot survey carried out with selected industry professionals. Additional spaces were provided within the questionnaire to add new negative affects based on their personal experiences. Operational Workforce represented randomly selected 400 participants from different independent projects. The questionnaires for the Operational Workforce were available in all 3 recognised languages (Sinhala, Tamil and English) in Sri Lanka.

5.1 Data Analysis

To determine the relative ranking of the assessment methods, the scores entered in the survey were transformed to RII values using the following equation where 'w' is the weighting given to each factor by the respondents, ranging from 1 to 7.

$$RII = (\sum w)/AN$$

In the formula, 'A' is considered as the highest weight (i.e. 7 for this research) and 'N' is the total number of samples. Accordingly, RII is the relative important index, where the answers are between '0' and '1'.

5.1.1 Recruitment modes of Operational Workforce

Five different modes of recruiting were identified and analysed according to the relative importance of findings. Most common mode of fulfilling the required number of Operational Workforce has been the 'output based subcontracting' as indicated in

Figure 3.

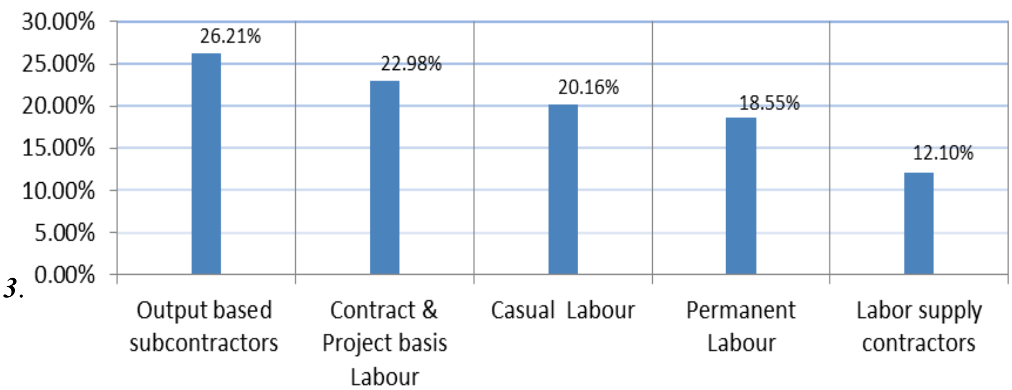

Figure 3: Recruitment Modes of Operational Workforce (Wijewickreme & Ekanayake, 2010)

5.1.2 Difficulties Experienced by Operational Workforce

Data received from both Managerial team and Operational Workforce were analysed with the use of RII. Relative and comparative importances of the identified negative effects are presented in ***Table 3*** below. Ranking of relationships between the findings from the viewpoint of Operational Workforce was compared against the viewpoint of Managers. From both viewpoints, most important reason was identified as 'Poor Retirement Benefits'. There wasn't any significant difference between management and operational workforce viewpoints on the 'Top 6' negative impacts.

Table 3: Comparative analysis of the negative effects of Operational Workforce

	Description	*%*	*RII of Operational Workforce*	*Ranking (By Workmen)*	*Variance*	*Ranking (By Management)*	*RII of Management Team*	*%*
a	*Poor retirement benefits*	*9.60*	*0.91*	*1*	***0***	*1*	*0.91*	*10.5*
b	*Dissimilarities in salary scales*	*9.50*	*0.90*	*2*	***+3***	*5*	*0.80*	*9.20*
c	*Gray areas in the career development*	*9.10*	*0.87*	*3*	***+1***	*4*	*0.82*	*9.50*
d	*Temporary nature of the occupation*	*8.90*	*0.84*	*4*	***+2***	*2*	*0.87*	*10.10*
e	*Lack of social recognition*	*8.80*	*0.83*	*5*	***-2***	*3*	*0.82*	*9.50*
f	*Non availability of recreation facilities*	*7.00*	*0.67*	*6*	***0***	*6*	*0.60*	*6.90*
g	*Being away from family and relatives*	*6.30*	*0.60*	*7*	***+5***	*12*	*0.46*	*5.30*
h	*Political & social influences*	*6.20*	*0.59*	*8*	***+2***	*10*	*0.48*	*5.60*
i	*Safety & sanitary facilities*	*6.20*	*0.59*	*9*	***-1***	*8*	*0.55*	*6.30*
j	*Interpersonal relationships*	*6.20*	*0.59*	*10*	***-1***	*9*	*0.52*	*6.00*
k	*Lack of trouble free communication*	*6.00*	*0.57*	*11*	***+3***	*14*	*0.38*	*4.40*
l	*Influence from the dependents*	*5.50*	*0.52*	*12*	***-1***	*11*	*0.48*	*5.50*
m	*Improper gender balance*	*5.40*	*0.51*	*13*	***-6***	*7*	*0.55*	*6.30*
n	*Behaviors of the immediate supervisor*	*5.30*	*0.50*	*14*	***-1***	*13*	*0.41*	*4.80*

Poor retirement benefit is considered as the most significant barrier for attracting Operational Workforce in to the construction industry, particularly within the Sri Lankan context. Thereby, introducing a social security system for operational workforce of Sri Lankan construction industry is considered as critical for attracting and maintain efficient, and productive construction workforce. Succeeding section discusses about social security system.

6. Social Security

Social security is a fundamental right according to the Article 22 of the Universal Declaration of Human Rights (United Nations, 1948, p. 5).

> *'Everyone as a member of the society has a right for a social security and is entitled to realisation, through national effort and international cooperation in accordance with the organisation and resources of each State, of the economic, social and cultural rights indispensable for people's dignity and the free development of the personality'.*

International labour Organisation (ILO) considers social security as a universal need. Social security is recognised as a basic human right by the ILO Conventions and United Nations charters such as International Covenant on Economic, Social and Cultural Rights as well (Ginneken, 2003). The objective of a social security is to protect the poor and vulnerable and to ensure that they have an acceptable standard of living. Social security may also involve smoothing consumption and reducing risk or spreading income over the life cycle. Often there is a redistribution of income among groups with differing needs (Ahmad, 1991). Majority of the public consider social security as the most important form of household wealth (Fedlstein, 1974). Neither the theoretical nor the empirical analyses were given due consideration or adequate attention to the existence and growth of social security.

6.1 Social security in construction industry in Sri Lanka

Poor retirement benefits could be considered as the major barrier to attract the current youth as their future sector of careers as illustrated in ***Table 3***. According to the findings of Wijewickreme & Ekanayake (2010), 6.25% of the operational workforces in construction industry are above their retirement age but still working due to absence of an effective and lifelong social security system. As per the 'A Theory of Human Motivation' (Marslow, 1943), 6.25% of the over aged Operational Workforce in construction industry should be in the level of Self Actualisation. However, in Sri Lankan construction industry context, the same is still fighting for their basic 'Physiological Needs' such as Air, Water, Food and Sleep. Sometime they were forced to work to fulfill their day-to-day requirements including their dependents such as grand children or their parents.

As stated in the iceberg model in ***Figure 2***, what could be observable were 'Pay' and 'Work'. Based on the findings in ***Table 3***, there were 14 other negative effects which could not resolve only with a 'Pay' to the Operational Workforce. Their requirements of workforces needed more and broad attention from the Management perspective. Demands of the Operational Workforce were not merely limited to a settlement through payment. Similarly, in the reverse version 'Just Work' for the 'Pay' could not settle the requirements of the Employee. Some of the requirements of operational workforce cannot be resolved without the intervention from the statutory organisations.

Professionals such as Client Advisors, Architects, Engineers, Quantity Surveyors, Planning Engineers, Contract Administrators, Builders, Contractors, etc. are working towards the future of the industry. Series of professional bodies are supporting them to develop their career status with CPD's, Seminars, Exhibitions, Award Ceremonies, AGMs, and Conferences but haven't seen an event organised for the Operational Workforce of the construction industry.

7. Conclusion

According to the findings of the research, it can be concluded that Operational Workforce will not be a commodity anymore. Human resources shall not be treated similar to the other commodities which can mobilise and demobilise similar to a Just in Time (JIT) activity sequencing of Supply Chain Management process.

They have to be considered as partners of the industry. As partners of the industry, they will become eligible to share profits. Suggested partnership arrangement is in line with the Goal 8 (Develop a global partnership for development) of the Millennium Development Goals (UN Millennium Project, 2000). The best profit that Operational Workforce looking for at present as partners of the construction industry is a retirement benefit. National level planning and resources management structure is an essential need to fulfill their requirements. Hence, industry needs to pay more attention to resolve the issues related to operational workforce in construction industry.

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Appendix A

Research Project on
Motivating Blue Collar Workforce Towards Construction Industry
Conducted By

Master of Science in Construction Project Management
Department of Civil Engineering, University of Moratuwa, Sri Lanka

Questionnaire Form 'D'

---

1. General Information

Name			
Age	☐ Years	Experience	☐ Years
Trade		Mobile	
Address			

2. What are the difficulties that you are experiencing as at present as a construction worker? (Weigh the range by giving **"1 for low"** importance and **"7 for high"** importance)

		Degree of importance						
		Low			Mid			High
		1	2	3	4	5	6	7
a.	Lack of social recognition	☐	☐	☐	☐	☐	☐	☐
b.	Temporary nature of the occupation	☐	☐	☐	☐	☐	☐	☐
c.	Behaviors of the immediate supervisor	☐	☐	☐	☐	☐	☐	☐
d.	Gray areas in the career development	☐	☐	☐	☐	☐	☐	☐
e.	Interpersonal relationships	☐	☐	☐	☐	☐	☐	☐
f.	Insufficient income	☐	☐	☐	☐	☐	☐	☐
g.	Dissimilarities in salary scales	☐	☐	☐	☐	☐	☐	☐
h.	Political & social influences	☐	☐	☐	☐	☐	☐	☐
i.	Influence from the dependents	☐	☐	☐	☐	☐	☐	☐
j.	Improper gender balance	☐	☐	☐	☐	☐	☐	☐
k.	Safety & sanitary facilities	☐	☐	☐	☐	☐	☐	☐
l.	Poor retirement benefits	☐	☐	☐	☐	☐	☐	☐
m.	Non availability of recreation facilities	☐	☐	☐	☐	☐	☐	☐
n.	Being away from family and relatives	☐	☐	☐	☐	☐	☐	☐
o.	Lack of troublefree communication	☐	☐	☐	☐	☐	☐	☐
p.	Other 1	☐	☐	☐	☐	☐	☐	☐
q.	Other 2	☐	☐	☐	☐	☐	☐	☐

Big Data and Decision Support System for Climate Change and Resilience Management of Built Environment

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Abstract

Every day, we create 2.5 quintillion bytes of data — so much that 90% of the data in the world today has been created in the last two years alone. This data comes from everywhere: sensors used to gather climate information, posts to social media sites, digital pictures and videos, purchase transaction records, and cell phone GPS signals to name a few (IBM 2013). Built environment, climate change and resilience management have similar situation. Best practices and intelligent systems utilization is a key factor in productively executing climate change and resilience management in built environment. The main purpose of this paper is present the Decision Support System for Climate Change and Resilience Management of Built Environment which the authors of this paper have developed.

Keywords: Decision support system, built environment, climate change, decision making, Regia.

1. Introduction

Global Pulse is a UN initiative aimed at bringing together expertise from the public, private, development, and academic sectors to develop approaches for harnessing data for policy and action. Its director, Robert Kirkpatrick, says that data collected through mobile device usage can spur effective action in two primary ways: by reducing the time lag between the start of a trend and when governments and other authorities are able to respond to them, and by reducing the knowledge gap about how people respond to these trends (World Economic Forum 2012).

Global Pulse has developed a loose taxonomy of types of new, digital data sources that could be relevant to global development (Global Pulse 2012):

Data Exhaust – passively collected transactional data from people's use of digital services like mobile phones (call detail records, location data, airtime purchase patterns), making purchases, transferring remittances or mobile money, etc., and/or operational metrics and other real-time data collected by UN agencies, NGOs and other aid organisations to monitor their projects and programmes (e.g. stock levels, school attendance); these digital services create networked sensors of human behaviour;

Online Information – web content such as news media and social media interactions (e.g. blogs, Twitter), web searches, news articles obituaries, e-commerce, job postings; this approach considers web usage and content as a sensor of human intent, sentiments, perceptions, and want;

Physical Sensors – satellite or infrared imagery of changing landscapes, traffic patterns, light emissions, urban development and topographic changes, etc; this approach focuses on remote sensing of changes in human activity.

Citizen Reporting or Crowd-sourced Data – Information actively produced or submitted by citizens through mobile phone-based surveys, hotlines, user-generated maps, etc; While not passively produced, this is a key information source for verification and feedback.

Can "big data" help design and build better cities? Many scientists apparently think so, based on the number of new initiatives in "informatics"– the acquisition, integration, and analysis of data to understand and improve urban systems and quality of life. One of those is the new Urban Center for Computation and Data (UrbanCCD) at the University of Chicago. The research center is using advanced computational methods to understand the rapid growth of cities. According to UrbanCCD's website, Catlett's vision for the role of computation in cities takes a broader view, "combining models on environment and climate with the flood of open city data to build complex simulations for city planning." Some of that data sets the team can draw on include: 740 data sets (including 311, crime, inspections, code violations, financial, GPS vehicle movement); data sets from State of Illinois, Cook County, and City of Chicago law enforcement, education, health, employment, and welfare agencies; consumer survey (nationwide), product purchase, advertisement data; electrical usage and building details for 480,000 Chicago buildings; longitudinal data on assets and services for South Side of Chicago neighborhoods; Chicago buildings and transport systems (Institute of governmental studies 2013).

Also aiming to make the most of the fast-growing volume of digital data and in order to improve the ability of Americans to extract knowledge and insights from large and complex collections of digital data, the Obama Administration announced a "Big Data Research and Development Initiative" worth more than $200 millions.

2. Methodology

The authors of this paper participated in the different EU projects related with Land information system (EULIS), built environment, climate change and resilience management: LEAN CC (Linking European, Africa, and Asian Academic Networks on Climate Change) and Android (Academic Network for Disaster Resilience to Optimise educational Development) project. In order to increase the efficiency and quality of the delivery of training, teaching and research activities a Decision support System for climate change and Resilience management of built Environment (DESiRE) has been developed.

The research object is a built environment for climate change mitigation, interested parties striving to attain their goals and micro, meso and macro environment making an integral whole. DESIRE was developed with the goal of integrating the environmental, energetic, political, economical, legal/regulatory, infrastructural, technical, technological, pollution, health, quality of life, social, cultural, ethical, psychological, emotional, religious, ethnic and other aspects of the process over the life of the built environment for climate change mitigation. New methods for performing multiple criteria analysis of the research object chosen have been developed (Kaklauskas 1999): a method of complex determination of the weight of the criteria taking into account their quantitative and qualitative characteristics; a method of multiple criteria complex proportional evaluation of the projects; a method of defining the utility and market value of a project; a method of multiple criteria multivariant design of a built environment life cycle.

Based on the analysis of existing intelligent systems (Pyke et al. 2007, Vogel et al. 2007, Djordjević et al. 2011), above research object and developed multiple criteria methods (Kaklauskas 1999) a Decision Support System for Climate Change and Resilience Management of Built Environment (DESiRE) consisting of a database, database management system, model-base, model-base management system and user interface was developed.

3. Decision support system for climate change and resilience management of built environment

The following tables make DESiRE database:

Initial data tables. These contain general facts about the climate change and resilience management of built environment considered. Tables assessing refurbishment of built environment solutions. They contain quantitative and conceptual information about alternative of built environment refurbishment solutions (as examples see Adaptation to climate change (http://iti.vgtu.lt/imitacijosmain/simpletable.aspx?sistemid=389), Climate change and resilience management in built environment (http://iti.vgtu.lt/imitacijosmain/simpletable.aspx?sistemid=540), Climate Change Policies (http://iti.vgtu.lt/imitacijosmain/simpletable.aspx?sistemid=391), Operationalizing a Resilience to Uncertain Climate Changes (http://iti.vgtu.lt/imitacijosmain/simpletable.aspx?sistemid=392), etc.).

