
Understanding the Construction Business and Companies in the New Millennium

Kalle Kähkönen & Martin Sexton

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Construction through Innovation Series

Understanding the Construction Business and Companies in the New Millennium

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Preface

The new millennium is producing, confirming and extending complex, systemic challenges for the built environment and the construction industry. The profound demands of sustainable development and globalisation are but two examples of changes which are transforming the strategic intent and operational activity of nations and companies. These challenges are demanding a thorough review of the assumptions on which competition and performance have been traditionally based.

The organisation and management of construction is moving toward a model founded on intense, more open, interaction between parties. Performance and competitiveness is being reconceptualised and operationalised through a systems paradigm; be it the organisational unit (for example, regional innovation systems, global alliances and partnering arrangements); the procurement regime (for example, PFI or PPP); or production (for example, off-site manufacturing). It is no longer credible to operate in a closed, linear way. The era of compartmentalised contributions from different construction actors is vanishing and, in its wake, new opportunities are opening up through greater transparency and closer collaboration and cooperation.

This volume articulates the current landscape, identifying new trajectories and pressures facing construction and construction companies, and the new management concepts and tools which are shaping, and responding to, this dynamism of the new millennium. The volume is structured into six sections: characteristics and performance of modern construction business; shaping companies with new managerial solutions; organisational studies and innovations; human resource management; means for improved competitiveness; and, industrialization in construction. Each section provides a survey of current and future issues and, perhaps more importantly, a stimulus to provoke us to evaluate our own thinking and own research, and to envision novel, appropriate futures which address the pressing challenges of this new, exciting, but uncertain millennium.

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Section I

Characteristics and
Performance of Modern
Construction Business

Design and Implementation of Performance Measurement Systems for Benchmarking in the Construction Industry

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Abstract

Performance measurement is an essential element of business management. It provides the necessary information for process control, and makes it possible to establish challenging and feasible goals. It is also necessary to support the implementation of business strategies. The effective implementation of performance measurement systems is not simply a matter of selecting the right measures, but it also implies a much deeper change in decision-making and also in the learning approaches adopted in the organization. In the last few years, there have been some initiatives concerned the establishment of performance measurement systems for benchmarking in different countries. The objective of this paper is to describe the scope of those initiatives and discuss its potential role for benchmarking construction companies, specially those involved in the design and implementation of new operations management ideas. This investigation is focussed on four initiatives, carried out in Brazil, Chile, the UK and the USA. The paper concludes by proposing some further directions on this research topic.

Keywords: Performance measurement, benchmarking, construction industry

1. Introduction

Despite the importance of performance measurement, it has not been widely implemented in construction companies and information on the performance of the construction industry as a whole is also scarce. The lack of performance measurement is still a problem that affects the construction industry in general. This is related to a great extent to the attitude and lack of training of managers [1]. In fact, several companies measure and control a wide range of project

variables, but only a few have performance measurement systems that provide key information for supporting decision-making [2].

Moreover, some companies have too many measures, most of them related to supporting rather than critical processes [3]. This tends to make it difficult for the company staff to understand what should be the priority and also to define the key indicators that should be used for comparison to other companies [4].

Performance measurement must shift from the traditional historical orientation, which looks only at the results and their main causes. Instead, the causes of the desired performance must be identified beforehand and then the measurement and control process that maintain these causes within prescribed limits can be designed [5]. This new focus is concerned with identifying goals and linking them to the critical factors required to achieve them.

However, the effective implementation of performance measurement systems is not simply a matter of selecting the right measures, but it also implies a much deeper change in decision-making and also in the learning approaches adopted in the organization.

An important role of performance measurement is to enable the company to do benchmarking. Benchmarking is a systematic process of investigation and learning of the performance against other similar organisations in key business activities. Then, lessons learned from the best practices should be used to establish improvement targets and to promote changes in the organization [6,7]. Benchmarking must be an integral part of the planning and on-going review process to ensure a focus on the external environment as well as to strengthen the use of factual information in developing plans [8].

The greatest benefits of the benchmarking process is the way that work gets done, rather than results, and the involvement of managers in the process [9]. Besides, it is used to improve performance by understanding the methods and practices required to achieve higher performance levels [8]. The general purpose of benchmarking is to encourage continuous learning for both managers and organisations, being used as an assessment tool [7]. Garvin [9] argues that the benchmarking process can promote a fertile source of ideas, but it only will occur in a receptive environment.

This environment can be created through Benchmarking Clubs, which involves a set of similar companies aiming to compare results and share practices. One of the propositions is that the benchmarking clubs have some similarities to communities of practices, which are groups of people who share a concern, a set of problems, or a passion about a topic, and who deepen their knowledge and expertise in a specific area by interacting on an ongoing basis [10].

The communities of practice are one mechanism, which involves the process of “Legitimate Peripheral Participation” [11]. This learning approach is broader than simply “learning by doing” or experiential learning, being also known “Situated Learning” [12]. According to Brown et al. [12], what the people pick up is a product of the ambient culture rather than of explicit teaching,

and this is called “process of enculturation”. For these authors, learning and acting are interestingly indistinct, learning being a continuous, life-long process resulting from acting situations.

In recent years, there have been some initiatives concerned with the establishment of performance measurement systems for benchmarking in different countries, such as Australia, Brazil [13], Chile [2], Denmark, the UK [6] and the USA [14]. Such initiatives typically aim to (a) offer some guidance for performance measurement, (b) provide some benchmarks that could be used by individual companies to establish their business goals and objectives, and (c) identify and disseminate best practices in the industry.

The aim of this paper is to raise some key issues related to the use of performance measures for benchmarking in the construction industry, and identify some key factors on the effective design and implementation of such performance measurement systems.

2. Initiatives of PMS for Benchmarking in the Construction Industry

Four initiatives were investigated: (a) KPI - Key Performance Indicators from the UK; (b) National Benchmarking System for the Chilean Construction Industry; (c) Construction Industry Institute Benchmarking and Metrics from the United States of America; and (d) Performance Measurement for Benchmarking in the Brazilian Construction Industry. Information about those initiatives was obtained in their web sites, from published papers, and also from interviews carried out with people involved in their implementation.

2.1 Key Performance Indicators (KPI) in the United Kingdom

The KPI Programme was launched by the UK Best Practice Programme in 1998. This programme is supported by the government, through national and regional offices. Recently the Constructing Excellence body was created, which is the amalgamation of Rethinking Construction and the Construction Best Practice Programme (CBPP). The Construction Excellence aims to achieve a step change in construction productivity by tackling the market failures in the sector and selling the business case for continuous improvement [15].

Four integrated programmes were created aiming to achieve the delivery of Constructing Excellence’ strategic objectives: (a) **innovation**, which aims to identify and promote tomorrow’s best practices; (b) **productivity**, which aims to improve the competitiveness of the UK construction industry; (c) **best practice knowledge**, which aims to create continuous improvement through the exchange of best practice; and (d) **engagement**, which aims to work with people, businesses and organisations to change the culture of the industry. These programmes are complementary and in each one there is a set of integrated programmes activities [15].

Nowadays the Key Performance Indicator (KPI) makes part of the Productivity Programme. The first set of KPIs was produced in November 2000, and the current set of KPI is based upon projects completed in 2002 [16]. The design of the first set of KPI was the result of an initiative involving extensive reviews by a panel of experts and the publication of a report. The set of KPIs is annually updated by the Construction Best Practice Programme [15].

For the implementation of the KPIs, companies receive a support handbook and guidance for measurement and access to an online software. The companies are responsible for collecting data, introducing them in the database, and for updating the project data. This software supports the analysis of the project performance in relation to the benchmarks. The companies involved can also access reports and wall charts, which contain graphs of performance (ranking curve and radar chart) for 10 key issues for construction such as client satisfaction, cost and time. The wall charts show the benchmark scores and allow an organisation's score to be benchmarked against a large sample across industry.

A few hundred companies have been participating in Best Practice Knowledge Programme, on a voluntary basis for demonstrations projects. The companies present their projects, which are reviewed by a panel of experts. Two main reasons have encouraged these companies to enter the KPI programme: marketing of the company and the opportunity to improve their performance.

The companies involved can participate in a Benchmarking Club and are given access to information from all main Benchmarking initiatives, clubs and organisations that provide services to the construction industry [15]. Each Benchmarking Club is a forum for individuals to learn about the principles of best practices, while creating a culture and a local support network for supporting continuous improvement. The Clubs are local services, and each new Club is started by the drive and vision of a person or persons in the local construction industry [15].

2.2 National Benchmarking System for the Chilean Construction Industry

The National Benchmarking System was developed by the Corporation for Technical Development (CDT) of the Chilean Chamber of Construction, with the support of the Program for Excellence in Production Management of the Pontificia Universidad Católica de Chile (GEPUC). This initiative started in 2001. By comparing key performance indicators, the CDT hopes to identify best practices and generate short-term improvement opportunities for participating companies [2].