Tables of multivariant design. They provide quantitative and conceptual information on the interconnection of the elements of built environment to be regenerated, their compatibility and possible combinations as well as data on complex multivariant design of a of built environment. Since the efficiency of a built environment refurbishment variant is often determined taking into account quantitative and qualitative factors a model-base of the DESiRE should include models enabling a decision maker to do a comprehensive analysis of the variants available and make a proper choice. The following models of model-base are aimed to perform this function: a model of developing the alternative variants of built environment; a model for determining the initial weights of the criteria (with the use of expert methods); a model for the criteria weights establishment; a model for multivariant design of a built environment refurbishment; a model for multiple criteria analysis and setting the priorities; a model for determination of built environment utility degree and market price; a model for providing recommendations. Some examples of a model for multiple criteria analysis and setting the priorities are follows: Adaptation to climate change (http://iti.vgtu.lt/imitacijosmain/simpletable.aspx?sistemid=389), Equity and Climate Change (http://iti.vgtu.lt/imitacijosmain/simpletable.aspx?sistemid=390), Climate Change Policies (http://iti.vgtu.lt/imitacijosmain/simpletable.aspx?sistemid=391), Operationalizing a Resilience to Uncertain Climate Change (http://iti.vgtu.lt/imitacijosmain/simpletable.aspx?sistemid=392).

Based on the above models, the DESIRE system can make until 100 million built environment refurbishment alternative versions, performing their multiple criteria analysis, determining utility degree, market price and selecting most beneficial variant without human interference.

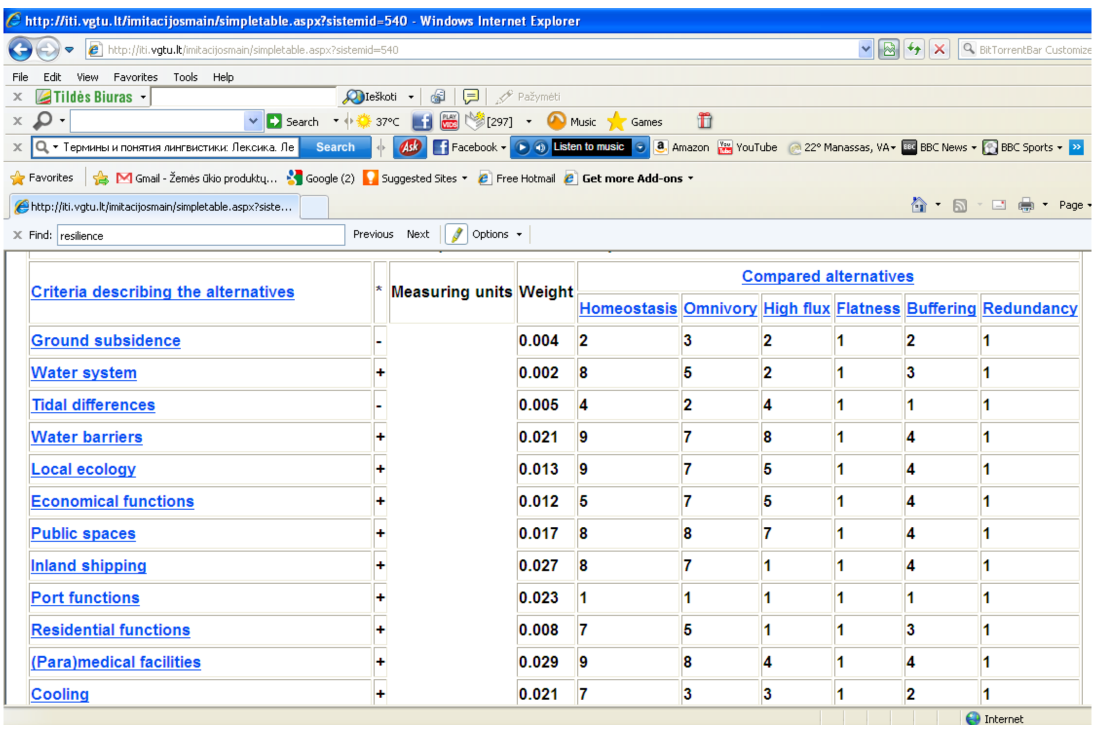
4. Case Study: Climate change and resilience management in built environment (Lithuania)

Floods are a risk in over 5% of Lithuania's territory, or 351,000 ha, including 193,000 ha of agricultural lands, 97,000 of forests, and 28,000 ha of urban territories. A 2011 preliminary estimation of the flood risks in the Republic of Lithuania by the Environmental Protection Agency (EPA) showed that between 1961 and 2010 Lithuania suffered flood damage worth about LTL 153,875,000. More than 70% of the damage fell on Rusnė and other coastal areas in Pamarys.

Rusnė is the only Lithuania's town on an island, in the southwest of Šilutė District. A modern bridge over the Atmata connects the town to the mainland and the road then leads to Šilutė. The other bank of the Skirvytė is in Kaliningrad Oblast, Russian Federation. A modern bridge was constructed over the Atmata, but there are times when even the bridge cannot save the locals from spring floods, which usually cover over 40,000 ha of meadows with water. The residents of Rusnė are protected from floods by levees. The island has a system of polders with 20 water-pumping stations. The land at the lake of Dumblė is 1.3 m below the sea level. Extreme floods are mostly characteristic of the areas in the lower reaches and delta of the Nemunas. The floods result from higher discharge in the Nemunas caused by snowmelt; because of ice jams the extent of submerged riverside land may often increase. Ice jams may prolong floods for extensive periods (by slowing down the receding stage). Such floods very often reach the level of a disaster. Floods resulting from snowmelt and ice jams account for about 70–75% of cases; about 15% are caused by heavy rains. The risk of floods may increase because of ice jams frequent in the Nemunas delta. Another 15% of cases may be attributed to other reasons such as the rising sea level in the Baltic Sea, accidents in hydrotechnical facilities and so on. Spring and winter are the typical flood seasons in Lithuania; they cover about 60% and 35% of cases respectively.

Using new methods for performing multiple criteria analysis of the research object chosen have been developed (Kaklauskas 1999), calculations were performed to estimate the weights of quantitative and qualitative criteria taking into account their quantitative and qualitative characteristics. Based on the calculated criteria values and weights, a decision making matrix for the town of Rusnė (see table 1; http://iti.vgtu.lt/imitacijosmain/simpletable.aspx?sistemid=540).

Table 1. Fragment of grouped decision making matrix of climate change and resilience management in built environment multiple criteria analysis



Criteria describing the alternatives	*	Measuring units	Weight	Compared alternatives					
				Homeostasis	Omnivory	High flux	Flatness	Buffering	Redundancy
Ground subsidence	-		0.004	2	3	2	1	2	1
Water system	+		0.002	8	5	2	1	3	1
Tidal differences	-		0.005	4	2	4	1	1	1
Water barriers	+		0.021	9	7	8	1	4	1
Local ecology	+		0.013	9	7	5	1	4	1
Economical functions	+		0.012	5	7	5	1	4	1
Public spaces	+		0.017	8	8	7	1	4	1
Inland shipping	+		0.027	8	7	1	1	4	1
Port functions	+		0.023	1	1	1	1	1	1
Residential functions	+		0.008	7	5	1	1	3	1
(Para)medical facilities	+		0.029	9	8	4	1	4	1
Cooling	+		0.021	7	3	3	1	2	1

The following alternatives have been chosen for the calculations: Homeostasis, Omnivory, High flux, Flatness, Buffering, Redundancy. The significance of the usage of Flatness and Redundancy could hardly be implemented in our concerned area. In contrast, the alternatives such as Homeostasis, Omnivory, High flux, and Buffering could be used in Lithuania. Those alternatives are composed to the area.

When analyzing the alternative Homeostasis we have noticed that such criteria as Water system, Water barriers, Local ecology, Public spaces, Inland shipping, (Para)medical facilities, Energy supply, Drinking water, Electricity, Sewage system, Main roads leading in/out of the area, Main water barriers, Risk information, Social structure, Evacuation plans, Water damage insurance, Safety policy, Areal system management, Urban planning, Modification of areas, Temperature, Sea level rise, River discharge, Societal and governmental issues, Rapid ice-sheet melting, Extreme storm, Maeslantkering failure plus extreme storm have high significance and only need a minor improvement or none at all. The matrix of the quantitative and qualitative information related to the alternatives with certain low percentages illustrates this clearly (cf. the criteria such as Ground subsidence, Port functions, Flooding-resistant buildings, Top-heavy system prevention, Port malaria incidents).

Fragment of climate change and resilience management in built environment multiple criteria analysis results are presented in Table 2.

Table 2. Fragment of climate change and resilience management in built environment multiple criteria analysis results

Wildcards	+	0.021	AVG MIN	AVG MIN	AVG MIN	AVG MIN	AVG MIN	AVG MIN
Rapid ice-sheet melting	+	0.026	0.0078 AVG MIN	0.0069 AVG MIN	0.0061 AVG MIN	0.0009 AVG MIN	0.0035 AVG MIN	0.0009 AVG MIN
Frozen port	+	0.009	0.0019 AVG MIN	0.0032 AVG MIN	0.0006 AVG MIN	0.0006 AVG MIN	0.0019 AVG MIN	0.0006 AVG MIN
Port malaria incidents	+	0.026	0.002 AVG MIN	0.01 AVG MIN	0.004 AVG MIN	0.002 AVG MIN	0.006 AVG MIN	0.002 AVG MIN
Enduring heat and drought	+	0.025	0.0067 AVG MIN	0.0067 AVG MIN	0.0058 AVG MIN	0.001 AVG MIN	0.0038 AVG MIN	0.001 AVG MIN
Extreme storm	+	0.03	0.0114 AVG MIN	0.0043 AVG MIN	0.0086 AVG MIN	0.0014 AVG MIN	0.0029 AVG MIN	0.0014 AVG MIN
Maeslantkering failure plus extreme storm	+	0.032	0.0096 AVG MIN	0.0075 AVG MIN	0.0085 AVG MIN	0.0011 AVG MIN	0.0043 AVG MIN	0.0011 AVG MIN
The sums of weighted normalized maximizing (projects 'pluses') indices of the alternative			0.2946	0.2329	0.2111	0.0456	0.1321	0.0456
The sums of weighted normalized minimizing (projects 'minuses') indices of the alternative			0.0103	0.0086	0.0099	0.0023	0.0046	0.0023
Significance of the alternative			0.2972	0.2361	0.2138	0.0574	0.138	0.0574
Priority of the alternative			1	2	3	6	4	6
Utility degree of the alternative (%)			100%	79.42%	71.94%	19.31%	46.43%	19.31%

When comparing the second alternative, mentioned in the table to the Homeostasis, Omnivory is less developed in the area. The system “when one becomes unavailable, other ways can be used” is not fully operational in the town of Rusnė and in Pamarys, as they are short of resources. Only such criteria as Energy supply, Drinking water, Electricity, Water damage insurance could prevent from local blackouts, heat and draughts. Because of the improper water area bottoms, the criteria like Port functions are not effective.

One of the implemented ways like High flux—implementation of urban planning—seems even less effective than the rest of the factors. Such vital criteria as Residential functions, Disaster management organization, Water-proofing ground level, Green area planning, Lining roads with pegs, Relocation are not strongly developed. They could be improved by 40% and more.

With a further analysis of the alternatives, abovementioned Flatness is one of the least established ones in Rusnė territory. None of the criteria has been developed in Lithuania. In the case of Rotterdam, most of the alternatives are being effectively used and adapted to the area.

The Buffering as an alternative should be financed and merits attention (but government policies are not in favour). Most criteria could be improved by 50% and more. Ground subsidence, Water barriers and local ecology are one of the most important criteria.

As we can see the situation with the criterion of Redundancy is the same as with Flatness—it is one of the least established in Rusnė territory.

Factors applicable to the evaluation system allows not only to analyze the different effects, but also through other data sources are using to create an effective public information system. The above-described system is applicable for Regional geo-information environment service for citizens, business and government – REGIA. Purpose of REGIA is to create favourable conditions for geography-based decision-making and to facilitate the exchange of information. REGIA is based on the cadastral map, with possibility to built-in different registers data. Working in the service environment, the REGIA administrators can create and manage their own data layers, store and manage information or documents, create and provide services based on geo-referenced data. REGIA is easy to use, no additional software or hardware is required - it is enough to have a computer with Internet connection. All REGIA services are managed through the web browser. REGIA operates on the cloud principle: all information created by a user, data recorded, uploaded documents are accumulated and stored in the REGIA servers and are accessible from any computer. It is up to the administrator to decide whether his data layer is publicly visible and who is entitled to use it. REGIA services in the review mode are publicly accessible www.regia.lt. REGIA is a powerful and handy tool specifically developed for local authorities: their people, civil servants and therein operating businesses. A person, using REGIA service, can quickly and easily obtain understandable information about the municipality activities and its adopted decisions. In the REGIA map people will always find information about the real property objects of interest to them, their addresses, value as well as companies, agencies and organizations operating there. New REGIA tools are being created that will allow residents themselves communicating through REGIA with local government and business service providers.

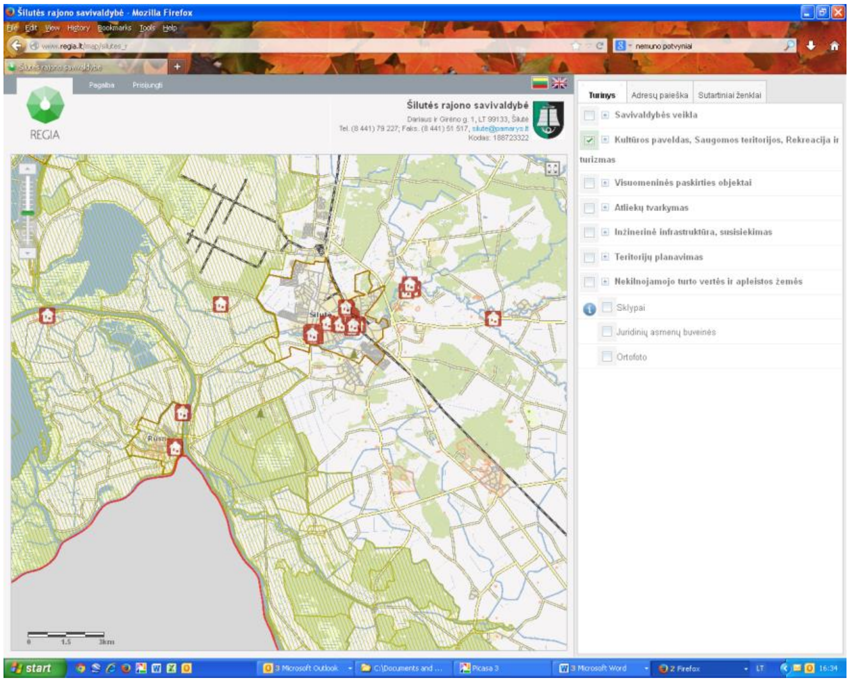


Figure 1: Fragment Regional geo-information environment service for citizens, business and government

Implemented by the Centre of Registers, REGIA is based on the cadastral map, with possibility to built-in different registers data. Working in the service environment, the REGIA administrators can create and manage their own data layers, store and manage information or documents, create and provide services based on geo-referenced data. REGIA is easy to use, no additional software or hardware is required - it is enough to have a computer with Internet connection. All REGIA services are managed through the web browser. REGIA operates on the cloud principle: all information created by a user, data recorded, uploaded documents are accumulated and stored in the REGIA servers and are accessible from any computer. It is up to the administrator to decide whether his data layer is publicly visible and who is entitled to use it. REGIA services in the review mode are publicly accessible www.regia.lt. REGIA is a powerful and handy tool specifically developed for local authorities: their people, civil servants and therein operating businesses. A person, using REGIA service, can quickly and easily obtain understandable information about the municipality activities and its adopted decisions. In the REGIA map people will always find information about the real property objects of interest to them, their addresses, value as well as companies, agencies and organizations operating there. New REGIA tools are being created that will allow residents themselves communicating through REGIA with local government and business service providers.