The selection of performance indicators was based on previous studies that included an extensive literature review and empirical research [17,18]. Initially, there were over 30 performance indicators that were analysed in several meetings involving company representatives. The indicators were later prioritised by the participants in a seminar with the purpose of reducing the number of indicators, based on the experience and needs of the companies. The aim of this

initiative was to use this set of indicators to promote continuous improvement and benchmarking between companies [19].

The set of indicators is concerned with five sub-sectors of the Construction Industry: (a) high-rise building; (b) low-rise building; (c) civil works; (d) heavy industrial construction; (e) light industrial construction. For each sub sector, four main indicators were collected and analysed. By 2001, the National Benchmarking System of Chile had in its data base 120 projects provided by 22 Chilean companies. All companies are members of the Chilean Chamber of Construction and they have committed themselves to keep using the performance measurement system until the end of the project [2].

For the implementation of these indicators, the companies involved received a support guidebook and had access to computer software, which enables comparisons to be performed [2]. The National Benchmarking System use both quantitative and qualitative tools for data analysis, such as: (a) mean; (b) ranking curves; (c) radar graph and (d) tables displaying companies result. Also, a correlation analysis is carried out on the data using Pearson's correlation, factor analysis and multivariate linear regressions [2; 20].

An evaluation system for managerial practices has been recently developed as an additional part of the Benchmarking initiative [20]. This system seeks to incorporate qualitative data to complement quantitative performance indicators. It compares managerial practices, identify relationships between performance data and determine industry trends.

2.3 Construction Industry Institute Benchmarking and Metrics

The CII Benchmarking and Metrics Programme started in 1993 [14]. It aims to provide performance norms to the industry, to quantify the use and value of best practices, and to help focussing CII research and implementation efforts. A committee of industry representatives working with the CII staff has developed its policy and is in charge of overseeing the execution of the program. This committee has defined critical performance measures that can be used in practice and developed a strategic approach to CII's collection, analysis, and dissemination of industry data. The Benchmarking and Metrics Committee meets on a regular basis for continuous development and improvement of the program [21].

The first data collection of CII Benchmarking and Metrics was in 1996 and the current set of indicators was established in the fifth review, in 2000 [14]. The CII Benchmarking and Metrics program collects the project data as an ongoing process through its website. The web site has an easy-to-use interface and is designed to collect data over the life of a project [21]. Participants receive real-time evaluation on their projects' performance using the web-based Progress Key Report.

Besides the web site and guides to support the implementation of the system, this program provides annual training to the Benchmarking and Metrics Programme company members,

aiming to improve the reliability of the benchmarking process [21]. The system is also used to analyse the impact of CII Best Practices on projects, but there is limited analysis or correlations on the management practices that might lead to improved project performance.

In January 2003, CII's benchmarking database had over 1100 projects from more than 70 CII owner and contractor companies, 11 ECI (European Construction Institute) companies and 4 BMPPs (Benchmarking Participants). This represents \$55 billion in total construction cost. The projects are from the heavy industrial, building, light industrial, and infrastructure industry groups, with the majority representing heavy industry [21].

2.4 Performance Measurement System for Benchmarking in the Brazilian Construction Industry (SISIND-NET Project)

The SISIND-NET Project is a fairly recent initiative, initiated in April 2004, that has been developed by the Building Innovation Research Unit of the Federal University of Rio Grande do Sul (NORIE/UFRGS) and the Association of Construction Companies from the State of Rio Grande do Sul (SINDUSCON/RS), with the support of the National Council for Scientific and Technological Development. It involves the design and implementation of a performance measurement system for benchmarking in construction companies from the State of Rio Grande do Sul. Its aims are: (a) devise a web-site for collecting and disseminating data, including a web based tutorial that can be used for training; (b) create a learning environment that will enable companies to share both qualitative and quantitative information related to their performance and best practices; and (c) promote workshops and training courses in different places in Brazil, aiming to disseminate and implement the set of measures.

The first stage of the SISIND-NET Project was the definition of the set of measures for benchmarking, based on the international experiences [14, 6, 2] and past studies in Brazil [22, 23]. Four criteria were considered in the definition of measures: (a) previous use of the measures by companies; (b) possibility of performing external comparison; (c) generic measure enabling the application in different projects context; and (d) mix of leading and lagging indicators. Several meetings involving both representatives of the companies and members of the research team were carried out for defining the set of measures. In each meeting a sub-set of measures was discussed, including their objectives, formulae, and data collection and analysis procedures. The final version of the set of measures was defined in the end of August 2004.

So far, eighteen construction companies from the State of Rio Grande do Sul have been involved in this initiative, most of them from the residential, commercial and industrial building markets, establishing the first Benchmarking Club in Brazil. A training course was provided for the companies' staff involved in the implementation of performance measurement in the companies. In October 2004, the implementation process was started and the data began to be sent to the database by the companies. Currently, the companies are starting to share results and practices in the Benchmarking Club, through monthly meetings. A web-based online tool for entering and processing data will be available for companies until March 2005.

One important result of this initiative is the participative process that has taken place in the Benchmarking Club. Through the meetings, the companies have participated in decisions concerning the choice and definition of measures, including the negotiation of data collecting criteria. As a consequence, the representatives of the companies involved understand well the set of measures and now they are aware concerning the relevance of each measure for them. This is an improvement in relation to similar initiatives carried out in Brazil.

As a consequence, the preliminary assessment of the involvement of the companies in the SISIND-NET Project indicates that they perceive this as a favourable environment to introduce and internalise the use of performance measurement. This process has motivated the systematic data analysis, due to the companies' interest of comparing performance and sharing practices with other companies in the same and different sectors.

In the following stages of this project, the research team intends to explore the learning opportunities provided by this initiative. This will be made by understanding the learning processes that is going on in the Benchmarking Club and also by the transfer of knowledge in a small group of construction companies. One of the main propositions of this study is that the process of learning of the Benchmarking Clubs can be motivated by using concepts of communities of practices, since it involves collective or collaborative learning in an informal manner. The potential of the Benchmarking Club for triggering managers' knowledge as well as for promoting organizational learning will be investigated.

3. Lessons learned from the benchmarking initiatives

Based on the experiences of benchmarking initiatives in UK, Chile, USA, and Brazil some key issues for the design and implementation of benchmarking systems were identified. Firstly, this kind of initiative demands a joint effort from several organisations, such as government, construction clients, individual companies, research institutions, and industry organisations. In the construction industry there are a number of barriers, due to its peculiarities, such as (a) construction is a project-oriented industry, each project is unique in terms of design and site conditions; (b) establishing a project performance measurement system and incorporating the measures into the company routine require a fairly intense effort; (c) the responsibilities for data collection, processing and analysis, in general, are not well defined at the beginning of the project; (d) each project usually has a different managerial team and the use of measures will depend on the capabilities and motivation of each manager [3].

In general, the set of measures for benchmarking should be simple and well designed in order to effectively support improvement initiatives. The set of measures must give a holistic, company-wide view including a mixture of leading and lagging indicators [24]. Table 1 summarizes the main set of performance measures adopted in each of the four initiatives. Although all sets involve a wide range of measures, some of them are common among the programmes, such as cost, time and safety. This suggests that such initiatives could be potentially involved in some kind of international benchmarking scheme.

As it is shown in table 1, the KPI and CDT programmes mostly involve lagging measures, based on outcomes. Such measures are important for accessing the success of strategies, but do not support the identification of improvement opportunities during the period for which the measure has been taken [24]. By contrast, the design of CII and SISIND-Net benchmarking systems includes a set of performance measures that can be used during the whole life of the project.

No measures related to suppliers' performance, employee satisfaction, site management, and quality management were found in CII, CDT and KPI initiatives. As these were considered to be of major importance for the Brazilian companies they were included in the SISIND-NET initiative.

The procedures for data collection should be also simple, aiming to facilitate the creation of the database and to make it simple to evaluate the project performance in relation to other projects in real-time. The four initiatives (KPI, CDT; CII and Sisind-Net) offer an interactive online tool for the collection and evaluation of the benchmarking measures. Such a tool allows the user to access an assortment of documents and provides immediate feedback for the Benchmarking Club members. Beatham et al. [24] suggest that the online tool must be used throughout the whole life of a project, in order to create continuous opportunities to analyse the results and to promote improvements. Another key issue of the implementation of the online benchmarking process is data confidentiality and security.

One aspect that has not been sufficiently explored by any of the initiatives is the alignment of the benchmarking measures to the company strategy. Therefore, Benchmarking Club members should be encouraged to design their own performance measurement system according to their strategy and capabilities, making sure that the set of measures is relevant and feasible for them. According to Hudson et al. [25], a strategic performance measurement system for small sized companies must be very resource effective and produce notable short-term results. In addition, it must be dynamic and flexible enough to accommodate strategic changes, which tend to be more frequent in small sized companies, which tend to have emerging strategies. For those authors, in practical terms, this means that the process should be iterative, in order to maintain the strategic relevance of performance measurement.

Table 1 – Comparison among the Benchmarking Initiatives (UK, Chile and USA)

Criteria		KPI (United Kingdom)	CDT (Chile)	CII Benchmarking & Metrics (USA)	SISIND-NET (Brazil)
Scope of measures	Lagging measures	Client satisfaction* Defects* Predictability cost* Predictability time* Profitability Safety Productivity*	Deviation of Cost by Project* Deviation of Construction Due Date* Change in Amount Contracted Rate of Subcontract Cost Client Complaints Efficiency of Direct Labour Accident Rate* Risk Rate*	Project Cost Growth Project Budget Factor Project Schedule Growth Project Schedule Factor Total Project Duration Change Cost Factor Recordable Incident Rate (RIR) Lost workday Case Incident Rate (LWCIR)	Cost Deviation* Time Deviation* Degree of Client Satisfaction (user) Degree of Client Satisfaction (owner) Average Time for Selling Units Contracting Index Ratio between the number of accidents and total man-hour input Index Non-Conformity Index in the unit delivery
	Leading measures		Effectiveness of Planning Urgent Orders Productivity Performance*	Total Field Rework Factor Phase Cost Factor Phase Cost Growth (owner data only) Phase Duration Factor Construction Phase Duration	PPC (Percentage of Plan Completed) Construction Site Best Practice Supplier performance (Sub contracted, material and design) Number of Non-Conformity in audit Degree of employee Satisfaction Training Index
Implementation	Positive issues	Online software for users Benchmarking Club	Online software for users Outlined system (qualitative analysis)	Online software for users Annual training Annual questionnaire for companies evaluation	Online software for users (in development) Benchmarking Club
	Difficulties	Availability of data and validity of data Do not offer opportunities for real time control	Commitment of companies Measures Standardisation Continuous measurement Keeping the project team	Commitment of the companies Implementation of improvement process based on the findings from the benchmarking program	Commitment of companies Continuous measurement
Note: * measures that could be used if measured during the process					

In terms of effectiveness, the KPI initiative in the UK is the only one that has been critically analysed in the literature, and the following difficulties have been pointed out:

- The KPIs are specific to projects and offer very little indication of the performance of the organisations themselves from a business point of view, apart from the customer perspective [26];
- It is important not only to use the right measures to measure the right things, but also to show the relationships between the different measures from a holistic viewpoint, since this is a way of identifying potential mechanisms for improvement [26];
- In general, the main difficulties in the whole process of the KPI programme are concerned to the availability of data and their validity [26];
- The most significant problem with the KPIs (in their current format) was that they do not offer opportunities for real time control. They are mostly designed to be used as post-result lagging KPIs. This kind of indicator is used only as a historic review [24].

Several companies in the benchmarking initiatives find difficult to start the implementation of measures, partly due to the lack of involvement of workers. Alarcón et al. [19] suggest that the implementation should start gradually with a small set of performance indicators that are relatively easy to measure. This might facilitate the development of a measurement culture within the organisation, which will facilitate future implementation, and then focus on critical processes.

The investigation of the four programmes indicated that some construction companies involved in those initiatives still have a limited view of benchmarking. They are simply interested in comparing their performance to other companies, especially from the same market segment. Such companies should see benchmarking as a source of new ideas, or a route to support performance improvement based on observed best practices. The information provided by benchmarking initiatives should enable a better understanding of the workings of business (their own or their competitors'), leading to improvement actions, instead of only being used for data comparison. Therefore, it is also important to promote training for the companies involved, including the communication of results, analysis of the evolution of the set of indicators, and encourage the exchange of practices and the creation of knowledge in Benchmarking Clubs.

4. Final Comments

This article has presented a brief description concerning the current stage of performance measurement systems for benchmarking that have been devised in four different countries (UK, Chile, USA and Brazil). The commonalities among these initiatives indicate that they potentially could be used for international benchmarking.

However, the social-economics realities and the construction sector environment among the four countries are different. Chile and Brazil have some similarities, which can promote good opportunities for sharing findings and best practices. These countries are characterised by the high number of small construction companies, large demand flotation, mainly in the housing-building sector and a very large informal market. In general, the companies in UK and USA tend

to be larger and the construction sector is better organised. Then, the impact of these four initiatives in terms of supporting learning processes must be investigated taking into account differences in the cultural and social context.

This paper has pointed out some of the benefits, problems and limitations of the existing systems. The lessons learned should be used for upgrading the existing initiatives and devising new ones. A joint effort involving several organizations is necessary for the successful design and implementation of performance measurement benchmarking programs. Such initiatives should not be limited to data collection, but also provide data analysis and training, as well as enable the exchange of best practices among the companies. Moreover, the set of measures should be assessed and revised periodically, according to the needs of the companies involved.

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The effect of procurement on the integration of the supply chain within the construction industry

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Abstract

As time goes by, more and more companies within construction industry are moving away from traditional procurement route towards innovative procurement methods. In the UK, partnering framework, prime contracting, PFI or PPP, etc. are some examples of procuring the construction work differently than it used to be in the past years. One of the key elements in all these procurement methods is the management of the supply chain. Key questions discussed around this area are how to make partnering and other methods successful; how to select and appoint suppliers; how to manage the integrated supply chain; how to build trust; who will lead the whole process; etc. This paper will look into the different questions mentioned above by explaining the basic rules of supply chain integration including: understanding the brief; understanding the whole process of construction by each trader involved; early involvement of suppliers and sub-contractors; effective management and leadership for integrated supply chain; effective communication and feedback on performance; etc. This paper will define supply chain integration within the construction industry and incorporate some findings from of an industrial case study on above issues discussed with emphasis of the effect of the adopted procurement method on the integration of the supply chain. The paper is part of the Supply Chain Integration Project undertaken by researchers of the SCRI Research Centre at the University of Salford.

Keywords: supply chain integration, construction clients, procurement, power, roles.

1. Introduction

If we look at, generally, why there are many initiatives to improve the performance of the construction industry; a few responses are obvious. The most obvious one is the bad reputation of construction industry for not delivering the projects: in time, within budget, and with desired quality. On the other hand, these initiatives for change are somewhat responses to gain the confidence of dissatisfied client/customers/end users. What does the client want, has also become

an area of research on its own, identifying the requirements and needs of the clients, specific to a project and overall from the construction activities, which includes: reduction in cost; improvements in profits; expenditure is kept within the budget limits; achievement of sustainable outcomes; predictability of construction programme, price, and quality; faster delivery than the competitors; development of a safe environment; etc. In reality, the above-mentioned client's wants are the aim and objectives (and if not then should be the aim and objectives) for all the participants involved in a construction project supply chain. But, on the other hand, these objectives cannot be realised if involved participants do not do any efforts to achieve them. And one of the ways to accomplish and get succeeded is to adopt integration and collaborative values and behaviour (mentioned here) as advocated by the research team here at Salford [1], and also by others within the construction industry such as Collaborative Working Centre of *be* (www.cwcltd.biz): FUSION; Fairness, Unity, Seamless, Initiative, Openness, and No blame. This paper will look into what sort of changes the new procurement methods and relevant initiatives have brought and are bringing within the construction industry with respect to achieving integration and collaboration within the involved organisations in the supply chain.

2. Supply chain integration through procurement

It is evident that the construction industry is becoming increasingly aware of the necessity to change current working practices and the attitudes they represent. Similarly, a number of organisations and individuals within the construction industry are already moving towards supply chain management through the use of partnering, framework agreements and techniques to rationalise their supplier base [2].

Hall et al. [3] advocate that the one of the enablers of supply chain integration is the chosen procurement route (which could be either PFI, partnering, or design-build-finance-operate). This is because it provides the formal links within which supply chain integration is attained and sustained. In their view, any consideration of any formal contractual terms is not only a legal tie but also a way in which knowledge and activity flow between organisations involved within a construction project. Akintoye et al. [4] support the above discussion by saying that when SCM in construction is adopted along with partnering and TQM concepts, it would successfully address the major current problems faced by construction industry overall and its clients specifically. Benheim and Birchall [5] also consider new procurement methods as a tool to integrate the construction supply chain, because it provides openness, trust, cooperation, harmony of decisions, sharing of benefits, intangible and long term investment, collective working routine, and a fair allocation of risk.

More than ten years have now passed since the publication of Sir Michael Latham's report 'Constructing the Team' [6] and seven years since 'Rethinking Construction' [7]. Many organisations have taken up the challenge to introduce new procurement initiatives such as Partnering into their organisations. There have been varying degrees of success and failure. There is also an opportunity to gain from this experience by capturing the lessons learned to avoid

duplicating mistakes and allowing organisations to replicate success. The objectives of involved organisations should be to:

- Prepare themselves for the change in culture;
- Learn from examples what goes right and how it could go wrong;
- Define the key elements of new procurement initiatives;
- Get the right people involved to define objectives;
- Design a fair and auditable procurement process, and last but not the least is;
- Be equipped to set up effective cost controls.

There are other issues, which the organisations involved should take care, including:

- Will these new procurement initiatives work for the organisation?
- What things go right and how it could go wrong?
- When things go wrong, how to correct them?

Every organisation will have unique wants and needs in making the effort to implement the initiatives. There is a clear need for:

- An understanding of best practice in procurement methods;
- A process for applying EU procurement rules to meet legal requirements and still get what you want;
- Designing a best value evaluation model;
- Setting up effective controls and managing budget with open book accounting; this may include questions such as Why is an open book approach important? What are the key elements of implementing and operating financial controls? And How to get what an organisation wants and making it work?
- Developing relational capabilities and leadership skills as an organisation and among individuals in the organisation, beyond the level related to traditional procurement.