Companies can use REGIA map as a tool for advertising their business that helps to direct a potential user to the place where desired goods or services are provided. Using the tools provided by REGIA, business services can be created and distributed on the basis of available data.

5. Conclusions and future work

In order to design and realize efficient built environment for climate change and resilience management, it is necessary to carry out exhaustive investigations of all the solutions that form it. The presented DESiRE enables one to form millions alternative versions. This system allows one to determine the strongest and weakest points of each built environment for climate change and resilience management and its constituent parts. The authors of the article are currently involved in an augmented reality research. The plans for the next stage of the DESiRE system development involves integrating this system with augmented reality systems, which the authors herein have also developed.

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The Widening Knowledge Gap in the Built Environment of Developed and Developing Nations: Lean and Offsite Construction in Nigeria and the UK

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Abstract

This paper assessed the knowledge divide between the UK and Nigeria construction industries in the area of lean and offsite construction. This study utilized literature review as a method of determining the extent to which lean and offsite construction has been identified as new knowledge areas in the built environment in Nigeria and the UK by using a benchmark of 15 literature materials from journals, books, published thesis and conference proceedings for each construction concept. The findings suggest that there are few published literary materials related to lean construction in Nigeria and there were no published materials related to Nigeria in the areas of offsite construction. The literature search for lean and offsite construction in the UK revealed that there were many materials about these topics. These literary materials have been in existence for several years in the UK. This exposes the knowledge gap which has been widening over the years between Nigeria and the UK.

Keywords: Lean construction, offsite construction, the UK, Nigeria, construction

1 Introduction

Innovation and research in the built environment have been tools for improving the economies of the world (Fairclough, 2002; Hodge, 2007). The construction industry is a key sector in national economic. Several concepts and theories have been developed over the years by academics in the UK, United States of America, Australia and other developed countries. Some of these include building information modelling (BIM) (Takim, Harris, & Nawawi, 2013; Volk, Stengel, & Schultmann, 2014); lean construction (Aziz & Hafez, 2013; Issa, 2013; Marhani, Jaapar, & Bari, 2012); offsite construction (Vokes & Brennan, 2013); value engineering (Kanapeckiene, Kaklauskas, Zavadskas, & Raslanas, 2011); supply chain and inventory management in the built environment (Marra, Ho, & Edwards, 2012; Martínez-Jurado & Moyano-Fuentes, 2013); benchmarking and key performance indicators (Alwaer & Clements-Croome, 2010). These new concepts which have been developed over the years by academics have shaped many construction industries.

The purpose of knowledge is found in its application; even though these concepts in the built environment might not be new to some countries and academics, there have been very few write ups about these theories in many developing countries of the world. Most economies in Africa are beginning to emerge and they are having one of the highest GDP growth rates in the world (fDB, OECD, UNDP, & UNECA, 2013; NBS, 2012). However, if these African countries have to bridge their infrastructure divide, modern methods of construction have to be employed.

This paper compares the literary gap, when it comes to the availability of these new built environment concepts in the construction industries of Nigeria and Great Britain. Nigeria and the United Kingdom stand as key economies in the developing and the developed world respectively. Therefore, there is a need to investigate the level of knowledge shared between these two nations in the built environment. For the purpose of this paper only two of these new construction concepts will be considered. These are ***lean construction and offsite construction.*** These concepts are associated with modern methods of construction, however the construction industries of Nigeria and the UK have to be reviewed to understand the educational and knowledge creation capabilities.

2 A comparative overview of the UK and Nigerian construction industries

Nigeria, former British colony has been independent since 1960 (Dantata, 2008).The prominence of construction organizations began in the 1940s with several construction projects (Isa, Jimoh, & Achuenu, 2013). This had a catalytic effect on the embryo economy at that time. At the moment the economy of Nigeria is one of the largest in Africa (Dantata, 2008). The construction industry in Nigeria has played a significant role over the decades, valued at about $3.15 billion, the industry continues to grow and this is based on the construction knowledge acquired from the British in the 1940s and 1960 (Isa et al., 2013). However this growth has not been reflected in the level and quality of construction delivery which has been marred by construction delays (Odeh & Battaineh, 2002) and lack of automation (Equere & Tang, 2010). The construction professions in the UK such as Architecture, Quantity Surveying, Estate Management, Building technology, land surveying, Civil engineering, were brought into Nigeria and taught as courses in early 1940s and 1970s (Isa et al., 2013). The building technology which has been taught and applied during this period is what is still in place now, although the use of ICT has become very common in Nigeria construction in recent times (Equere & Tang, 2010). There has been a low level of innovation, research and development in the Nigerian construction related institutions compared to the UK.

The UK construction industry has been investing and encouraging construction innovation and research, with many tertiary institutions which are well funded to investigate the areas of sustainability and improved housing provision. The UK construction knowledge base is vast and well structured. Great Britain has been utilizing information technology for compounding the construction industry's Knowledge and information inform of databases which are available online (Fairclough, 2002). Research and development which is supported by the Department of Trade and Industry (DTI) has gone beyond construction for profit but for sustainability, waste reduction and it is more people oriented (Hodge, 2007). The measures put in place over the years have led to the development of knowledge areas in lean construction and offsite construction. These areas have only now been the major topic of many developed construction industry because of their inherent benefits.

The awareness of any form of theory or knowledge is evident in the readily available literature or academic community related to it. The academic community in Nigeria may not have been very familiar with of some of these supposedly new concepts; however there is a need to investigate and ascertain if there is a knowledge gap in these areas.

3 Lean construction

Lean construction rests on the production techniques of lean production. Lean production began in Toyota car manufacturing in the 1950s and it was developed by Ohon, a Japanese Engineer (Alarcón, 1997; Green, 1999). This system of production adopted the principle of eliminating waste before and during production. This terminology was created by the research team at Toyota (Green, 1999). Waste is viewed as anything synonymous to shortfall in expected performance. Therefore, the concept of lean production engulfed all activities from design to production. This innovation in production management brought about massive success in Toyota.

Lean construction is evidence that successful principles in manufacturing can be applied in the construction industry. The cost, duration and quality of construction project delivery improved greatly as a result of lean construction (Sacks, Koskela, Dave, & Owen, 2010; Tezel & Nielsen, 2013). However, some drawbacks in this new construction technique have been identified in employee's response to change. Notwithstanding, the opinion of some academics such as Green (1997) has not deterred the application of lean construction in many construction companies around the world. Under lean construction, most projects have an outlined objective which has already been established at the design stage, this makes design concurrent with production (Alarcón, 1997; Green, 1999). The control of construction activities throughout the entire process is also very unique; control in lean construction is viewed as monitoring individual activity against the established duration and time. This may be very common in most traditional approaches but lean construction utilized monitoring as a basic objective in production.

Waste reduction during production is the significant force of lean construction. Therefore, these methodologies revolve around waste reduction. Apart from this methodology, the basic instruments of lean construction as identified by Koskela (1997) includes multifunctional task groups; kaizen; just in time deliverables; co-marksmanship; customer orientation and information, communication and process structure.

Lean construction has been applied in the UK, USA, Japan and some developing countries (Sacks et al., 2010; Sadreddini, 2012) , other developing nations such as Nigeria is yet to include lean construction as a new construction method (Adamu, Howell, & Abdulhamid, 2012). The benefits lean construction has needs to be tapped for the greater good of the built environment.

4 Offsite construction

The term offsite construction refers to a construction where part or the entire building component is manufactured in a controlled environment such as a factory (Arif & Egbu, 2010). Offsite construction is regarded as an integral part of modern methods of construction. Modern method of construction (MMC) is different from the traditional method because it does not make use of the usual building materials which involves bricks or blocks. This form of construction became common in the UK after the Second World War but there have been some evidence of manufactured construction before this time (Vokes & Brennan, 2013).

This form of construction is divided into four types which is components manufactured and sub-assembly, volumetric pre-assembly, non-volumetric pre-assembly and modular buildings (Arif & Egbu, 2010). Components manufactured are the usual elements of a building such as doors, bricks, tiles and windows. These components are manufactured in the factory and are found in manufacturers catalogues. Non-volumetric pre-assembly are individual units of building elements which are mainly wall claddings, wall panels or bridge units (Vokes & Brennan, 2013). This type of building construction is considered to be a modern method of construction, skeletal frames of building units or building services (Farrell, 2010). Volumetric pre-assembly is in the form of plants rooms, cold rooms or any form of specified units of a building which is attached to the services. Volumetric pre-assembly is produced in the factory where there specification of the required element is manufactured and transported to be included in the space (Blismas & Ron, 2007; Chiang, Hon-Wan Chan, & Ka-Leung Lok, 2006). The final stage of offsite construction is modular building; this type of offsite construction ensures that the entire building is manufactured in a controlled environment, the final product is transported to the site for fixing on a foundation (Brioscu, 1975; Brioscu & McEvatt, 1973). Modular buildings are becoming common in the construction of homes, prisons, health centres, office complexes and shopping malls. This process has a lot of benefits ranging from reduced cost, time, improved quality of buildings, productivity and management of labour (Gibb & Isack, 2003). However, some of the demerits of this form of building erection in the UK have been identified to have its toll on the employees who need to be trained to acquire new skills in construction. Change is inevitable but most contractors in the UK still prefer the traditional methods of construction.

Recent studies of offsite construction in the UK indicates that it has grown to about £6 billion in 2006 (Gibb, 2007) from about £2.2 billion in 2005 (Goodier & Gibb, 2007), this figure is increasing because of the general acceptance of this method of construction. This figure has made significant contribution to the growth of Great Britain’s construction industry over the decade. The construction industry in Nigeria may not have been extensively adopted modular buildings, but other categories of offsite construction such as non-volumetric pre-assembly and manufactured building components have been used over the years, however there are no significant data or literature supporting these.

5 Research methodology

Several online databases were reviewed to extract relevant literature in the areas of lean construction and offsite construction. These databases are of the academic and general online sources such as Emerald journals, Google scholar and search, Science direct and Education abstracts (EBSCO) were the main sources of literature. The category of literature used for this investigation includes books, thesis, conferences papers, and academic journal articles. Although other literatures exist in company websites and trade magazines and government reports, the quality of these write ups did not match up to the peer-review materials and academic journal articles. The scope of data search was limited to literature in the built environment academia of UK and Nigeria or any related write ups from other countries which mention Nigeria or the UK. Fifteen key journals, articles, thesis or books search was attempted for each category.

Table 1.0 Keywords and key phrases used in the literature search

THEME	*KEYWORDS/PHRASES*
Lean construction	*"Lean construction"; "lean construction in the UK"; "lean construction in Nigeria"; "lean"; "lean and UK"; "lean construction and UK"; "lean construction and Nigeria".*
Offsite construction	*"Offsite construction"; "offsite construction in the UK", "offsite construction in Nigeria"; "manufacture construction in the UK"; "manufactured construction in Nigeria"; "Industrialized building system"; "modular buildings in the UK"; "modular building in Nigeria"; "prefabricated building in the UK"; "prefabrication of building in Nigeria"; "Prefabrication of buildings"; "constructing offsite".*

6 Result and discussion

The literature search revealed that the keywords used for lean construction in the UK produced fourteen journal articles and one book. This met the benchmark of fifteen literature search for this category. There were only four materials found for the keyword related to lean construction in Nigeria. The materials found for lean construction in Nigeria were three journals and one conference proceeding. The benchmark of fifteen literary material related to lean construction was not met.

Offsite construction in the UK met the benchmark of fifteen literatures which were found mainly through google search and scholar. This included five books, one thesis, one conference proceeding and eight journal papers. There was no literature found for offsite construction in Nigeria after using the entire keywords. Also the literature search revealed that lean construction which began in early 1990s has not been adopted in Nigeria. The year of the write ups in this study range from 1990 to 2012. Although there has been literary materials written by Koskela in 1992, this knowledge has been disseminated to many nations of the world like Nigeria where there were less than five materials found. Offsite construction began sometime in the 19th century according to the search but majority of academic write ups for offsite construction began in the 1970s (Brioscu & McEvatt, 1973). These materials have been existing when Nigeria began its massive urbanization programs (Mabogunje, 1965). This implies that many Nigerian authors or academics in the built environment neglected or have not attached much importance to the emergence of new methods of construction during this period. In this analysis majority of the literature found for offsite construction in the UK revealed the benefits and growth offsite construction has contributed their construction industry within the last forty years. At the moment, there appears to be no write up about offsite construction in Nigeria. It appears that offsite construction in Nigeria has not been well documented or included in the Nigerian training curriculum. Although some multinational construction companies in Nigeria may have adopted volumetric and non- volumetric pre-assembly for complex construction works, the use of this method of construction remains alien to most academics in Nigeria.

From the results lean and offsite constriction in Nigeria may appear to be almost 22 years behind the UK. This implies that the construction industry growth in Nigeria has been facing some hidden setbacks when it comes to adopting new methods of construction. Lean and offsite construction has been a major catalyst in the growth of major developed construction industries especially in the UK. These innovations in construction industry have been used to improve construction delivery and performance. The available literature in this study for lean and offsite construction has proved that there is available knowledge in the UK if this method of construction has to be applied.

Table 2.0 Category of literature sources from the UK and Nigeria about lean and offsite construction

Construction concept	References	Sources of literature	Category of literature	UK Author/ Related to the UK construction industry	Nigerian Author/ Related to the Nigerian construction industry
Lean construction	Sacks, Koskela, Dave, and Owen (2010)	EBSCO	Journal article	YES	NO
	Genaidy, and Minkarah (2006)	EBSCO	Journal article	YES	NO
	Becker, Shane, and Jalselskis (2012)	EBSCO	Journal article	YES	NO
	Yu, Tweed, Al-Hussein, and Nasseri (2009)	EBSCO	Journal article	YES	NO
	El. Reifi and Emmitt (2013)	EBSCO	Journal article	YES	NO
	Nahmens and Ikuma (2012)	EBSCO	Journal article	YES	NO
	Chen, Goodlad, Sprague, and Housley (2012)	EBSCO	Journal article	YES	NO
	Nahmens and Ikuma (2012)	EBSCO	Journal article	YES	NO
	Sadreddini (2012)	EBSCO	Journal article	YES	NO
	Pasquire and Salvatierra-Garrido (2011)	EBSCO	Journal article	YES	NO
	Adamu and Abdul Hamid (2012)	Google scholar	Journal article	NO	YES
	Oyewobi and Ogunsemi (2010)	Google scholar	Journal article	YES	YES
	Abdullah, Bilau, Enegbuma, Ajagbe, and Ali (2011)	Google scholar	Conference proceedings	YES	YES
	Adamu, Howell, and Abdulhamid (2012)	Google search	Journal article	NO	YES
	Green (1999)	Google scholar	Journal article	YES	NO
	Picchi and Granja (2004)	Google scholar	Journal article	YES	NO
	Alarcón (1997)	Google scholar	Book	YES	NO
	Thomas, Horman, Minchin Jr, and Chen (2005)	Google scholar	Journal article	YES	NO
	Miller, Packham, and Thomas (2002)	Google scholar	Journal article	YES	NO
Offsite construction	Pan, Gibb, and Dainty (2007)	Emeral Journals	Journal article	YES	NO
	Arif, Bendi, Sawhney, and Iyer (2012)	Google search	Conference proceedings	YES	NO
	Azam, Ahamad, and Wan Hussin (2012)	Google search	Journal article	YES	NO
	Blismas and Ron (2007)	Google search		YES	NO
	Chiang, Hon-Wan Chan, and Ka-Leung Lok (2006)	Science direct	Journal article	YES	NO
	Farrell (2010)	Google search	Thesis	YES	NO
	Gibb (1998)	Google search	Book section	YES	
	Arif and Egbu (2010)	Emerald Journals	Journal article	YES	NO
	Pan and Sidwell (2011)	Google search	Journal article	YES	NO
	Atkinson, Gray, and Lucas (2001)	Google search	Book	YES	NO
	Brioscu (1975)	Google scholar	Book	YES	NO
	Brioscu and McEvatt (1973))	Google search	Book	YES	NO
	Lawson, Grubb, and Prewer (1999)	Google search	Book	YES	NO
	Winch (2003)	Google search	Journal article	YES	NO
	Kempton (2010)	Google search	Journal article	YES	NO

The Nigerian construction industry requires a lot of innovations, designs to bridge the knowledge divide. The construction industry in Nigeria is less automated compared to the UK; therefore there will be challenges in adopting new techniques such as lean and offsite construction. Apart from this, offsite construction depends on manufacturing; Nigerian manufacturing sector is has a lot of setbacks limiting its growth. Also, most academics have concentrated their efforts in contributing more knowledge to the only available areas without exploring and adopting new possibilities. This has grossly added to the widening gap in terms of knowledge available in between Nigeria and the UK when it comes to lean and offsite construction.