3. Construction clients' role and power in integration

Clients have played a central role in construction, and has been studied since long time [8], including with regards to supply chain integration [9]. Some authors have criticised and called for change in clients' procurement strategies and tendering procedures [10, 11]. Briscoe et al. [12] argue that clients have a critical role for integration of the supply chain because it is the client that makes the initial decision to procure construction works and the way in which procurement takes place. This, in turn, influences the degree of supply chain integration and ultimately the overall success of the project. Therefore, they concluded that the client is the most significant factor in the success of supply chain integration through adoption of new procurement routes and the client must develop practices that facilitate such integration if the construction process is to be improved. Another conclusion, which they drew, was if the long-term relationships in the supply chain are to be nurtured. Changes in the client's traditional approach will often be necessary and a clear change programme will need to be established specially in the realm of procurement to turn from adversaries into partners [13].

London and Kenley [14] also concluded the similar statements from their research by stating that clients can impact on construction supply chain and their organisations, through the initial procurement decision and demand system. The client firms need to understand their supply chain, their own role in proactive management of a project supply chain, and the importance of new procurement initiatives. They also argue that often being the initiators of the supply chain, client firms have integral part within the whole chain and they potentially can have the greatest impact on the supply chain through their procurement decisions. From this position clients can exercise their authority upon the supply chain to achieve better value [15]. Clients also need to understand that these new procurement initiatives have potential to result in:

- Flexible and adaptable facilities;
- Maximise use of what they've already got;
- Start immediately, move fast and finish early;
- Minimise capital cost;
- Minimise whole life cost;
- Greater predictability;
- Think long term against short term pressures;
- Committed and involved supply chain participants.

3.1 Typology of construction clients

But now we should ask a question: are all clients ready to take up this role? According to Cox and Ireland [16], the majority of clients within the construction industry are not in a position of dominance over the supply chain because of the nature of their ad-hoc construction profile combined with their misunderstanding of the marketplace. Only the regular clients are in the better position to be able to leverage the supply chain effectively and implement integrated supply chain management concept successfully through introducing new procurement strategies such as partnering, strategic alliances etc.

First the possibilities and extent to develop supply chain integration from a client perspective depend on the specific construction sector. In some sectors, clients have a position that enables them to take up supply chain integration, and in some sectors not, for instance:

- Housing: Clients are customer, and do normally have no influence on the supply chain;
- Commercial building: Clients are operator and/or co-developer of buildings, and thus can play an active role in the supply chain if they want;
- Infrastructure: Clients are service providers to the public, and often has extensive influence on these services and on other service providers, so this kind of clients is often able to exercise considerable authority upon the supply chain.

Second the possibilities and extent to develop supply chain integration depend on the characteristics of a client, including:

- Buildings portfolio owner or single building owner;
- Experienced client or not;
- Professional client or not;
- Institutional or individual client;
- Public or private organisation;
- Local or international organisation.

3.2 Factors influencing construction clients' roles and power

In addition to the type and position of clients within the construction sector they are in, various external factors are affecting clients' roles and power vis-à-vis their supply chains, including size of the suppliers market, global or local suppliers market, influence of regulations on clients

(public or private), and market share of the client, e.g. large clients dominating other smaller clients in particular client markets, having major influence on suppliers, and thus the ability to exercise power on suppliers.

Based on the above notions, including the type of sector and clients, and external factors, clients that are able to play a dominant role can exercise power upon the supply chain, and develop procurement strategy aimed at supply chain integration. In this paper, such a client is observed to play a dominant role and enforce integration upon the supply chain; or even mobilise own integrated supply chain, e.g. through framework agreements with contractors, specialists, suppliers, architects, structural engineer etc., such as BAA's framework agreements.

4. Achieving effective integration through procurement

Proverbs and Holt [17] advocate that supply chain downstream (including principle contractor, subcontractors, material suppliers, etc.) should be targeted as a mean of effectively reduced overall construction costs. They refer it as 'downstream strategic alliances' (DSAs). They also advocate early involvement of subcontractors and suppliers in the similar manner as of early contractor involvement. This would give an opportunity to downstream participants to offer their expertise, which could result into potential cost savings. Such integration would come through introduction of new procurement policies and also help converting suppliers from providers of product to providers of services. Often such new procurement methods have a long-term strategic perspective and relational aspects to it [18, 19]. Many of these clients create multi-project environments implying multi-project procurement and repetitive tendering arrangements with contractors [20]. In this perspective contractors are observed as partners adding value to the client's business instead of merely doing projects for the client [21].

4.1 The 'aspirational' move

The historical or traditional procurement process (see Figure 1) was the only acceptable process in the construction industry until around a decade ago. The process had made a specific culture within the construction industry which contributed towards the inefficiency of the construction process overall. The reliance was only on the lowest cost tenders. Other concepts included were; designers should design, constructors construct, and maintainers maintain; no formal collaboration and no formal flow of information; a free market would drive efficiency; suppliers won't offer what they can't afford; etc. The big issue, which prevailed, was that winners of the project either misunderstand project, or make mistakes. The phrase that can best summaries the whole process could be 'You don't know what is excluded until too late!'

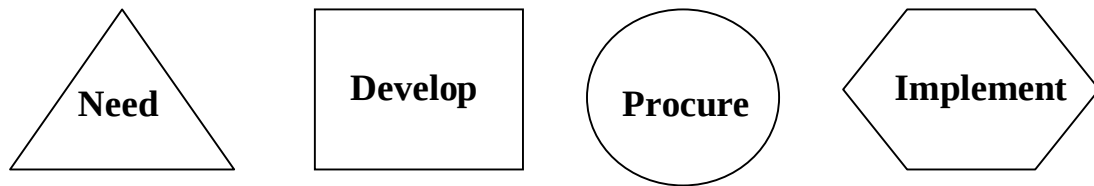


Figure 1: The Historic Procurement Process

Now here comes a period where new procurement processes are being initiated within an organisation and the process can be considered as a transitional process (see Figure 2). This process includes 2 Stage Selection/Tier 1 Partnering concepts. These concepts results in following:

- Implementers have early chance to understand needs of the client/customers;
- Designers and implementers can discuss options together, which could include Implementers providing “constructability”, critique; etc.

But there are still issues that prevent the process to be carried out in its full spirit. These include:

- People don’t share ideas within the project development team;
- Ongoing supplier relationships could be undermined while new initiatives are introduced
- Contractors’ supply chain is not involved at the outset of the project. In fact, the contractor does not have an integrated supply chain; etc.

In order to define how effective this process is, not much could be commented except ‘Good ideas undermined by lack of commitment’.

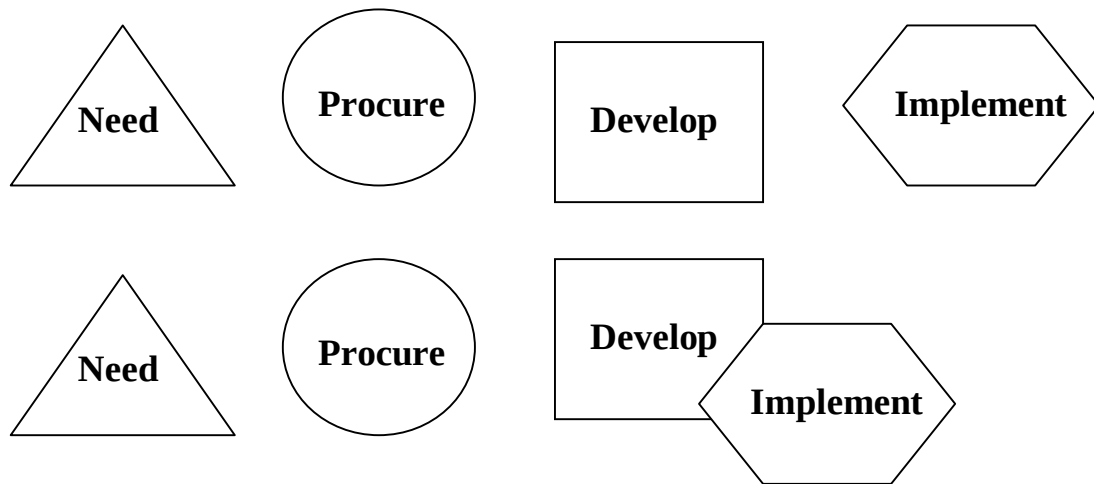


Figure 2: The Transitional Process

The most desirable next step is to move towards the aspirational process (see Figure 3), which is based on the whole concept of Integration and collaborative working within the whole supply chain. The concept propagates:

- Pre-selection and appointment of long term supply chains partners;
- Early formation of project teams - involvement and commitment of all principal partners at the outset of a project;
- Shared goals, objectives, and outcomes of all the supply chain partners; etc.

Since, the whole process is like a ‘culture shock’ for the construction industry, a few issues are

- No common understanding of these new procurement initiatives;
- People don’t realise how radical and different it is from the traditional and transitional processes;
- Requires faith and trust, leadership, awareness by client to positively and proactively exercise his/her authority in order to achieve the full benefits of the process; etc.

The bottom line is that only a small number of companies are ready and willing to take such process on board.

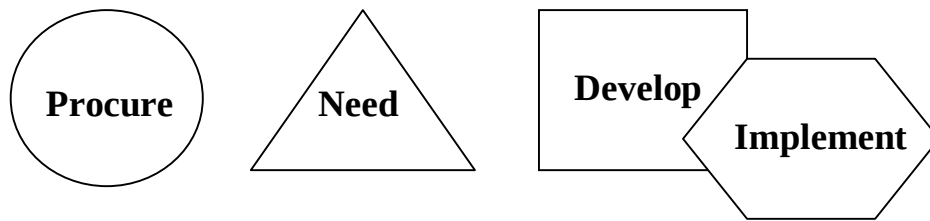


Figure 3: The Aspirational Process

4.2 The ‘real-world’ move

Various examples of strategic thinking and long-term structured action by clients in terms of their procurement policies and methods have shown positive effects on value and efficiency levels of construction work. In this paper the case of the integrated procurement of the upgrading of railway crossings in the Netherlands is presented as an example:

Around 2000 the Ministry of Transport, Public Works and Water Management took decision to increase safety of all railway crossings in the country dramatically, and reduce number of casualties to a minimum. This particularly applied to those crossings guarded without barriers, but only warning lights, particularly in rural areas. The decision implied that all 600 crossings without barriers throughout the country would need barriers within 10 years time. When the ministry was preparing the tender specificities of the crossings were discussed, general parts identified, and uniformity increased. In the tender one approach for all projects was defined based on a performance concept, which was standardised as much as possible. Criteria to bidders did apply to time and cost guarantees for delivery, and general specifications and safety conditions to the crossings only. Because of public building regulations, a solution was found to put the tender to the market by asking the complete market of contractors and suppliers for railway crossing for a bid, which came down to five certified firms. After discussion with all parties the entire project was assigned to the entire market. In order to keep the planned schedule and gains the condition was that the firms had to create a combined firm to execute the work. The firms did start a joint firm on one location with a single management. The work started in 2002, and still needed to be ready by 2010; implying the reconstruction of about 80 crossings per year. The Ministry had a fixed maximum annual budget. Payment was based on the actually delivered number of crossings per year. At the end of each year the progress was measured and evaluated against open book cost calculations followed by price negotiations. Due to the learning curve the first three years the number of crossings delivered rose from 40 to 80 to 120, and the cost efficiency gain amounted to 30% over three year, which was used for annual price reductions and moderate increase profits for firms.

In this particular case, by revising its procurement strategy, the client organisation did not only manage to integrate the supply chain and achieve the planned cost levels and additional efficiency

gains, but did actually integrate the complete suppliers market and all demand in this particular case on a national scale.

5. Discussion and conclusion

Green et al. [22] support the idea and make a concluding remark that ‘within the context of integrated procurement approaches in construction, the conditions of mutual dependency will prevail across integrated supply chains. This will provide a significant break with the rump of construction industry. Clients may benefit through a more integrated services. Integrated supply chains potentially stand to benefit by competing primarily on the basis of innovation and expertise rather than cost. Construction firms are currently investing in new skills and the development of integrated supply chains for the purpose of competitive positioning. However, such trends are highly dependent upon a continuous flow of work of this nature’. This kind of interdependent co-development of integrated supply chains by clients and contractors (and specialists, suppliers etc) who are more or less equally powerful and dependent on each other is one path of supply chain integration in which issues such as trust and partnering, and sustaining multi-project procurement and repetitive contracting play a major role to achieve supply chain integration. This path is largely reflecting what most previous authors have been arguing on this matter. However, besides this bilateral path of interdependent co-development towards supply chain integration, for certain construction sectors, unilateral paths towards supply chain integration must not be disregarded, such as in housing, where contractors teaming up with specialists and suppliers, or groups of specialists, or suppliers who also install pre-installed houses through supply chain integration business models. And from the client’s perspective, certain powerful clients develop their own supply chains without being dependent on existing supplying parties in the construction market. These differentiated views on development paths towards supply chain integration, including differentiated view on construction clients and construction sectors will lead to a more balanced and realistic view on and discussion about what supply chain integration in construction actually is and could be, and the role of new procurement initiatives in order to achieve the supply chain integration.

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The search for causes of dissatisfaction in the building industry

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Abstract

Rework and failure in the Dutch building industry can lead to dissatisfaction for involved parties. Literature and former research gives insight into preventing these problems based on a linear relation between cause and consequence. However, it can be questioned whether dissatisfaction for involved parties is caused by one aspect or one party only. This article describes a part of an ongoing research conducted to get insight into dissatisfaction. The article describes arbitration as a data source and describes a method to get insight into dissatisfaction using this data source. Temporary results show while parties have a legitimate claim for money or repair in a conflict it is often not a party being right *or* wrong but rather being right *and* wrong. A possible way to deal with multiple causes for problems is by acting and interacting of involved parties.

1. Introduction

In the Netherlands a substantial part of the building industry's turnover is lost due to deficiencies, rework and failure which can all lead to dissatisfaction for involved parties. In literature several authors search for relations between these problems in the building industry and what it might have caused. A linear relation is presumed between cause and consequence. Fenn et al. [1] state in their search for causes of disputes: "if it is possible to identify causal factors the construction industry's actors might seek to avoid or forestall them". Kumaraswamy and Chan [2] focus on productivity to develop counter-delay strategies. In their research lower productivity is identified as a key contributor to (or a root cause of) delays.

Although this former research gives insight into preventing problems based on a causal relation, it can be questioned whether dissatisfaction can be caused by one aspect or one party only. Possibly dissatisfaction is caused by a multiple-dimensional phenomenon existing of multiple causes which amplify each other. Handling this more dimensional phenomenon is possible through acting and interacting. Literature shows this organizing through continuously construction of meaning of parties involved. The organization is

not static and not fixed on beforehand but is continuously constructed through interaction. For example, Bouwen [3] states, based on social construct reasoning, that by focussing on the relational quality, new possibilities for conversations among parties can be created and new ways of intervening can be invented. Also according to Hosking and Morley [4] “Relational processes are considered to be instrumental to connect inputs to achieve outcomes. In contrast, when the relationship between person and context is seen as one of mutual creation, the concept of process is very different. This is because outputs cannot be reduced to the inputs of either actor or context, but rather are seen as the emergent product of their interrelation.”

The underlying research, in the Netherlands, is conducted to get insight into dissatisfaction in the building industry. The starting point of this research is the parties being actors in their process of demanding and supplying a construction product. Parties create their dissatisfaction during the building process. Although of course, it is not their goal, parties are unaware their acting and interacting leads to dissatisfaction. In this research the focus is to find causes for dissatisfaction and their inter-correlation whereby the acting and interacting of parties might be of large influence.

This article first describes the use and usefulness of arbitration jurisprudence as an information source. The exploring of arbitration data should give insight in the form of data possible to obtain from the information source and should confirm the researcher being not prejudiced when extracting information from the arbitration jurisprudence.

The article secondly describes a method to get insight into dissatisfaction in the Dutch construction industry using the arbitration jurisprudence. Using the method two different procedures are distinguished in discovering dissatisfaction based on the arbitration information source. The first procedure (A) focuses on finding correlations between arbitration variables which are not visible on beforehand. The second procedure (B) starts with presumptions of correlations between variables obtained from the arbitration information source. The presumptions are derived from literature or defined as a hypothesis. Of both the procedures an example is described and temporary results are shown.

2. Arbitration

The underlying research started as a survey research to get insight into dissatisfaction by using the knowledge of project participants. By means of interviews the insight was to be obtained. However, there was some scepticism whether accurate and sufficient information would be available. This scepticism is confirmed by the experience of Barber et al. [5]. Barber et al. describe the measuring of costs of quality failures and the hurdles they experienced when collecting data: “Records kept by the construction

company were inadequate for even just an analysis of failures, costs placed against rework were incomplete, it proved extremely difficult to obtain a reliable view of type and quantity of failures and relating costs from interviewees' perceptions, and filling in standard forms by company personnel proved also unsuccessful because they were already filling in too many forms and because the personnel did not have the necessary details." An information source which is easier to access and which contains more detailed information than a survey is possibly found in arbitration jurisprudence. The information source used in the underlying research is the jurisprudence of the Court of Arbitration for the building industry in the Netherlands [6]. The jurisprudence of Court of Arbitration for the building industry in the Netherlands is public available in the form of arbitration judgements.