7 Conclusion and recommendations

Knowledge or information precedes application. Therefore the quantum of academic literatures on a subject will definitely affect the level of knowledge and understanding of the subject. Modern methods of construction such as lean and offsite construction have been applied to improve construction cost, duration, quality and performance in the UK for several years now. However, there has been little knowledge about these construction techniques in a developing nation such as Nigeria. The construction industry in Nigeria has been applying the traditional method of construction and the associated problems with this approach persist. Cost and time over runs are consistent with the traditional method of construction and many academics in Nigeria built environment have noted this (Aibinu & Jagboro, 2002; Dada & Jagboro, 2007). Also, solutions proffered by these academics in improving cost and time overruns have not identified lean and offsite construction as one of the possible means of managing these challenges.

The knowledge gap in the built environment between the developed and developing nations typified by Nigeria and the UK in this analysis is widening considering the number of years when literature relating to lean and offsite construction has been produced. Apart from this new knowledge is added yearly to the UK construction industry because of the extent of innovation and research. If this knowledge gap has to be bridged, there has to be more research, analysis, write ups, training, workshops and conferences about modern methods of construction related to lean and offsite construction in Nigeria and other developing nations.

8 Recommendations for further research

This paper has only examined the knowledge divide by using literature search from online sources. There is need for extensive studies using quantitative methods which will involve surveys, rigorous scientific analysis and also qualitative method which has to involve interviews. This will adequately determine the extent in which knowledge in the built environment is spreading to less developed nations.

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Knowledge Transfer Partnership: Implementation of Target Value Design in the UK construction Industry

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Abstract

Knowledge Transfer Partnerships (KTP) are unique research programmes designed to bring innovation by joint effort of academia and industry to provide innovation in technology, process and management for the UK Industry. This paper describes an undergoing research on a collaborative project management approach which could increase the project delivery efficiency in the UK construction industry. UK Construction Industry has always been criticised by the industry experts about its lack of efficiency and innovation to deliver client's value. The KTP research project aims to implement Target Value Design in the UK construction industry. Target Value Design (TVD) is lean project management approach focused to deliver client's value and provide better control over the project cost. TVD has been only implemented in the US and this research focuses to develop a framework to implement TVD in the UK Construction Industry.

Keywords: Knowledge Transfer Partnership, Project Delivery, Target Value Design and Lean

1. Introduction

Construction Industry is one of the largest sectors in the UK economy. It accounts for £90 Billion to value added and 2.93 million jobs (roughly 10% of total UK Employment). It has been affected due to the 2008 recession, following which GVA contribution to the UK economy fell from 8.9% (2007) to 6.7% (2011) (BIS, July, 2013). Post economic downturn, the UK Government has been trying to gain efficiencies in the construction & infrastructure sector to deliver more for less and generate confidence in the construction sector growth. This resulted in the issuing of various government strategies like setting up BIM (Building Information Modelling) Task group, Procurement strategy (Office, 2011).

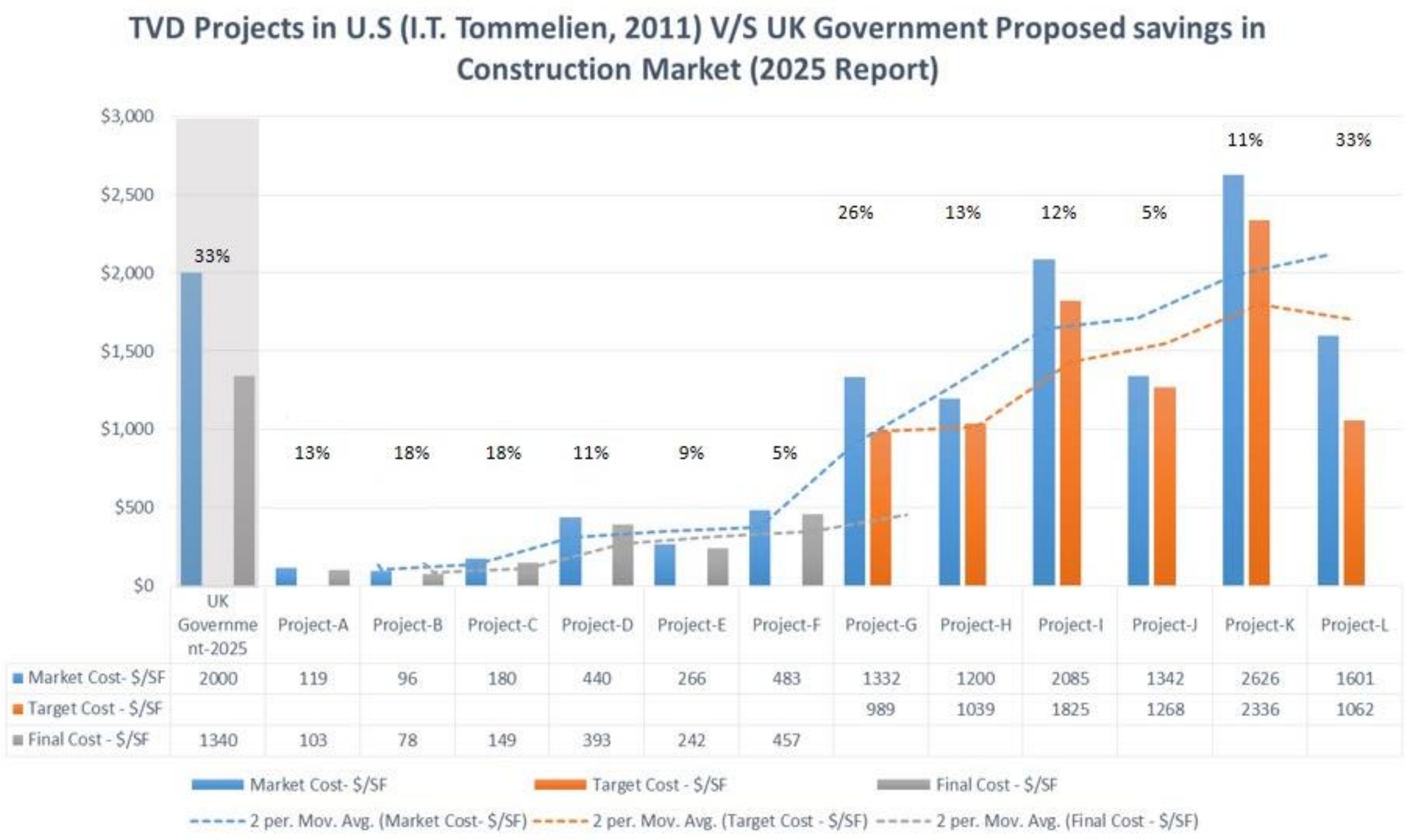
The Industry experts have always highlighted the UK construction industry as highly inefficient and proposed innovation at various areas of industry's traditional practices (Banwell, 1964) (Latham, 1994) (Egan, 2004). The common areas of improvement highlighted were Capital cost, Construction time, Predictability & defects. Industry performance still lacks in various areas, the Project Predictability figures for 2012 highlights time predictability of 34% (projects, as whole, finished on or before predicted time), Cost Predictability came out to be 61% (final project cost on or below predicted cost). This combined with the negative attitude of the industry due to the recession resulted in only 2.7% industry profitability in 2012 (Folwell, et al., 2012).

H.M Government has set out various targets for the UK Construction Industry in the Construction 2025 Report (2013).

- **Lower Costs -** 33% reduction in the initial cost of construction and the whole life costs of built assets.
- **Faster Delivery** – 50% reduction in the overall time, from inception to completion, for new build and refurbished assets.
- **Lower Emissions** – 50% reduction in greenhouse gas emissions in the built environment.
- **Improvement in exports** – 50% reduction in the trade gap between total exports and total imports for construction products and materials.

2. Need of Target Value Design

Target value design (TVD) is a management approach where the cost act as an input to design and design process is a collaborative iterative process constantly updating cost to align client's requirement with their constraints (cost, features, time, etc.). TVD is based on target costing principles from manufacturing industry and was developed in P2SL Labs, University of Berkeley, California. In past decade, TVD implementation has proved to be very successful in delivering client's needs in a set Target Cost below the Market Price (Ballard, 2013).



	UK Government-2025	Project-A	Project-B	Project-C	Project-D	Project-E	Project-F	Project-G	Project-H	Project-I	Project-J	Project-K	Project-L
Market Cost- $/SF	2000	119	96	180	440	266	483	1332	1200	2085	1342	2626	1601
Target Cost - $/SF								989	1039	1825	1268	2336	1062
Final Cost - $/SF	1340	103	78	149	393	242	457						

Figure 1 - TVD Projects performance V/S UK Government Targets

Figure-1 illustrates the cost saving vision of the UK Government for 2025 and it can be compared with the cost savings documented in 12 projects which used Target Value Design in the United States (Tommelien, et al., 2011). Project A to F have been completed with the final cost savings ranging from 5% to 18%. Projects G to L were incomplete and the expected cost saving ranged from 5% to 33%. This comparision highlights the possible contribution of project cost saving from adaption of Target value design. There is no evidence of Target Value Design implementation in the UK. Most of the documented TVD implementations in the US have been achieved in a collaborative environment with IPD[1] (Integrated Project Delivery) setting.

To address the UK industry problems, University of Salford & Infra Projects Ltd collaborated to initiate a KTP to develop Target Value Design framework for the UK Construction Industry.

3. Methodology

Knowledge Transfer Partnership (KTP) is a collaborative research programme initiated by Technology Strategy Board (TSB) across the UK. It aims to transfer the knowledge and expertise from the academia world to the UK Industry to allow them to increase their productivity, technology and services. On the other hand, the knowledge base partner also gains insights about the knowledge needs of the industry and business relevance of their input. A KTP Associate, university employee but working at the industry partner office is at the centre of the project.

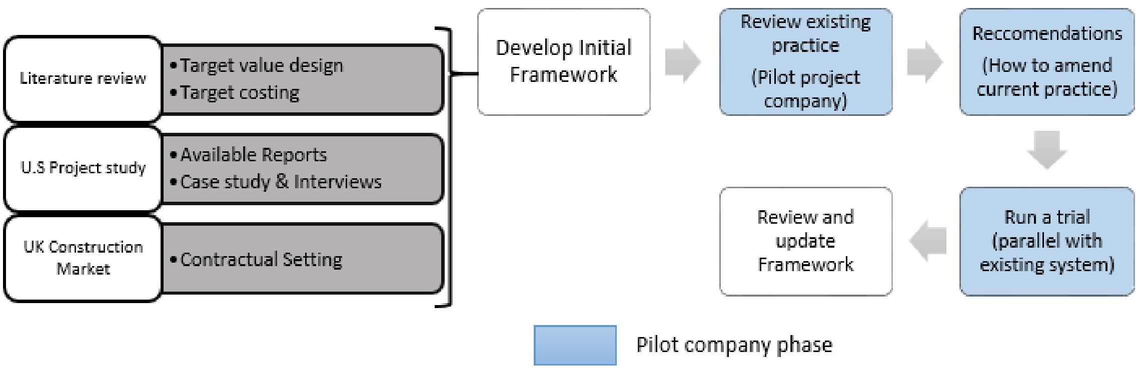


Figure 2 – Research Methodology

This KTP Project is a two year collaboration between Infra Projects Ltd and University of Salford. It has been aimed to transfer the expertise and knowledge of Target Value Design to

[1] Integrated Project Delivery (IPD) is a project delivery approach that integrates people, systems, business structures and practices into a process that collaboratively harnesses the talents and insights of all participants to optimize project results, increase value to the owner, reduce waste, and maximize efficiency through all phases of design, fabrication, and construction

Infra Projects Ltd to allow them to deliver better Project Delivery solutions in the Built Environment Industry.

The Aim of the of the project is

*"**To develop and Implement Target Value Design processes, procedures and supporting ICT for use in heavy infrastructure construction**"*

There are four objectives of the KTP;

- Detailed analyses of the market and the use of TVD.
- Analyse UK Construction Industry and alignment of TVD Approach.
- Produce Prototype Target value Design Framework.
- Pilot Implementation of the developed Target Value Design framework.
- Project review and evaluation, including cost benefit analysis.

The research methodology adapted to achieve various objectives of the KTP Project can be seen below.

4. Target Value Design

Target Value Design (TVD) is a management practice/ process which aims to achieve the maximum value in a set target cost lower than the Market Benchmark Price (Ballard, 2012).

Target Value Design aims to generate client's value within the client's conditions of satisfaction (Time, cost, features etc.). It is an adaptation of Target Costing from manufacturing industry and focuses on establishing values for the client and delivering them in a set Target Cost using various cost and design management tools. The target value/cost acts as an integral input to the design process (Zimina, et al., 2012) (Figure -2).

The first project using TVD approach was Tostrud Fieldhouse at St. Olaf College, USA by Boldt Company in 2002. The term Target Value Design was first used years later by Hal Macomber, Greg Howell and Jack Barberio in 2007 for the adoption of target costing to construction field (Macomber, et al., 2007).