Not all disputes originating from dissatisfaction will end up in arbitration. Possibly dissatisfaction in the construction industry is not completely represented by dissatisfaction in arbitration disputes. However, arbitration judgements show dissatisfaction in a drastic form, the intensity of dissatisfaction is that high parties conclude they themselves cannot settle the conflict and need a third party to settle the conflict, furthermore, they dare to take the risk of losing the dispute and pay additional costs. In Figure 1 the Dutch building industry as a set of transactions is shown. The transactions in which one party is, or both parties are, dissatisfied is shown as a subset. At this moment, it is not proven parties to be indeed dissatisfied when using arbitration; this is assumed and needs validation. Furthermore, possibly the arbitration cases are not entirely a subset of dissatisfaction but do have an overlap with the transactions in which one or both parties are satisfied in the Dutch building industry. This might be the case, for example, when both parties start an arbitration procedure entirely based on parties' policy.

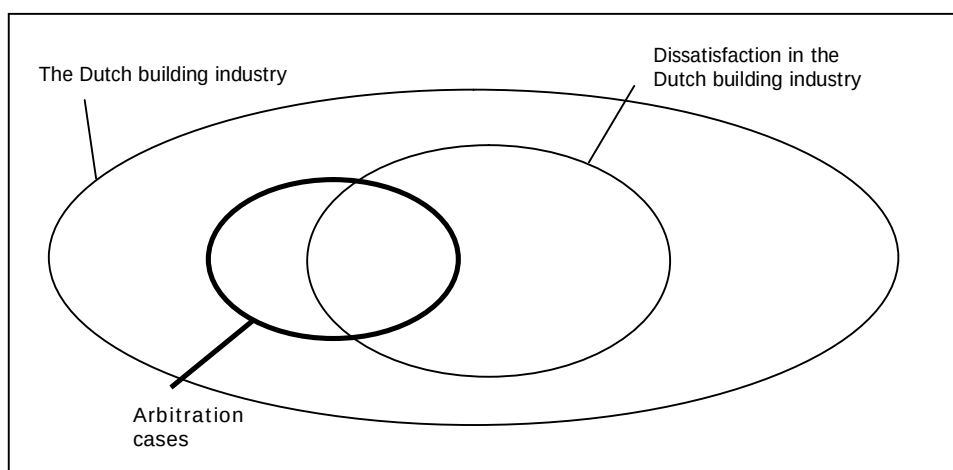


Figure 1. Arbitration cases in the Dutch construction industry

A phase in the underlying research is focussed on exploring arbitration data. In this phase two steps are distinguished. The first step in the phase establishes whether

dissatisfaction exists in the Dutch building industry and how the dissatisfaction is expressed in the arbitration judgements. The second step in the phase establishes whether the researcher is able to obtain information sufficiently independent of prejudice. The first step shows dissatisfaction, often of both parties, in the form of claims made by each of the parties. The arbitration judgements describe in general the following procedure. A party initiates the arbitration procedure with a demand existing of multiple claims. In the first phase of the procedure both parties have the opportunity to present claims and answer the claims made by the other party. Claims often exist of the claim made for an amount of money or rework/repair. Next, the arbitrator pronounces judgement existing of judging the party getting its' claim rewarded or rejected and a motivation of this pronounced judgement. The second step is based on the former findings and exists of asking cooperative readers to extract information from the arbitration judgements by answering questions. The co-readers were asked to read five arbitration cases and to note answers to the following questions: (a) "what does each of the parties claim from the other party?", (b) "is this claim rewarded by the arbitrator?", and (c) "how does the arbitrator motivate his pronounced judgement?". The answers of the co-readers were mutually compared and were compared to the answers noted by the researcher.

Results of the reading of arbitration cases by co-readers show mainly consistency in the answers of co-readers and the researcher. There is no significant incorrectness in reading the arbitration cases and answering the described questions (a) "what does each of the parties claim from the other party?", and (c) "how does the arbitrator motivate his pronounced judgement?". All readers note similar answers. However, answers to the question (b) "is the claim rewarded by the arbitrator?" were not consistent. Occasionally (but consistent throughout the five cases) claims were rewarded according to a reader and not rewarded according to another reader.

Based on the insight obtained from the reading of arbitration judgements the arbitration information shows two types of variables. The first type of variables (1) can have different values within an arbitration case; each variable is dependent on each of the parties' claims. These variables are shown in Table 1 in the left column. The second type of variables (2) can have different values within the sample, however, are constant within a single arbitration case; each variable is dependent on the building project. These variables are shown in Table 1 in the right column.

Table 1. Different variables in arbitration cases

Variables which differ within an arbitration case, and differ within the sample and population	Variables which are constant in an arbitration case, and differ within the sample and population
Claim of each party (demanding or supplying) in words	Initially claiming party
Claim of each party (demanding or supplying) as an amount of money	Does a party appeal against an arbitrator's decision?
Claim of each party (demanding or supplying) as a relative percentage of what is totally claimed by both parties	Contract price
Reward by the arbitrator, motivated in words	Type of contract
Reward by the arbitrator as an amount of money	Type of demanding party
Reward by the arbitrator as a relative percentage of what is totally rewarded by the arbitrator	Type of supplying party
Resulting dissatisfaction as an amount of money	Type of sector
Resulting dissatisfaction as a relative percentage of the total remaining dissatisfaction	Number of arbitrators
	Type of arbitrator
	Dates of contract/ delivery/ start of arbitration/ oral application/ verdict

Possibly, based on these variables the acting and interacting of parties can be observed. Furthermore, possibly dissatisfaction can be deduced from these variables. The following method is based on finding correlations between the variables as observed.

3. The method

The method used in the underlying research exists of two procedures. The first procedure (A), starts with a empty mind, empty of presumptions of dissatisfaction manifesting itself in a certain way. The goal of this procedure is to find correlations between variables which are not visible on beforehand. This procedure is based on statistical analysis. The second procedure (B), starts with presumptions of correlations between variables. The presumptions are derived from literature or defined as a hypothesis. An example of the latter procedure is the presumption the demanding party not being able to get its claim rewarded; and ends up being still the most dissatisfied compared with the supplying party. Van Bladel [7]. Describes two different kinds of parties based on Galanter's difference between 'one-shotters' and 'repeat-players'. According to van Bladel private demanding parties are 'one-shotters' because they use arbitration only once and supplying parties are 'repeat-players' because they more often use arbitration. Subsequent a correlation must exist between the claiming party (demanding or supplying) and the claim and reward. Of both procedures an example of temporary results is shown in the next paragraph.

4. Temporary results

Based on the two described procedures the following temporary results can be found. A first temporary result of discovering the claiming by parties and the rewarding by the arbitrator shows a variation of different claims. The different claims are shown in Table 2. A percentage is given of how often a claim is made for what reason.

A second emerging result is the fact that a party can be right and wrong by claiming for compensation. An example of this situation is as follows: a demanding party (client) is dissatisfied with a minor non-conformity. The supplying party (contractor) denies the claim of the demanding party for rework. Acting upon this denial the demanding party refuses to pay a term. Acting upon the non payment of the term the supplying party stops the execution. Who is right and who is wrong? The demanding party has the right to complain about a minor non-conformity, however, does not have the right to refuse paying. On the other hand the supplying party does not have the right to deny the non-conformity, however, does have a rightful claim for the payment of the term. Table 2 shows based on the different claims the number of claims the party is right according to the arbitrator, the number of claims the party is wrong, the number of claims the judgement is not explicit, and the number of claims the party is both right and wrong.

Table 2. Claims of the parties and rewarding by the arbitrator

Claim of each party (demanding or supplying party)	N Party is right	N Party is wrong	N Party is both right and wrong	N Unknown	N total	% of total
Pay non-judicial costs	1	3	4	3	11	3,1%
Pay expert's advice	3	5	6		14	3,9%
Pay invoices	1	1	2		4	1,1%
Pay rework		4	2		6	1,7%
Pay additional work	17	8	11		36	10,1%
Pay arbitration process	15	27		1	43	12,0%
Pay interest	3	12	22	4	41	11,5%
Pay damage	5	11	3	1	20	5,6%
(Payment remaining)	13	4	7	4	28	7,8%
Action by the other party	2	5		2	9	2,5%
Repair/rework object	15	20	10		45	12,6%
Non-compliance penalty	1	5	2		8	2,2%
Non payment of costs of arbitration	9	34			43	12,0%
(Non payment remaining)	3				3	0,8%
Non accessibility of other party		3		22	25	7,0%
Remaining reasons	11	9	1	1	22	6,1%
Total	99	151	70	38	358	100%

A third temporary results emerging from the arbitration data is the motivation of the arbitrator why a party is right, why wrong, or why a party is both right and wrong. By distinguishing two levels the insight into the arbitrators' motivation is expanded. The first level shows why a party is (partly) right or (partly) wrong. Table 3 shows the arbitrators motivation why a party is right and gets its claim rewarded (level 1). Table 4 show the arbitrators motivation why a party is wrong and does not gets its claim rewarded (level 1). A second level shows a further in-depth motivation by the arbitrator (Table 5 and Table 6). For example, a party claims payment of additional costs. The arbitrator motivates the party being wrong and having no rightful claim for money (level 1), because there is no additional work at all (level 2). Another example is a party claiming payment of arbitration process costs. The arbitrator motivates the party being wrong and having no rightful claim for money (level 1), because the party is wrong for 50% in the arbitration process, resulting in each party having to pay its own costs (level 2).