"Main idea of TVD is to make a client's value (design criteria, cost, schedule & constructability) a driver of design, thereby reducing waste & satisfying or even exceeding the client's expectation" (Zimina, et al., 2012)

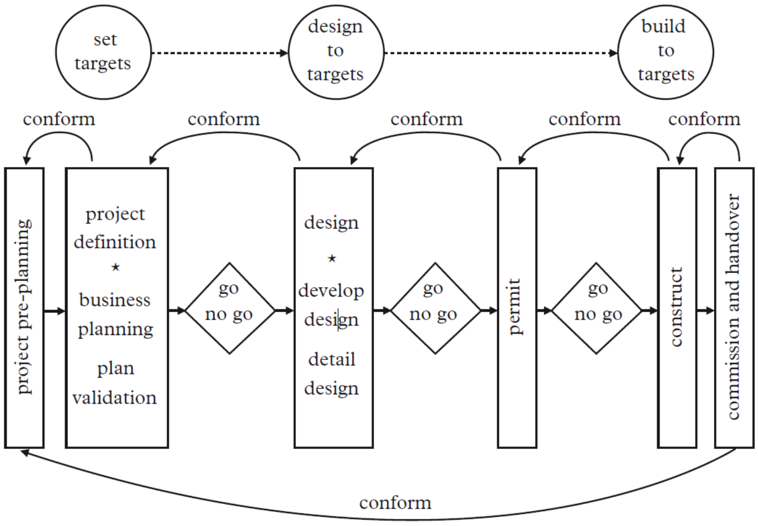


Figure 3 - TVD Process (Zimina, et al., 2012)

Target value design (TVD) inherits its process elements from Target Costing. However, In TVD, project is not only defined on the basis of the target estimate/profit but also keeping Client's business and operation model as a core element of the Project's Value. Design brief, cost, schedule and constructability are also integral elements in defining the client's value definition. The process initiates with project planning, which includes market analysis of risks and opportunities to validate the project definition and plan (figure 3).

In TVD, detailed scope of project and set Target Cost drives the Design. It follows various principles of Target Costing (Manufacturing Industry), such as anticipating design decision's implications and eliminating design alternatives with low build-ability. However, these techniques are still in development phase and the industry is still in learning phase. Therefore, it is recommended that cross-functional teams work together and share expertise in order to identify the range of required characteristics of the project likes schedule and constructability (Ballard & Reiser, 2004).

4.1 Value in TVD

"TVD Targets the value profile of the project. It is composed of broadly two types of components in a product or process. Ones that directly deliver value, and those characteristics that are conditions for realization of value. The former include the functionalities and capacities that enable the customer to best accomplish their purposes. The latter typically include cost, schedule, and location" (Ballard, 2013).

4.2 TVD principles

According to (Macomber, et al., 2007), TVD turns current design practice upside-down:

It broadly has five fundamental components (Figure – 4)

(1) **Setting the Target Cost for design**: "Rather than estimate based on a detailed design, design based on a detailed estimate".
(2) **Work Structuring**: "Rather than evaluate the constructability of a design, design for what is constructible".
(3) **Collaboration**: "Rather than design alone and then come together for group reviews and decisions, work together to define the issues and produce decisions then design to those decisions".
(4) **Set-Based Design**: "Rather than narrow choices to proceed with design, carry solution sets far into the design process".
(5) **Collocation**: "Rather than work alone in separate rooms, work in pairs or larger groups, face to face".

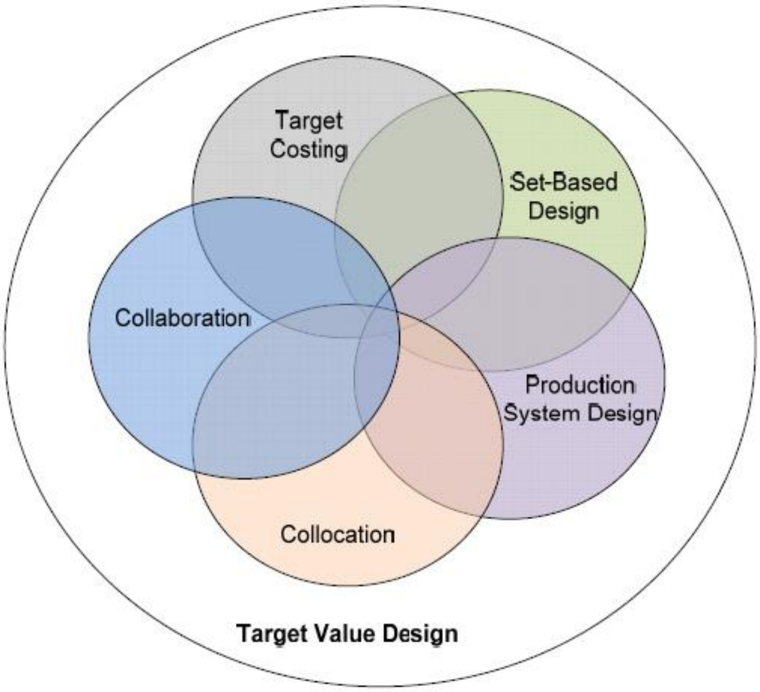


Figure 4 - Target Value Design (Macomber, et al., 2007)

4.3 TVD case studies

Table 1 - TVD Case Studies

Project	*Contract*	*Detail*	*Result (Expected)*
University of California, SF - Medical Center at Mission Bay, SF	*Two Stage GMP (Guaranteed Maximum Price)*	• *289 patient bed* • *869,000 square ft* • *$1.5 Billion Project*	• *$765 million for design and construction – Feb 2015* • *Roughly 10-15% Savings Expected*
Alta Bates Summit Medical, Oakland	*IPD, IFOA (Integrated Form Of Agreement)*	• *240 patient beds* • *230,050 square feet*	• *$245 Million project – Jan 2014* • *10-15% savings expected*
UHS, Temecula	*IPD, IFOA*	• *5 Story Building* • *178,000 square ft*	• *$159 Million Project – September 2013* • *30 % – US Standard* • *40% - California State*

4.4 Current TVD practices

All TVD projects have been documented in California region's healthcare projects. A detailed analyses of available literature and case study suggests that TVD approach has been applied with a set of lean tools to enable the effective TVD implementation and achieve the set Target

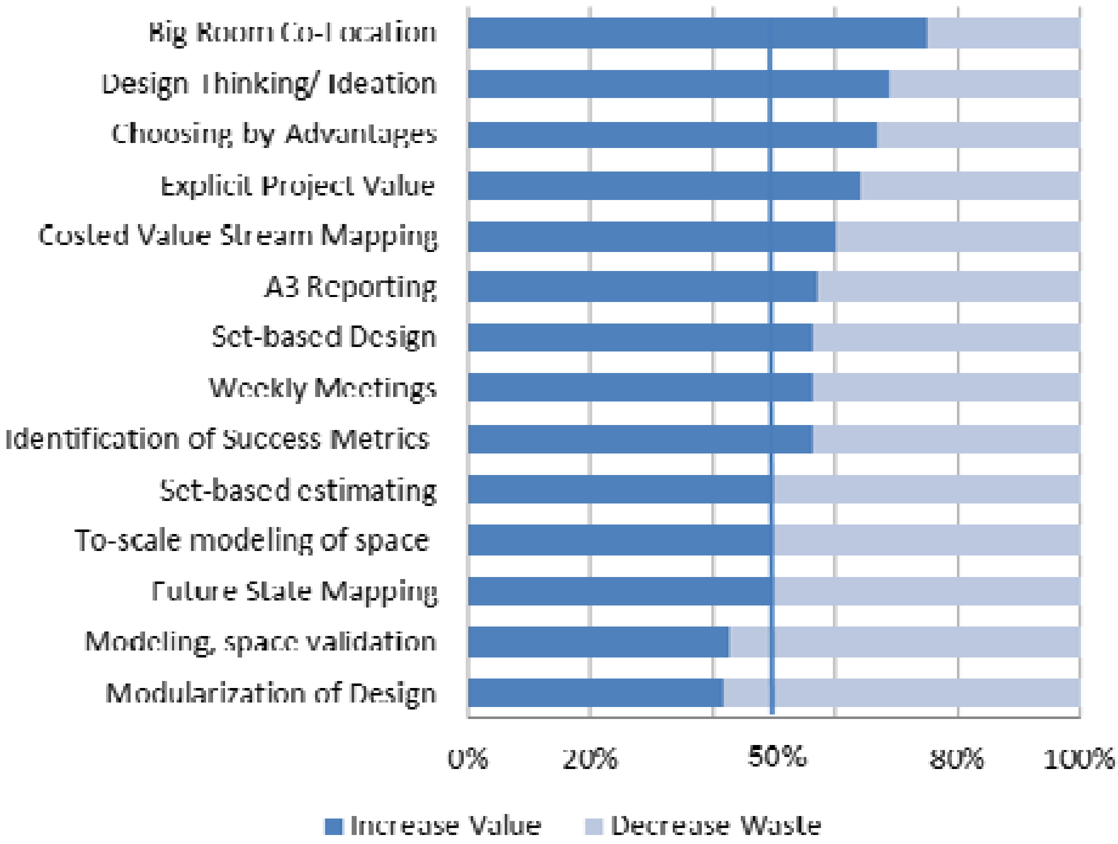


Figure 5 - Current TVD Practices

Cost. Industry professionals were interviewed in a research to identify various Lean practices which help increase value and decrease waste in the project delivery (Novak, 2012). (Figure – 5)

5. TVD enablers

A set of 17 benchmarks practices have been set by P2SL Labs, University of Berkeley, California to ensure the successful implementation of TVD. These Benchmarks have been updated twice. However, these benchmarks are focused towards US Construction Industry equipped with IPD (Integrated project delivery) and Multi party collaborative contract IFOA (Integrated Form of Agreement).

KTP research project team has extracted four conditions/practice from the 17 Benchmarks which could provide the minimum required setting for TVD Implementation in any Non-IPD Environment. These are

1. **Early Collaboration of stakeholders** – Early Collaboration of major stakeholders in the project is essential to ensure that all necessary expertise is available from the beginning of the project. This not only enables team to set the right targets and goals as per client's requirements but also use structure a collaborative design process to achieve cost targets and required design features.

2. **A shared risk & rewards mechanism** – It is necessary to motivate various project stakeholders to work hard towards project's interest, hence, it is required to align team members' interest with the project/client's interest. In the UK, Contracts like NEC-3, PPC -2000 with little amendments allow to provide such mechanism.

3. **Cluster Organisation -** A cluster organisation is a project hierarchy system inspired from the manufacturing industry. Clusters are groups divided amongst the project team based on the trades (MEP, Structure etc.). Each cluster has a cluster leader who is a part of the core team governing the project delivery decisions. (Figure – 6).

   (Nicolini, et al., 2000) Explains, *"A cluster is, in many respects, a 'design & construct' mini-project that takes place within the larger framework of the project. It is a place where a limited number of designers, suppliers of materials or components engage in intensive collaboration to design & deliver a significant, recognizable element of the overall building working to reduce costs, improve value & minimize waste".*

4. **Iterative design cycles with continuous cost engineering in a collocated setting** – It is necessary to design various elements, systems of the overall design in an iterative design cycle carrying maximum number of options to last responsible moment of decision. The centre of iterative process is client needs. The major difference is from traditional design management practice is parallel process of aligning the expected cost of various design options to the target cost. These collaborative efforts are attempted in a structured collocated setting, allowing team to interact and share expertise to reach the required design and cost.

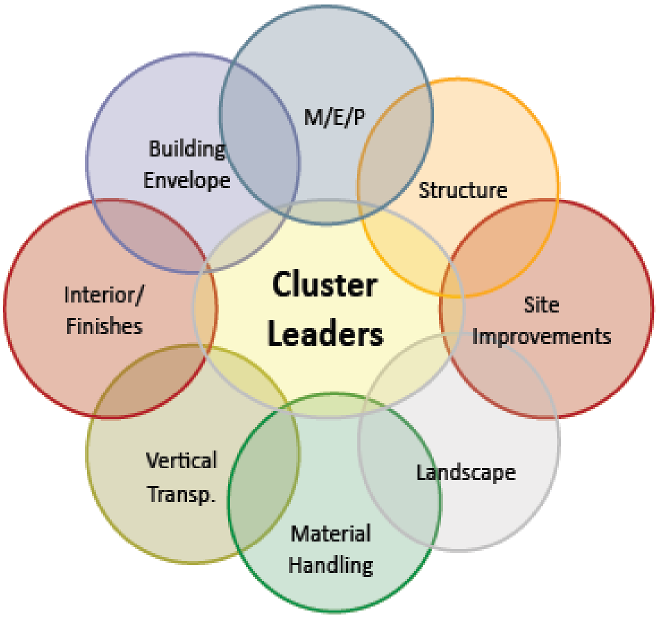


Figure 6 - TVD Design Clusters (TVD - Dr Glenn Ballard)

6. The way forward

The KTP Project is half way through, initial research and analyses objectives have been achieved. An initial draft of TVD Implementation has been completed. As part of the project objectives, team is discussing the possibilities of pilot implementation of Target Value Design with various organisations. It is aimed to gather learning from the pilot project and update the framework for the UK Industry. Post KTP Project, Infra Projects Ltd will use the framework and TVD expertise to deliver better project delivery services enabling various project delivery teams to deliver the client's requirements in a cost controlled environment and adding value to various projects and to the UK Construction Industry.

Acknowledgement

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Contributions of Women Managers to UK Construction Industry

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Abstract

Women managers are highly under-represented in the UK construction industry, which is typically considered as male-dominated, despite the various initiatives taken by the government and other organisations to improve the status of women in construction. The vertical and horizontal segregations in the industry are clearly evident for the less number of women in top managerial level and in mainstream construction respectively. The industry has been facing many challenges, including skills, labour shortages and recruitment difficulties, for many years now. Therefore widening the recruitment pool with potential candidates, targeting at non-traditional entrants, has become a necessity. This further emphasises to give more consideration on equality and diversity issues. But in reality little has been changed when looking at the number of women entering, retaining and progressing in the construction. Number of research studies conducted has focused on what industry could do for women in order to attract more women. On the other hand, this research intends to explore what women managers can do to the industry. In doing so, it tries to find out the ways in which women managers, despite their vulnerability, contribute, using their power, authority and leadership styles, to make the industry more attractive to women and other disadvantaged groups. This paper presents the research findings on the contribution of women managers in the context of the UK construction industry.

Keywords: women managers, contributions, construction industry, UK

1. Introduction

Improving the representation of women at managerial levels in construction is vital to address the skills shortages and recruitment difficulties in the industry. The industry culture and the image act as one of the major barriers for many women to consider construction as a career. The changes happening within the industry in terms of the culture and image is so slow to realise. This research argues that it is part of the responsibility for the women managers, who have gone through a career phase in construction (might have faced barriers and challenges on the way) and have now come to a position where they have certain level of power and authority in construction, to make a contribute for the industry to become less hostile and more attractive not only for the women who are already in the industry but also for any women who would like to choose a career in construction in future.

The under representation of women managers in construction has been reviewed and the reasons behind the under-representation have also been highlighted from the literature. The focus of this research, which was on 'women managers in construction', is justified. The contribution of women managers towards the construction industry is provided with the support of both the literature and the empirical evidences.

Accordingly, this paper is structured as follows. First, the research justification is provided. Second, the study focus is introduced. Third, the literature review on the key areas of the research is presented. Fourth, the research methodology adopted is presented. Fifth, the key findings are given followed by the conclusions.

2. Research justification

Construction in United Kingdom (UK) is one of the pillars of its economy. Construction output was predicted to grow by around 11% by 2011, led by a surge in the building of schools, ambitious housing targets and developments for the London Olympics (CIOB, 2008). But a shortage of buyers in the current market conditions is impeding the progress. Increased demand of construction will also increase the demand for construction personnel as it is labour intensive. In order to meet this demand, nearly 88,000 people were reported to be required annually, to add to the existing workforce of the industry (Construction Skills, 2007). However, the current economic climate challenges the industry to fulfil this requirement. A later report by Construction Skills (2008) revealed that the slowdown in the housing market and related sectors has reduced the annual requirement of construction from the previous average of 88,000 people per annum to 42,000 per annum between the years 2009 and 2013. From the previous forecast produced at the end of 2007, this is a total fall of 184,000 new recruits needed by the industry over 4 years.

Therefore the major problem that the industry has at the moment is its survival with the economic crisis. The construction industry faces difficulties in delivering projects in time, at the required quantity, within the anticipated budget and at the optimal quality. The other problems that exist in the industry for a long time are identified as low productivity; low performance; high fragmentation; poor image; high dissatisfaction among clients; skills and labour shortages; and recruitment difficulties.

The shortage of people, with the technical and managerial skills, to fully utilise the new technologies and skills demands has been a problem for many years in the construction industry (Egan, 1998; Whittock, 2002; Construction Skills, 2007). The results of a new skills survey conducted by the Chartered Institute of Building (CIOB, 2008) show that skilled trades and crafts people, and those with senior and middle management experience are in great demand within the construction industry. The survey found that the demand for middle and senior managers is an on-going and increasing problem within the industry (more than 80% of the respondents found recruiting senior management and middle management difficult).

The current rate of recruitment is not sufficient to meet the current and future demands of the construction industry. The industry faces recruitment problems with its traditional source of labour – young men aged 16-19 (Gurjao, 2008). The industry's reliance on migrant workers for senior and middle level managers is not always a possibility (migrant workers are not common as senior and middle managers in UK construction due to their poor English language competence, see CIOB, 2008).The recent immigration regulations (such as restricted skilled workers see UKBA, 2011) impose further challenges on recruiting workers from outside the European Economic Area (EEA). Therefore recruiting from a wider pool of talents and skills will be a requisite to address these recruitment difficulties and the skills shortages (Dainty *et al*., 2004).

Women are highly under-represented in the UK construction industry despite the various initiatives taken by the government and other organisations to improve the status of women in construction. The role of the women in employment is changing radically in most societies and in Britain, nearly half of the total workforce is women (CIC, 2009). However, women constitute nearly 10% of the UK construction workforce (NAWIC, 2009; Opportunity Now, 2007; CITB, 2003). When this 10% is further divided into various occupations, nearly 85% hold administrative and secretarial posts, 10% are employed in a professional capacity in design and management areas, and the rest are attached to craft and trade level employees (CITB, 2003). Therefore, construction specific work carried out by women as a percentage of the total construction workforce is just 1.5%, of which 2/3 is in professional capacity.

Increasing the number of women working in construction will improve the status of the industry in terms of utilising the full range of skills available in the population and assisting construction organisations to become more efficient and adaptable to the needs of its customers (Agapiou, 2002; Davey *et al*., 1999). Agapiou (2002) claims that the aim of the researches that focused on improving the participation of women in the construction workplace were more to solving the labour resources crisis and skill shortages rather than improving equal opportunities for women. High dissatisfaction among clients, being one of the problems in the industry, can be addressed by increasing the women numbers as they are, by nature, good with people, less confrontational and are more likely to listen to the opinions of others, which will be beneficial when dealing with clients (Bennett *et al*., 1999). The construction industry involves stakeholders from multi-disciplines and at different levels. This aspect makes the industry more fragmented. Promoting collaboration and teamwork are crucial in order to reduce the fragmentation and increase integration among stakeholders. Female values generally tend to be developed through socialisation processes that include building relationships, communication, consensus building, power as influence, and working together for a common purpose (Trinidad and

Normore, 2005). In support of that, studies by Gale (1994) also acknowledged that these 'feminine traits' were beneficial in negotiation situations. Further, EOC (2005) have identified the benefits of having a diverse workforce as addressing skills shortages, meeting wider customer demand, widening the range of skills and aptitudes among employees to improving the quality of service delivery, and projecting a modern, positive and corporate image to both potential recruits and potential customers. Despite these advantages and the number of efforts taken to solve the skill shortages and to improve the equal opportunities for women, the industry has failed to make significant progress in recruiting and retaining more women.

The main reasons behind the low number of women in construction are the barriers they face in recruitment, retention and progression. The image of the construction (Fielden *et al.*, 2001; Fielden *et al.*, 2000; Bennett *et al.*, 1999; Gale,1994); lack of career knowledge even among the professional career advisors (Agaipou, 2002; Fielden *et al.*, 2000; Gale, 1994; Harris, 1989); culture and working environment Dainty *et al.*, 2000; Fielden *et al.*, 2000; Bennett *et al.*, 1999); informal recruitment practices (Fielden *et al.*, 2001; Fielden *et al.*, 2000); family commitments (Lingard and Lin, 2004; Agapiou, 2002; Lingard and Francis, 2002; Fielden *et al.* 2000; Greckol, 1987) have been pointed as the major barriers by various scholars (see Amaratunga *et al*., 2008). Lack of women on recruitment panels was also identified as a particular problem for the low representation of women in construction as it increases the likelihood of informal recruitment practices in the industry (Amaratunga *et al*., 2007). In addition to these identified organisational factors, the personal factors such as 'domestic responsibilities', 'undervaluing own leadership skills and competence', 'limiting personal beliefs', 'insufficient self-confidence' etc. have been highlighted as the top barriers for women's progression into senior roles (Manning, 2007).

Taking both the problems faced by the industry and the barriers faced by women into account, it can be argued that a 'two-way' contribution is needed between women and the industry in order to improve the representation of women in construction and also to address the skills shortages, recruitment difficulties, and equality & diversity issues in construction. Number of studies has been conducted on how to make the industry more attractive to women. However, little has been researched on the contribution women could make towards the construction industry. In this context, this research aims to explore the contribution women could make towards the construction industry.

The nature of the in-depth analysis limits the possibilities to explore the contribution of all the women who are attached to the industry. Women are found at various levels and occupations within the construction industry. This research focuses on the women who are at managerial levels in construction.

3. Research focus

This research focuses on women managers in construction. The vertical and horizontal gender segregation pattern in the industry clearly indicates the underrepresentation of women in management levels and in professional capacity respectively. Vertical segregation is the concentration of men and women in different levels of the professional hierarchy whereas horizontal segregation refers to the concentration of men and women in various sectors or occupations of the industry. The typical gender segregation in the construction industry indicates that the concentration of men and women in different kinds of jobs are conforming to societal expectations of the gender (EOC, 2004). In this regard, women are more likely to work in administrative and secretarial, personnel services and sales occupations, whereas men predominate in skilled trade occupations, process, plant and machine operative occupations and managerial occupations (Hibbett, 2003).

Based on the statistics given in the previous section, women are concentrated in administrative and secretarial positions, or other positions not directly involved with the construction process. Greed (2000) refers that these women appear to exist in a quite different 'social space' within the 'same' physical space that women professionals might find demanding and alienating (p.188). Among the women involved in mainstream construction, the women in professional capacity comparatively shows better representation than those in craft and trade levels. Since women at the professional level are amongst the most represented, by implication the scope for removing barriers is greatest. However, the under-representation of women at senior management roles (see EOC, 2006; Dainty *et al*., 2004) makes the process slow in terms of minimising the barriers to improve the entrance, retention and progression of women.

There are three main reasons to set the research focus on women managers in construction. First, they have been in the industry long enough to understand the context, culture and difficulties; second, they have really progressed in their career while in the industry, despite the barriers identified; third, they have come to a position where they possess certain level of power and authority to take decisions and make influences. Therefore, it is appropriate to mention that women managers are comparatively in a better position to make a contribution towards the construction.

Managers and professionals in the industry can be categorised under four types as non-management roles (these positions are generally self-directed); supervisory roles (these positions typically fulfil a supporting role to middle management); middle management roles (these positions are mainly responsible for managing the whole process of a project and for leading a project team); senior management roles (these positions are often the ones of power where company-wide decisions are made) (Bennett *et al*., 1999). The women managers who are at the middle and senior management levels have been considered for this study.

4. A review on the key areas of the research

The research on contribution of women managers in construction can be linked to key knowledge domains such as gender, leadership and construction. The gender role definition and leadership styles women typically exhibit influence the contribution women could make. Brief literature review on the key areas is presented.

4.1 Gender role definitions

In our society it can obviously be observed that men and women play distinctively different roles. Each gender in a society shows a standard set of behaviours and characteristics. Sex role stereotypes are widely held beliefs about such behaviours and characteristics (Singleton, 1987). An essentialist viewpoint argues that gender roles are the result of innate biological differences between the sexes (Sammons, 2009). Contrary to the biological determinism perspective, the constructionist view argues that "gender is a social institution that has produced historically variable sets of norms and expectations regarding how one ought to behave, decide, think, how one should relate, where and how one should work" (Barrett, 1995, p.9). The researcher's viewpoint does not totally disagree with the essentialist view about gender which says that biological sex has an influence over the gender behaviours and roles. However, the claim that the gender is an invariant factor and lack of evidences to confirm the direct relationship between biological sex and gender behaviours (see Renzetti and Curran, 1989; Sammons, 2009) fade the researcher's level of agreement to this viewpoint. As we can see in our day today life, the changing gender role in the society fairly convinces the fact that the gender behaviour can be learned and changed to fit to the environment and culture and to perform accordingly. For example, in the context of this research, women who were once considered as unsuitable to hold positions of power and leadership or careers involving intelligence, have now begun to serve in such capacities. This made the researcher to support the constructionist viewpoint of the gender role, where it is the social factors that determine one's gender role and in accordance with such factors people adopt different gender behaviours. The gender stereotype expects the people to behave in certain manner based on the societal expectations. When women behaviours are not according to the expectations, then they are accused for gender discrepancy. This stereotype acts as a barrier for women to change or learn the gender role, even though changing is mandatory at certain circumstances. This sets back women to make effective contribution in construction.

4.2 Leadership styles in construction

Women managers being the main focus of this study, the contribution they can make towards the industry is explored having taken their leadership styles into consideration. Organisations have paid attention to leadership styles of their people who occupy managerial positions, holding the belief that leadership is an important factor in achieving business success (Giritli and Oraz, 2004). The leadership attributes and management attributes are not the same but closely related. One of Peter Drucker's quotes say 'management is doing things right; leadership is doing the right things'. Cunningham (1986) viewed the relationship between leadership and management in three different ways such as leadership is one competence among a range required for effective management; leadership and management are two concepts but related; leadership and management are two concepts but with a partial overlap. Sadler (2003) expresses that management is a rational process, calling in to play abilities such as verbal and numerical reasoning, whereas leadership is more intuitive, involving emotional intelligence. Zaleznik (1992) suggests goals are viewed impersonally for managers, in contrast, leaders adopt a personal approach to goals that reflect their own visions or deeply held beliefs. According to Kotter (1990) management is about dealing with complexity whereas leadership is about coping with change.

These comparisons indicate that there is a blurred line between leadership and management and they are not absolutely separate. Therefore isolating leadership from management may not be effective to achieve business success. A leader-manager model is believed to be more effective and ideal to be placed in top positions, than leader alone or manager alone models. This idea is supported by Stevens (2007), who proposes a leader-manager model as an effective one for construction. He believes the leader-manager skill is the new driver in the construction industry, as the reality of the industry demands we have dual roles. Thus, he concludes that in order to better serve the construction industry the leadership role is to be redefined as having a business management component.

The appropriateness of particular type of leadership behaviour largely depends on the situational variables such as culture of the organisation, nature of tasks, characteristics of followers and societal values (Eagly, 2007). The project-based nature of construction industry with its temporary multi-organisations will almost certainly have an important influence on the managerial leadership styles of professionals working in it (Giritli and Oraz, 2004). Although, in most project environments, there is a strong preference for a democratic participative style, it may not be the most effective for all situations. Naum (2001) states that large capital investment projects coupled with high complexity of decision issues can require different styles of leadership, and he admits that a participative style of leadership with bureaucratic organisation is expected to be more appropriate than a directive style. Nevertheless, the leaders may have to impose more authoritarian styles at times when there is a need to control the workers. Nicholas (1990) suggests that a less participative, more directive style might be more appropriate when there is less time and high pressure to complete the work. Another study, by Pheng and Lee (1997), on construction project managers revealed that most of the respondents agreed that the project manager should possess firm and capable leadership qualities. The study by Bresnen *et al*. (1986) showed that task-oriented forms of leader behaviour are more appropriate where subcontractor labour forms the bulk of the workplace. During the different phases of the design process, styles may need to allow for more debates, fine-tuning and deliberation (Giritli and Oraz, 2004).

The literature argues that the construction industry uses a combination of different leadership styles due to the nature of the industry. Thus, it is difficult to determine the most appropriate leadership style to conform to each particular situation in the development of a project. Naum (2001) says that leaders may have to switch from one style of leadership to another or combine elements of different styles until the right balance between concerns for tasks and concerns for people is reached.

4.3 Leadership styles of women manages

The gender role definitions discussed earlier seems to affect the leadership characteristics men and women exhibit. Based on a review of the extant literature on female leadership and survey of comparative studies of male and female leaders, it was concluded that among managers, women tended to be more democratic or participative in their leadership styles compared to men (Carli and Eagly, 2007; Eagly and Carli, 2003). They also reported that a meta-analysis of 45 studies, examining gender differences in transformational leader behaviours, found that female leaders used a more transformational style compared to male leaders. Research findings of Trinidad and Normore (2005) show that women adopt democratic and participative leadership styles in the corporate world and in education. Several studies focusing on transformational leadership indicated that women are perceived, and perceive themselves, as using transformational leadership styles more than men (Eagly, 2007; Bass *et al.*, 1996; Druskat, 1994; Rosener, 1990; Kark, 2004).

In contrast, other scholars have argued that there are no significant gender differences between men and women in their leadership behaviours. Powell (1990) in his analysis of a number of research studies found that male and female leaders exhibit a similar amount of task oriented and people oriented leadership behaviour. Further Pounder and Coleman (2002), based on various studies, have summarised the idea of 'little or no difference' and 'no evidence for any dissimilarity' in the leadership styles, leadership effectiveness and competencies of men and women.

The particular leader role in construction can demand the styles of leaderships to be exhibited, irrespective of whether the role is played by men or women. Therefore, to be an effective leader in construction, women managers are required to exhibit a range of behaviours within the boundaries of their style, and outside the boundaries if the situation demands so.

4.4 Summary

The literature points out three key points. First, the gender role definition and gender stereotypes influence the characteristics and behaviours of women; second, the appropriate leadership styles for construction varies on situational attributes thus demands a combination of different leadership styles; third, women are perceived as using transformational or participative or democratic or people oriented type leadership styles more than men, though some other researchers argue that there are no significant gender differences between men and women.

These key points have been considered when analysing the contribution of women managers. As construction industry demands different styles of leadership on different occasions, in order to be effective, women managers who are playing leading role in construction are required to exhibit different styles. Though they are perceived as better transformational leaders, there are instances where they have to exhibit transactional or authoritative styles. Then the element of gender stereotype evaluates the behaviour of women (who are authoritative) negatively and gives less respect. If women behave in a stereotypically female gendered way in a leadership role, they are not respected for not leading effectively, but if they behave overlay in a male way they are not respected either for their gender discrepant behaviour. This contradiction imposes a challenge for women managers in leading roles in getting the right balance between the gender behaviours and the effective leadership styles. These aspects are linked with the empirical evidences in exploring the contributions of women managers towards the construction industry.

5. Research methodology

This researched adopted a case study strategy. Case study is an empirical inquiry that investigates a contemporary phenomenon within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident (Yin, 2009, p.18). This study considered individual as the case, in this scenario it was the 'woman manager in construction'. Three case studies have been conducted to explore and investigate the contributions of women managers, thus this research adopts a multiple, holistic case study approach. The women managers have been selected based on the following selection criteria, where the woman manager performs senior management role in the construction industry and has been in the construction industry at last for ten years. As this research has an exploratory nature, a self-selection sampling was used as the most appropriate technique. Self-selection sampling occurs when the researcher allows each case, usually individuals, to identify their desire to take part in the research, where a request is made to the respondents to take part in the research and the data will be collected from those who respond (Saunders *et al*., 2009, p.241).