Table 3. Rewarding of the claim (level 1)

Claim is rewarded because (level 1)	N	% of total
The use of arbitration	44	12,3%
Rightful claim payment of expert	4	1,1%
Rightful claim payment of additional work	21	5,9%
Rightful claim remaining	15	4,2%
Rightful claim payment of interest	24	6,7%
Rightful claim payment of damage	5	1,4%
Rightful claim PART of payment remaining	34	9,5%
Rightful claim PART of costs procedure	14	3,9%
Rightful claim of PART of repair/rework	9	2,5%
Rightful claim of repair/rework	15	4,2%
Does not have to pay amount of money	12	3,4%
Remaining reasons	13	3,6%
Unknown	148	41,3%
Total	358	100%

Table 4. NOT rewarding of the claim (level 1)

Claim is NOT rewarded because (level 1)	N	% of total
Non-compliance penalty not rewarded	5	1,4%
The use of arbitration	40	11,2%
No rightful claim payment of expert	3	0,8%
No rightful claim payment of additional work	3	0,8%
(No rightful claim remaining)	88	24,6%
No rightful claim payment of interest	8	2,2%
No rightful claim payment of damage	3	0,8%
(No rightful claim PART of payment remaining)	37	10,3%
(No rightful claim PART of payment of interest)	24	6,7%
(No rightful claim PART of repair/rework remaining)	9	2,5%
No rightful claim repair/rework of non-conformance	18	5,0%
No rightful claim repair/rework remaining	2	0,6%
Unknown	103	28,8%
Remaining reasons	15	4,2%
Total	358	100%

Table 5. Rewarding of the claim (level 2)

Claim is rewarded because (level 2)	N	% of total
To decide not possible	8	2,2%
Building of house conform governmental approval	2	0,6%
Justly incurring PART of costs	6	1,7%
Cut down costs by supplier	3	0,8%
Admitted by counter party	11	3,1%
Outstanding invoices	3	0,8%
No repair/rework at all	2	0,6%
Justly incurring of costs	7	2,0%
Party did get insufficient information	3	0,8%
Repair/rework third party if supplier lacks activity	3	0,8%
Reasonably decided	5	1,4%
Partly just claim of additional work	2	0,6%
Justly claim of hidden deficiency	5	1,4%
justly claim of additional work	9	2,5%
Delivered materials insufficient	4	1,1%
Has to be accepted as completed	5	1,4%
Not attended to in case	5	1,4%
Demanding party did not agree with additional work	2	0,6%
Supplier is willing to repair/rework	2	0,6%
Delivery has been done	2	0,6%
Remaining reasons	21	5,9%
Party is right in arbitration process	3	0,8%
Party is PARTLY right in arbitration process	21	5,9%
Party remains (fin.) balance	26	7,3%
Parties agree	3	0,8%
Claim is matter of procedure	26	7,3%
Substitutional claim and primary combined attended to	2	0,6%
Counter party is lacking activity	2	0,6%
Invoice is made payable	2	0,6%
Execution of work is insufficient	11	3,1%
Reward for devaluation	2	0,6%
Unknown	150	41,9%
Total	358	100%

Table 6. NOT rewarding of the claim (level 2)

Claim is NOT rewarded because (level 2)	N	% of total
No reason for reward	2	0,6%
Responsibility other party not definite	2	0,6%
Number of days and amounts of money not correct	3	0,8%
Number of days not correct	6	1,7%
Call in of guarantee rightful	2	0,6%
Amount(s) of money not correct	13	3,6%
To decide not possible	5	1,4%
Non-conformance not perceived	3	0,8%
Claimed amount too high	12	3,4%
Insufficient evidence	11	3,1%
Claimed is more than non-conformances	3	0,8%
Non-conformance is insufficiently shown	2	0,6%
No worth in claiming	2	0,6%
Insufficient deliverance of evidence	2	0,6%
Repair/rework instead of money rewarded	2	0,6%
No non-conformance at all	6	1,7%
No additional work at all	3	0,8%
No hidden deficiencies at all	2	0,6%
Choice of materials or method	6	1,7%
Costs are arbitration costs	2	0,6%
Costs incurred for self-interest	5	1,4%
Costs of repair/rework calculated	2	0,6%
Not attended to in case	5	1,4%
Supplier should have know as an expert	3	0,8%
Supplier is willing to repair/rework	2	0,6%
Causal relation not confirmed	3	0,8%
Party is partly wrong	55	15,4%
Party is wrong	5	1,4%
No remaining (fin.) balance for party	10	2,8%
Claim is matter of procedure	26	7,3%
Situation is not cause for deficiency	2	0,6%
Counter party is not lacking activity	2	0,6%
Remaining reasons	38	10,6%
Unknown	105	29,3%
Total	358	100%

Using 20 arbitration cases a fourth result confirms the presumption as made by van Bladel. The demanding and supplying party claim more or less equally at the start of the arbitration process based. This is shown in Figure 2 using relative percentages¹.

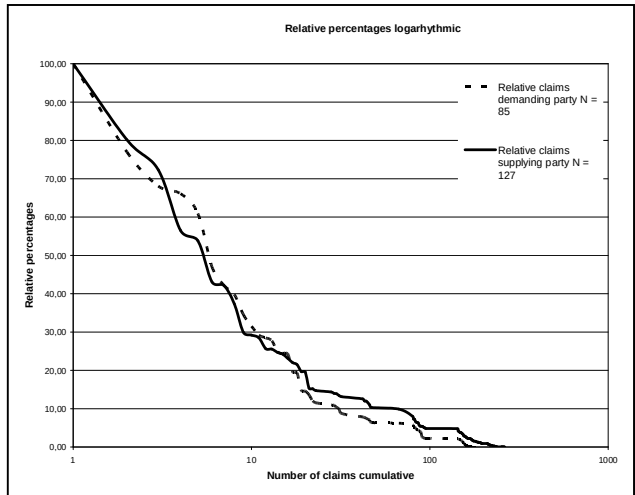


Figure 2. B3.1 Relative claims

The demanding party does get significant less rewarded compared to the supplying party Figure 3.

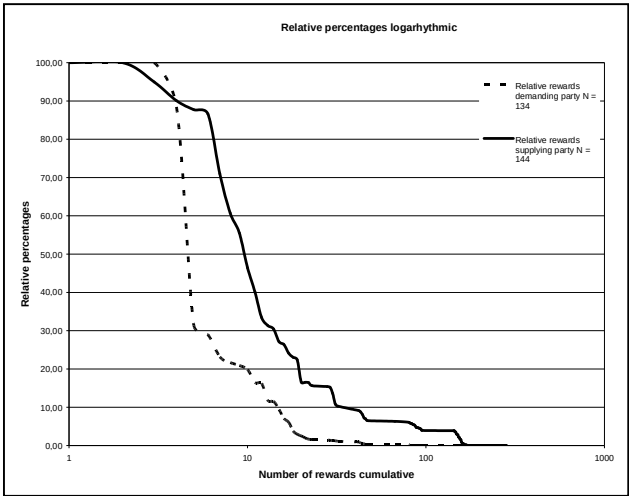


Figure 3. B3.1 Relative claims

¹ The relative percentages are derived from the amounts of money claimed/rewarded/resulting by a party relative to the total amount of money claimed/rewarded/resulting. Claims that do not have a financial component are not included.

Finally, what is claimed minus what is awarded results in the demanding party ending up with the biggest remaining claim Figure 4.

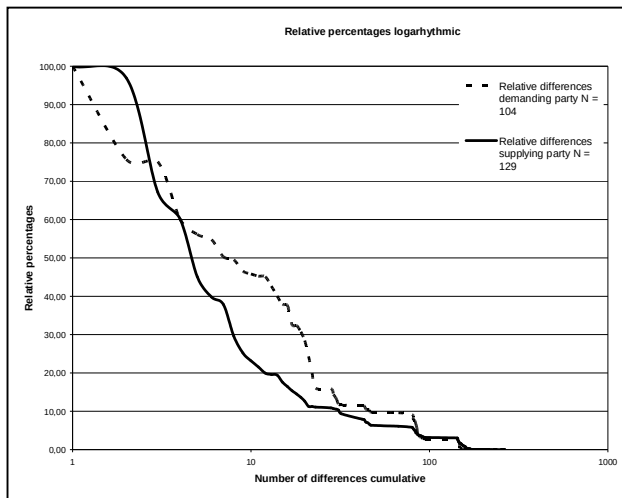


Figure 4. B 3.3 Relative resulting claim

Fenn et al. [1] used a survey to compare the occurrence of disputes in the construction industry versus the industry of chemical processing. They did find a correlation between the type of contract and the occurrence of disputes. In this research the sample of arbitration cases appeared too small to find variation in types of contract. Increasing of the number of arbitration cases in the sample might reveal results.

5. Discussion and conclusions

The basic research question ‘does dissatisfaction exist within the Dutch building industry?’ is confirmed using arbitration cases as a data source. The assumption that in all cases leading to arbitration one party is or both parties are dissatisfied is not contradicted. Therefore, arbitration cases will give insight into dissatisfaction.