In addition, expert interviews also conducted to explore the contribution of women managers. Purposive sampling, which facilitates the researcher to select cases that will best enable to meet the objectives (Saunders *et al*., 2009), was used to select the experts. 5 experts, who excelled in areas related to gender, leadership and construction, were selected to represent the fields of study, which in turn ensured the adequacy in capturing the necessary information from the identified knowledge domains.

Data collection and analysis are developed together in an iterative process in a case study (Hartley, 2004). In-depth interviews, Multiple Leadership Questionnaire (MLQ) and Personal Attribute Questionnaire (PAQ) formed the main data collection tools within the case studies conducted. The in-depth expert interviews were also conducted using semi-structured interviews. Figure 1 illustrates the data collection techniques and the sources of evidence used for this research.

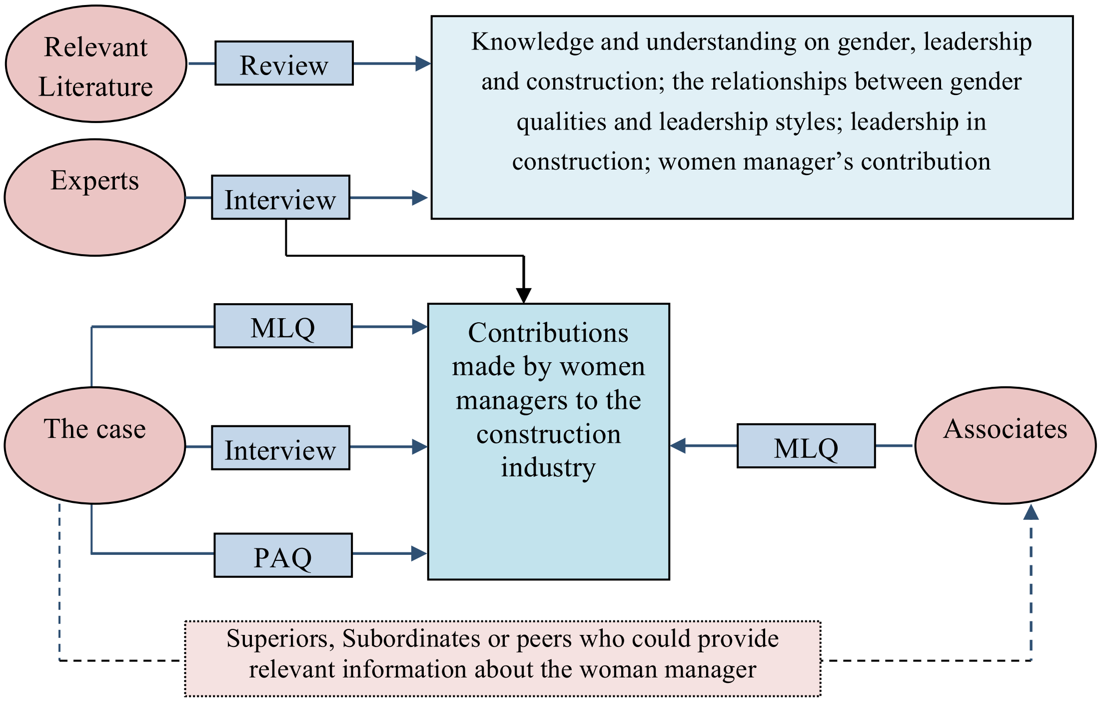

Figure 1: Research techniques and the sources of evidence used for the research

MLQ was used to identify the leadership styles exhibited by women managers in construction. MLQ identifies the characteristics of leaders and helps individuals discover how they measure up in their own eyes and in the eyes of those with whom they work. Thus it facilitates to capture a 360 degree view on the leadership styles exhibited by women managers. In order to increase the use of multiple sources of evidence, document review in the form of company websites, professional magazines and news articles were used to collect data about the women managers. Personal Attributes Questionnaire

(PAQ) by Spence *et al*. (1975) was used to measure the personal traits of women managers in terms of masculine or feminine adjectives. In-depth interviews were conducted to explore the contributions women managers make or willing to make towards the construction; the barriers they face and the ways of eliminating or minimising such barriers; the benefits women managers could bring through their contribution. The interviews used to capture expert knowledge also identified the possible contribution that women could make towards the construction industry.

6. Key findings

This paper summarises the key findings from the case studies and expert interviews on women managers' personal traits; the leadership styles; and the contributions they made to the industry.

The study on their personal traits, also with the support of PAQ, reveals that two women managers have strong personality almost equally in both masculine and feminine gender qualities. But the third woman manager possesses relatively more masculine personality compared to what she possesses as femininity adjectives. She mentioned the reason may be due to her cultural background as she is from a culture where being direct or showing masculine qualities was not a problem at all.

The leadership styles are classified in many different ways by various scholars. This research used the classification given in the Multiple Leadership Questionnaire (MLQ) (See Bass and Avolio, 2006) to identify the leadership styles of the senior women managers in the construction industry. The main classifications used are transformational, transactional and passive-avoidant. Transformational leadership is a process of influencing in which leaders change their associates' awareness of what is important, and move them to see themselves and the opportunities and challenges of their environment in a new way. This leadership styles has five behaviours such as Idealized Attributes (IA) (builds trust); Idealized Behaviours (IB) (acts with integrity); Inspirational Motivation (IM) (Inspires others); Intellectual Stimulation (IS) (encourages innovative thinking); and Individual Consideration (IC) (Coaches people). Transactional leaders display behaviours associated with constructive and corrective transactions. The constructive behaviour is labelled Contingent Reward (rewards achievements) and the corrective behaviour is labelled Management-by-Exception - Active (monitors mistakes). Another form of Management-by-Exception - Passive (fights fires) leadership is more passive and "reactive": it does not respond to situations and problems systematically. In this regard it is similar to laissez-faire styles – or "no leadership" (avoids involvement). Accordingly, both styles can be grouped together as 'Passive - Avoidant Leadership'. Both types of behaviour have negative impacts on followers and associates. However this style is appropriate where the staff is highly skilled, experienced, educated, have pride in their work and have the drive to do it successfully on their own.

All three women managers exhibit a degree of leadership styles that is more than the expected universal norm and their level of exhibit is classified as high. However in the styles Management-By-Exception Active (MBEA), Management-By-Exception Passive (MBEP) and Laissez-faire (LF), all have shown a lower value. In these three styles the leader's involvement is minimal and these styles are appropriate to lead an individual or a group of people who are self-motivated and self-leading. Showing lower values in such styles interprets that the women managers do not avoid getting involved. In all three cases, it shows that the women managers exhibit both transformational and transactional leadership styles at a higher frequency rate compared to the Non-transactional (or Passive-Avoidant) behaviour. At the same time all three women managers perceive themselves as using transformational leadership styles more often than the transactional styles. The women managers feel that the transformational style is effective in construction, though it is not the only style which is effective at all the time. The experts also supported that since the industry is moving towards collaboration, mentoring, guidance, relationship building, and communication, transformational leadership is to be used by the managers, irrespective of their gender. But they all agreed that certain situations demand authoritative styles. Women managers also agreed that they have to act in an authoritative way depending on the situation, though they comparatively feel less comfortable in such instances.

The major factors that influence women managers' contributions are categorised under personal, social and organisational factors. Personal factors consist of childhood experience, personal traits, leadership, educational background, family background, domestic responsibilities, personal beliefs, level of confidence, knowledge and expertise and gender qualities etc; social factors includes societal expectations, gender stereotype, respect for women's behaviours etc; and organisational factors consist of role performed, gender composition and segregation, organisational culture, barriers and opportunities, legislation, recruitment and promotions etc.

The contributions they made are captured at five different levels such as individual, team, project, organisation and industry levels. The 'individual level' mainly refers to the their subordinates and peers. The team level refers to the team that they are leading. The project level refers to the entire projects that are under their purview. The organisation level refers to the board level activities and decisions they make. The industry level refers to their contribution in general not only within their organisational boundaries but also outside the organisation, through professional institutions, network or associations and engagement with other bodies. Contributions made by women managers at individual level are mentoring, motivation, career advice, and problem resolution; at team levels are forming effective team, avoiding isolation (for female employees), problem resolution, encourage collaboration and motivation; at project level are problem resolution, taking responsibilities, avoiding isolation, making structural changes, leadership and decision making; at organisation level are decision making, policy development, problem resolution, promoting family friendly culture, and leadership; and at industry level being a role model, attract more women, increase awareness, engage with school students and career guidance.

The employees and the organisation will benefit with better work life balance, training and development particularly for female employees, better working environment, networking and collaboration. The potential recruits will have better knowledge on careers in construction, will have increased access to career guidance, have networking opportunities and will be inspired to consider careers in construction. In effect the industry will benefit by having a mixed workforce, improved image, improved equal opportunities, and fair recruitment practices. Thus, these contributions not only benefit the employees and the organisation, but also benefit potential recruits to the industry and the construction industry as a whole.

7. Conclusions

This paper is produced based on the literature review and on empirical analysis on the contributions of women mangers to the construction industry.

The problems that the industry faces in terms of skills shortages, recruitment difficulties, poor image, high fragmentation, low productivity, low performance and high dissatisfaction among clients and the barriers that the women face to enter, retain and progress in the industry need to be addressed. Addressing these problems are the responsibilities for the industry as well the disadvantaged women. Women managers who have progressed in the industry and been there for long enough to understand the culture and the difficulties are in a position to make a contribution towards the industry. The contribution of women managers has been presented at five levels ranging from individual to industry.

The empirical evidences support the literature that the transformational leadership is a preferred style by women managers, though they are able to exhibit transactional styles when necessary. The experts' interviews reveal that the culture in construction is moving slowly towards collaboration leaving more scope for women to join the industry. The women who were studied have the power to influence organisational policies. However, they admit that the few number of women in managerial position (less than 1%) is not sufficient to make a shift in the culture. In order to achieve the critical mass, the industry needs to attract more women particularly to the mainstream construction. This would make an impact in the culture and the image of the construction.

This research has made a contribution to knowledge by exploring the contribution of women managers towards the construction, thus highlighting the benefits women managers could bring to the construction and women. This paper will be a supportive resource to any reader interested in women managers' contribution.

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Factors Influencing the Effective Implementation of VET in Government Vocational Training Centres in Oman

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Abstract

Vocational Education and Training (VET) is an effective way of enhancing the knowledge and skills levels of trainees and it has become of prime importance in economic, employment and social integration strategies worldwide. In Oman, VET has a crucial role to play in meeting the socio-economic, demographic, environmental, and technological needs of Omani citizens today and in the years ahead, and the significance of VET is realised in order to deliver qualified and skilled human resources to counteract the shortages in the Sultanate's workforce and achieve its development plans. However, despite the evident government support, figures indicate the level of unemployment graduates form the Government Vocational Training Centres (GVTC) in Oman is high, to an extend that these graduates require retraining because they do not have the appropriate skills and knowledge to work. Furthermore, some studies and government reports confirm problems facing the development of VET such as the mismatch between skill levels among young Omanis graduating from the GVTCs and the labour market requirements, and the predominance of expatriates occupying private sector jobs, especially within vocational work. These issues prevent VET from being effective in terms of promoting Graduate Employability (GE), and thus represent the rationale for conducting this research.

This paper will therefore elaborate of the role of VET in developed countries, deriving the measures that influence effective implementation of VET. The paper also shares the findings of qualitative methods employed to identify that challenges facing the implementation of VET programmes in the GVTCs in Oman, involving various VET stakeholders, including top and senior managers, trainees, graduates, and employers from the government and private sectors. The findings suggest a need for a radical change in the Omani VET programmes to address employability skills in order to meet the needs of the labour market requirements. Recommendations are thus provided to aid effective development and implementation of VET programmes in Oman.

Keywords: vocational education, vocational training, Oman

1. Literature review

Vocational Education and Training (VET) can be traced back to the Industrial Revolution in England in the eighteenth and nineteenth centuries. Subsequently, the notion of VET spread to Western Europe and then to all parts of the world, being considered as an important tool at all levels of education and employment. The point is made by UNESCO (2010), that country-specific usages of the term VET are evident, resulting from variations in systems of education, and the differing requirements of countries in respect of the human capital needed to ensure the achievement of development goals. This analysis concurs with that of Cave and Blyth (2008) who highlight some countries' possession of advanced technologies and their specific needs for well-qualified manpower. Therefore, VET has become an effective way of supporting countries in their efforts to enhance the skills levels of trainees, and hence, it is recognised as being of prime importance in economic, employment and social integration strategies worldwide (Pullen *et al*, 2012).

It can also be appreciated that VET is important through its key role in economic development, and through its ability to react relatively quickly to changing demands from the employment market, by its training function. As a country's economic growth and strength are dependent upon its human resources, any means by which these can be enhanced are valuable. According to Tripney *et al* (2012), the linkages between productivity, employment and poverty were addressed and VET was specifically pinpointed as an intervention that is advantageous in efforts to stimulate productivity, alleviate unemployment, and hence, reduce poverty.

1.1 VET in developed countries

In the developed countries, VET has been demonstrated as one variable that contributes to economic growth since it is classified as an instrument of modernisation (Eichhorst et al, 2012). Most of these countries are concerned about the ease with which young graduates can make the transition from vocational school to work in the labour market (Hanushek et al, 2011). For example, Germany is often championed for its well-established VET which provides the 'dual system' of apprenticeships, offering a genuinely respected alternative to education (Pullen et al, 2012). The effective implementation of VET programmes in Germany, which connects labour market requirements and considers new challenges in terms of employability, leads to life satisfaction which is linked to a stable society (Lohmar and Eckhardt, 2011). And in Australia, there has been an increased focus on VET to improve employability skills, and a move towards making them more prominent and explicit in the education system and the labour market. In the UK, engaging youth in VET programmes has helped to prevent unhealthy behaviour, such as smoking, alcohol or drug addiction, and has reduced the incidence of delinquency (Department of Education, Employment and Workplace Relations, 2011). And yet other studies have been conducted by the European Centre for the Development of Vocational Training (2011), revealing that the developed countries have reaped social benefits from their implementation of VET.

Table 1 below shows a summary of the role of VET in Australia, Germany, the UK, and the USA, as examples of developed countries demonstrating good practice in respect of implementing VET and delivering Graduate Education (GE) such that trainees and graduates are able to secure suitable occupations. This will aid this study to understand the expected role of VET in Oman.

Table 1: VET Experiences in Australia, Germany, the US and the USA

Developed Countries	Experiences Learned for this Research		
	Suitability of VET programmes with the labour market requirements	**Stakeholders' satisfaction with VET programmes**	**Ways and methods for evaluating trainees and graduates**
Australia	• Involving all VET stakeholders in designing and developing VET programmes. • Insuring VET quality. • Increasing the national vocational qualifications. • VET comprises sets of industry competencies, which are designed to support competency-based training and specification of knowledge and skills required in the workplace.	• Providing opportunities for continuing in higher education level. • Diversity programmes and occupations. • Equipping trainees for the workplace. • Enhancing employability in the labour market. • Achieving equitable outcomes in VET. • Increasing investment in VET. • Expanding the value of public VET expenditure. • Offering satisfied qualifications for the different occupations.	• Offering standards for evaluating VET programmes. • Providing vocational national qualifications. • Promoting quality and national consistency in terms of qualifications. • Establishing flexible pathways of assessment and delivery of VET. • Developing the National Skills Framework for assessing trainees and graduates.
Germany	• Dual System is linking between on-the-job training in industry and part-time compulsory training at the vocational schools. • There is co-operation between industry and	• VET is deeply embedded and widely respected in the society. • Students usually join VET after finishing their general education.	• Offering qualifications in a broad spectrum of vocational and flexibly adapts to the changing needs of the labour market. • The economy and not the state that is responsible

	educational organisations. • Developing the programmes to be suitable for labour market requirements. • Involving all stakeholders in developing VET programmes. • Increasing the investment of VET by involving the industry's employers. • Promotion of employability in work environments.	• Most graduates have the choice of joining higher education. • In dual system is the high degree of engagement and ownership on the part of employers and other social partners. • Trainees have freedom to choose their direction of specialisation. • Reducing the unemployment rate of the graduates. • Integrating work-based and school-based learning to prepare apprentices for a successful transition to full-time employment. • Improving the career guidance.	of VET. • The evaluation system includes a combination of theoretical and practical aspects. • The variety of vocational certificates at the end of each year in VET system.
UK	• VET has been committed by the government and employers to a step improvement in the level of employability skills. • The conscious attempt to engage employers in designing and developing VET. • Improving the VET policy with participation of industrialists and business owners. • Concerning the quality and efficient and sharing them with employers.	• Extensive resources have been made available for enhancing VET programmes. • Enhancing the social values of VET. • Guaranteeing the adequate VET programme for both men and women at all levels. • Balance in taking the trainees' needs and the labour market requirements. • Increasing the diversity of VET programmes for the trainees. • VET has traditionally been regarded as inferior to moderate, academic learning, educational structures have always been	• The assessments methods are flexible and allows for tailor-made training solutions for VET providers and employers. • Offering massive of vocational programs and qualifications. • Vocational qualification certification demonstrating the occupational competences and a record of graduate's achievement. • Continuous improvement in providing different evaluation methods and certificates. • Graduates have continuous assessment and

		closely related to status and social class. • *Providing the information and careers guidance.*	*progress record.*
USA	• *Strong employability skills are embedded in this system.* • *Involving various stakeholders and agencies in developing VET.* • *The responsibility of VET is between the educational bodies in the government, the community and the employers.* • *Strong employability skills are embedded in this system.* • *Increasing the on-the- job training programme and the apprenticeship programmes.* • *Provision of work-based training by employers as part of some VET programmes.* • *A focus on preparation for highly skilled occupations.* • *Providing incentives for employers, teachers, trainers, businesses to develop workplaces that use skills appropriate for high performance organisations.*	• *Diversity of pathways which offers by High Schools and the Community or Junior College, Technical College and Post-Secondary Training Programme.* • *Improving employability skills, career information and career awareness in trainees.* • *Offering the on-the-job training programme and the apprenticeship programs.* • *Linking between education experience and work experience is involved to provide high quality integration between academic and VET.* • *High quality integrated academic, VET and occupational field.* • *Linking trainees' apprenticeship to a broad strategy of career development.* • *Providing an opportunity for continuing in university level.*	• *Insuring the high quality programmes.* • *Promoting the assessment system within several qualifications.* • *Certification of occupational as well as academic skill levels of participation of young people.* • *Theoretical and practical examinations to insure providing the highly skilled occupations.* • *VET varies from state to state, thus there are many vocational qualifications.* • *On-the-job training and the apprenticeship programmes have became the most important type for evaluation and selection the skilled graduates.*

1.2 VET in Developing Countries

In the developing countries, both within and outside the Arab World, the outcomes of VET are varied. On the one hand, government policies have played a major role in some of these countries and VET has been introduced in attempts to satisfy increasing demands for vocational and skilled labour, which in turn can promote the creation of a strong industrial base across all development sectors, ultimately increasing the standard of living in the society concerned (Langthaler, 2013). In this connection (Agrawaliv, 2013) shows that in Japan, Korea, and Singapore, the VET systems are well established and have contributed significantly in the process of economic growth.

On the other hand, many studies in developing countries (Agrawaliv, 2013; UNICEF and Suruhanjaya Syarikat Malaysia, 2013); have revealed that despite governments' willingness to invest in VET, as for example, in Indonesia, Malaysia, Philippines, Thailand, Sri Lanka, Bangladesh, China, India, Nepal, Pakistan, Egypt, Iraq, and Tunisia, there have been many obstacles to its success. Such obstacles are seen in the high rate of unemployed graduates, low enrolment, high drop-outs, poor quality of teachers, inequitable access for women and rural populations, limited private sector involvement, low employability skills achievement, insufficient budgetary allocations, and some social and cultural concepts.

Similarly, although the strategies of the governments of the six Gulf Co-operation Council (GCC) countries (Oman, Kingdom of Saudi Arabia, Kuwait, Bahrain, Qatar, and United Arab Emirates), have emphasised the importance of VET in developing knowledge-based economies and building a more qualified workforce to meet growing labour market demands (World Economic Forum and European Bank for Reconstruction and Development, 2013), VET has been negatively influenced by several factors. These are seen in social, cultural, educational, economic, and financial variables, all of which dilute the potential of VET to achieve social and economic goals (Al Rawahi *et al,* 2012; Gulf Talent, 2011; Samman, 2010; Gokhale, 2006; Fasano and Goyal, 2004; Metwally, 2003; Mellahi, 2000).

1.3 VET in Oman

Among the GCC countries, Oman is the third largest in size and population in the Arabian Peninsula, and its geographical location has contributed to the development of many vocational crafts and industrial trades. Not surprisingly, therefore, throughout all the stages of Oman's Five Year National Development Plans (1976–to date), VET has received government attention and focus (Al Jardaniah, 2013), resulting in the expansion and development of premises, construction, workshops, and the provision of machinery and tools, to keep abreast of the VET developments endorsed by the country's various economic sectors. Continual support for VET and greater employability has been steadfastly addressed by His Majesty Sultan Qaboos, who has encouraged Omani youth to take advantage of VET opportunities and available employment (Shura Council, 2009). Indeed, VET's main objectives are to meet the Sultanate's development needs for occupational skills among nationals so they can take jobs in various technical fields. These objectives were reinforced at the Technical and Vocational Education and Training Meeting in 2012 in Muscat which discussed the importance of building skills for work and life, the challenges of development, the need to enhance skills and the role of VET in this respect, and youth employment in the Arab region in general (Oman News Agency, 2012), as well as in the specific context of Oman, as the means of achieving sustainable development.

However, despite the evident government support, figures indicate the level of unemployment of the Government Vocational Training Centres' (GVTCs) graduates to be high and some such graduates require retraining because they do not have the appropriate skills and knowledge to work (Gulf Talent, 2011; Al Nabhani, 2012; Gonzalez, *et al,* 2008; Spottl, 2008). Furthermore, some concerns appear in MoMP (2010a) reports regarding negative attitudes among youth towards manual work, further adding to a general reluctance to join GVTCs, and a scarcity of Omanis in the industrial labour force (MoMP, 2010b; MoMP, 2010c; Al Nabhani, 2012). Some studies and government reports confirm problems facing the development of VET such as the mismatch between skill levels among young Omanis graduating from the GVTCs and the labour market requirements, the growing number of job seekers among VET graduates, and the predominance of expatriates occupying private sector jobs, especially within vocational work (MoMP, 2013; Oman Daily Observer, 2013; Al Rawahi *et al,* 2012; MoMP, 2011; Wilkins, 2002). These issues prevent VET from being effective in terms of promoting **G**raduate **E**mployability (GE), and thus represent the rationale for conducting this study as detailed in the following section. Based on this, this paper intends to explore the reason behind ineffective role of VET in Oman.

2. Conceptual framework

Based on the findings form Table 1 which describe in details, the experiences learned from the developed countries, these lessons and experiences will underpin the exploration of the role of VET in Oman under four main themes as shown in Table 2 below.

Table 2: The Conceptual Framework for the Effective Implementation of VET

Themes	***Criteria***	***Research enquiry***
Role of VET programmes in meeting labour market requirements	• *Suitability of VET programmes for the labour market requirements* • *Stakeholders' satisfaction with VET programmes* • *Methods of evaluating VET programmes*	• *What is the role of VET programmes in meeting the labour market requirements in Oman?*
Motivational drivers for engaging in VET	• *Personal desire* • *Family and friends' influence* • *Community influence* • *To establish their own business* • *Developing own knowledge and skills* • *No opportunities to access general and higher education* • *Financial motives* • *Improving personal profile*	• *Why do trainees enrol with GVTCs?*
Effective engagement of VET stakeholders in developing graduate employability	• *Significance of graduate employability to VET programmes* • *Effective engagement in graduate employability* • *Promoting the relevant skills requirements for the labour market*	• *What are the perceptions of VET stakeholders about graduate employability?*

The perception of VET programmes	• *Social and cultural* • *Educational* • *Economic and financial*	• *What are the factors influencing the development of VET in terms of graduate employability?* • *How do these factors influence the development of VET and graduate employability?*

The rest of this paper shares the findings of qualitative methods employed to identify that challenges facing the implementation of VET programmes in the GVTCs in Oman, involving various VET stakeholders, including top and senior managers, trainees, graduates, and employers from the government and private sectors.

3. Qualitative data collection

The main aim of the qualitative data collection is to explore the effectiveness of the implementation of VET programmes in the Government Vocational Training Centres in Oman, through identifying;

- The role of VET programmes in meeting labour market requirements
- Motivational drivers for engaging in VET
- Effective engagement of VET stakeholders in developing GE
- The factors influencing the development of VET of VET programmes

Table 3 below show the summary of the interview questions, covered by four main themes derived from literature;

Table 3: Themes and Questions: Interviews and Focus Groups

Themes	***Interview and focus group questions***
1. Role of VET programmes in meeting labour market requirements	*Q1. Do you think that vocational training programs meet the labour market requirements? Explain your answer?* *Q2. From your view, are you satisfied with VET programs that are offered to the trainees at the centre? Please give explanation for your opinion?* *Q3. From your opinion, what is the way to evaluate trainees at the end of program duration in your centre?*
2. Motivational drivers	*Q4. What do you think of the reasons that influence trainees' decisions to engage in the*

for engaging in VET	*VET programmes?*
3. *Effective engagement of VET stakeholders in developing graduate employability*	*Q5. In your view how significant is the issue of graduates' employability in the development of vocational training programmes?* *Q6. Do you think that the graduates' employability should be considered as an indicator of vocational training programmes quality in the context of vocational training? Explain your opinion?* *Q7. Please indicate your opinion in the main skills in terms of their importance in assisting a smooth transition from vocational training centre to employment sectors?*
4. *The factors influencing the development of VET of VET programmes*	*Q8. From your opinion, what are the major factors that influencing the development of VET in term of employability in the GVTCs and in the labour market?* *Q9. How do these factors influence the development of VET and graduate employability?*

To achieve this, face to face semi-structured interviews were conducted with 30 VET stakeholders as follows; two VET officials from the General Directorate of Vocational Training at the Municipality of Man Power, fourteen top and senior management from the five Government Vocation Training Centers (GVTCs), five trainers from the GVTCs, three employers from the government sector, and six employers from the private sector. Table 4 below show a summary of the targeted interviewees.

Table 4: Sample of Interviewees

Interviewees from MoMP	***Interviewees from GVTCs***			***Interviewees from the labour market***	
VET Officials	*Centre*	*Top and Senior Management*	*Trainers*	*Government sector employers*	*Private sector employers*
	Al Seeb	*4*	*1*		
	Saham	*2*	*1*		
	Sur	*5*	*1*		
	Ibri	*2*	*1*		
	Shinas	*1*	*1*		
2		14	5	3	6
(30) interviewees					

4. Main findings

4.1 Theme 1: Exploring the role of VET programmes in meeting the labour market requirements within the Omani context

a. ***Suitability of VET programmes with the labour market needs:*** Although, the perceptions of VET stakeholders towards the suitability of VET programmes for labour market needs reveal some positive views, the opinions of private sector employers and graduates are negative. They believe that these programmes do not meet labour market requirements. This result is attributed to the following problems:

- Lack of involvement of all VET stakeholders in designing and developing VET programmes
- Lack of co-operation between industry and the GVTCs
- Lack of national vocational qualifications; the vocational certificate is the only VET qualification
- Lack of linkage between on-the-job training in the private companies and the GVTCs
- Lack of promotion of the employability skills in VET programmes and work environments

b. ***Stakeholders' satisfaction with VET programmes:*** Although most stakeholders are satisfied with VET programmes, private sector employers, and graduates, graduates are not. They cited the following shortcomings in VET programmes:

- No opportunity for continuing in higher education in the universities
- Lack of diversity in programmes and occupations especially for females
- Lack of promotion of the employability skills in VET programmes and in the labour market
- Lack of appropriate qualifications for the different occupations
- Lack of respect for VET within society
- Lack of integration of work-based and school-based learning to prepare apprentices for a successful transition to full-time employment in the industrial area

c. ***Ways and methods of evaluating trainees and graduates:*** There is a difference between the employers' perception and the other stakeholders' views concerning how to evaluate trainees and graduates in GVTCs. However, the majority of participants agree with the following points:

- The Vocational Certificate should be changed to improve its status
- There should be more involvement of government and private sector employers in evaluating trainees and graduates

- There should be appropriate standards for evaluating trainees and graduates
- There should be more than three levels of national vocational qualifications
- There is no flexibility in assessing and delivering VET
- There is a lack of implementation of the ooccupational standards and skill testing in the assessment of trainees and graduates
- There are no opportunities to offer qualifications across the broad spectrum of vocational occupations or to adapt to the changing needs of the labour market
- The evaluation system concentrates on theoretical rather than practical aspects.

It is therefore concluded that VET within the GVTCs does not play an effective role in meeting labour market requirements.

4.2 Theme 2: Identifying the motivational drivers to engage in VET programmes

The qualitative findings reveal two types of motivational drivers:

a. ***Negative motivational drivers,*** which are reported by the majority of top, senior management, VET officials, trainers, government and private employers. For example, lack of ambition for future education, financial incentives to join programmes, and a gap filling experience work.

b. ***Positive motivational drivers,*** which are revealed by trainees and graduates. For instance, personal and family desire to learn, the chance to continue technical education, obtaining a job immediately after graduation, establishing their own business, developing their own knowledge and skills and improving personal profiles.

4.3 Theme 3: Investigating the engagement of VET stakeholders in developing graduate employability

a. Significance of graduate employability to VET programmes

The majority of VET stakeholders confirm that the ongoing improvement of employability within VET programmes may assist trainees to strengthen their personal abilities and skills, evaluate their own occupations which will enable them to identify the main problems within the work market, and finally to apply theoretical concepts for the benefits of the jobs they undertake.

b. Effective engagement in graduate employability

The majority of VET stakeholders support the idea of crediting the employability and VET quality equally and believe that each serves as an indicator of the other. They consider it important to engage all stakeholders in developing GE, which will lead to improvement in VET programmes. They agree that there is a lack of engagement in GE.

c. Promoting the relevant skills requirements for the labour market

This research reveals that the majority of respondents tend to agree on the need to develop a particular package of employability skills in VET programmes. They agree with the significance of key skills, intellectual skills, career management skills, self-sufficiency skills, and personal attributes in terms of their relation to the issue of GE. These are believed to be more important than other types of skill such as awareness of national and international issues, and awareness of religious beliefs and values.

4.4 Theme 4: Analysing the factors influencing the development of VET in terms of GE

Different factors are seen to affect VET, thereby creating various perceptions of VET programmes, which differ according to the background of participants, and their level of experience. The participants believe these factors can be categorised as:

a. Social and cultural

b. Educational

c. Economical and financial

5. Summary and conclusions

This paper described the role of VET in developed countries, deriving the measures that influence its effective implementation, through definitions of four main themes. These themes were used to guide the main enquiry in this paper in order define; the role of VET programmes in meeting labour market requirements, the motivational drivers for engaging in VET, the effective engagement of VET stakeholders in developing GE, and the factors influencing the development of VET of VET programmes. The findings of the qualitative methods employed to identify that challenges facing the implementation of VET programmes in the GVTCs in Oman, suggest a need for a radical change in the Omani VET programmes to address employability skills in order to meet the needs of the labour market requirements.

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