Distinguishing demanding and supplying parties is useful. The presumption that the demanding party is the most dissatisfied party in arbitration can be confirmed Figure 2 through Figure 4.

Conflicts exist while both parties have a legitimate claim for money or repairs. Temporary results show that parties can both be right and wrong (Table 2). Opposite of what parties go for in arbitration, results show that often it is not a matter of being right *or* wrong but being right *and* wrong. In 99 of 358 claims the party is completely right, in 151 of 358 claims the party is completely wrong, in 70 of 358 claims the party is both right and wrong, and in 38 of 358 claims the arbitrator does not pronounce judgement. Parties start the arbitration process claiming money or rework from the other party. Whilst doing this they explicitly reject the claims of the other party. This at least

indicates lack of interaction between the demanding and supplying party. In this way the claims can become an autonomous process which continuously is strengthened by lack of interaction.

The blaming of the other party being the cause of problems is earlier identified by Chan and Kumaraswamy [8]. In their research they asked clients, consultants, and contractors to identify the main factors causing project delay. Although agreeing on the major causes the clients and consultants blamed the contractors to have a lack of experience in planning and site monitoring, and the contractors blamed the consultants (architects/engineers) to have a lack of design experience. [2] suggest that differences in perceptions as to causes of delays by different groups and the blaming for delays to other groups may discourage a search for the root causes of the delays. The origin of such biases may be traced to group conditioning, as well as to the present adversarial nature of the contractual systems, including the clashes, blame allocation and defence postures induced by the not uncommon 'extension of time' claims and associated costs in construction contracts.

In earlier research dissatisfaction was observed as an linear relation (difference) between the construction object as expected and later actually experienced [9-11]. This linear relation was also earlier defined by Aplebaum et al. [12]. Aplebaum et al (2000) define dissatisfaction in the light of medical service: Satisfaction or dissatisfaction with a service occurs when there is a “disconfirmation” between expectations an actual performance. Satisfaction occurs when actual performance exceeds expectations; dissatisfaction occurs when the patient’s experience with a medical service falls below expectations. However, dissatisfaction is not only dependent of the linear difference between expected and experienced, possibly being dissatisfied is more dimensional. Both the acting and interacting of parties influence dissatisfaction. To what extent and in what way needs further research.

In the underlying research the two procedures are further used to discover dissatisfaction. The arbitration data might give insight into results as found in other research, for example, [13] and [14].

Can we find a trace that suggests that a particular party in a particular construction context is predisposed and that legal or arbitration actions are infected by these predispositions rather than be based on being dissatisfied solely with the building product? [13]

Can we find some evidence that contractors plan claims at tender stage and sometimes during the course of a project? [14] Rooke et al. also “found evidence that strategy (of

anticipation/planning on/of claims) varies from company to company, project to project and even in some companies, from individual to individual” [14]

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Changing value networks, money flows and investment targets

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Abstract

Building construction and infrastructure investments share of GDP depends on the structure of society. The basic assumption is that construction's role gets smaller in developed society. Yet, recent developments have shown that in the case of non-residential construction the level of advancement of a society is not as important a factor as the pace of change of the industrial and commercial base. In housing production, on the other hand, the basic assumption has proven correct. Since the year 2000 the European Union member states have invested more in renovation of housing than in new building. The structure, operations and value networks of building construction are changing.

The study describes how the volume and content of money flows change as investment in new building construction and infrastructure are replaced by investment in maintenance and renovation that maintains usability. The entire process from the clients to the implementers is going to change.

The presentation is based on a Licentiate thesis accepted at Tampere University of Technology in 2001 in Finland [1].

Keywords: Construction, Building Contracting, Material and Product Industry, Building Costs, Input-output Analysis, Income Distribution, Investment Expenditure

1. The Money Flows of Construction - an Input-Output Analysis

1.1 Introduction

The research problem is to link together construction volume, content, contracting and use of construction products. Related surveys are made on the national-economic level. So the goal of the study is to develop a national-economic level market analysing system which allows surveying construction as a whole and different sectors and contracting individually within the same framework.

The analysing system is to cover both new building construction and civil engineering and also renovation of built environment. In addition to quantitative changes in construction, the system must be capable of analysing the impact of technological changes within construction sub-sectors on the demand for both contracting and the construction products industry. The construction products industry is industry that produces the materials and components used on construction sites. Foreign trade in construction products is the importation and exportation of the same products.

1.2 Selection of Research Method

The structure, production and development of the national economy are monitored by the internationally agreed national-economic accounting system. Its key task is to calculate the gross domestic product (GDP). The GDP includes only the end products of various sectors. End products are products that are either consumed, added to capital or exported during the year of observation. Intermediate products are used to make end products. The value-added of a sector is arrived at by deducting the value of raw materials, semi-finished products and services bought from other sectors. The GDP is the sum of the value-added of all sectors.

The input-output statistics related to the accounting depict the relations between construction and other sectors. Input-output statistics are a form of so-called double-entry accounting of supply and its end uses. The supply table shows the production of goods and services by various sectors as well as their imports. The consumption table shows the products used by sectors as intermediate or end products or exported. The columns of the input-output table comprise the intermediate-product inputs purchased from other sectors and used own basic inputs by sectors. The rows of the table display the outputs of sectors divided into demand for intermediate-products by other sectors and demand for end-products by households, enterprises and the public sector, as well as investments and exports.

The basic inputs of the input-output tables are wage costs, employer's social security contributions, production taxes and subsidies, fixed capital outlays and operating surplus. Intermediate-product inputs consist of imported goods and goods and services purchased from other sectors including VAT, production taxes and product subsidies. The input structure indicates the need of the basic and intermediate inputs used by a sector.

1.3 The Advantages of Input-Output Analysis

The input-output method allows analysing inter-sector relations on the national-economic level. Use of the inverse matrix allows converting a sector's input structure into an overall input structure that reveals, in addition to the use of basic inputs by a sector, also the basic inputs from other sectors used to manufacture intermediate products.

The input-output method is suited for this project which intends to examine the relationships between the sectors involved in construction as construction volumes and the internal structure change. Input-output analysis provides the research a framework which links the value of the output of a sector to its content and construction to the national economy. The compatibility of the method selected by the project with official statistics broadens the perspectives on the study.

The key idea of this study is to treat construction as an entity made up several different markets. That is why the input structures of building components are determined instead of those of building construction and civil engineering. Overall basic input structures are calculated for building components using the inverse matrix in order to determine money flows. The impact of the internal structure and volume of construction are analysed based on the market shares of building components. Building components can also be combined into entities smaller than building construction and civil engineering such as typical contracting fields, construction product industry sub-sectors and building types.

2.1 Solution

The input data of the study consist of the results of several construction economics related cost studies dealing, for example, with units costs of structures and construction cost indices. The key concern in the adaptation of input data has been to break construction down into components of similar input structures (input coefficients, chart 1), to establish these input structures, and to determine their market shares.

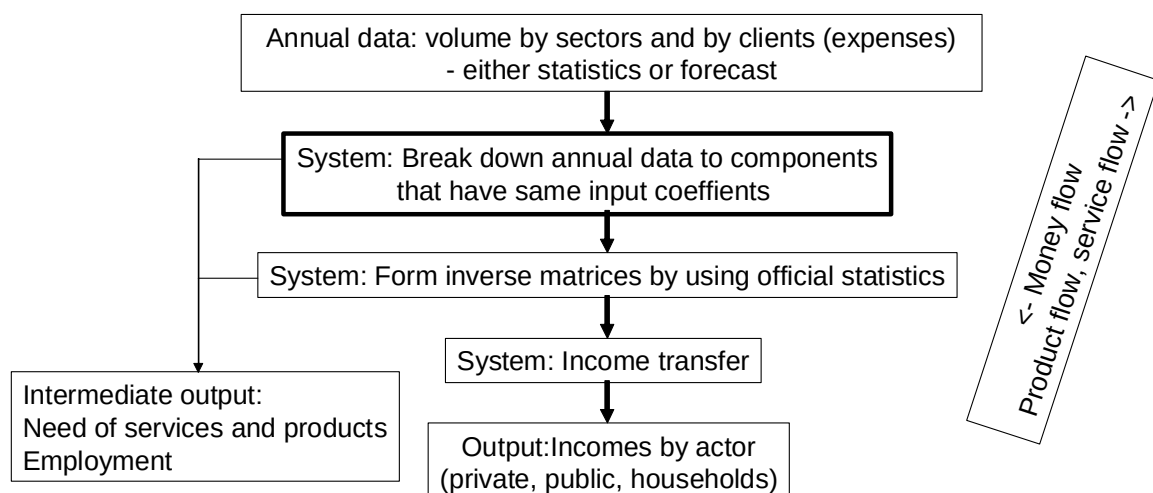


Chart 1. Inputs, outputs and structure of model.

The micro-units of building construction are 26 building components and those of civil engineering 10 contracting fields, which were selected mainly on the basis of the use of intermediate products and degree of prefabrication.

Using statistical data as input data allows analysing the impact of domestic demand on various sectors annually. The results are best suited for annual assessment of sector development or comparison of sectors. The method is too rough for product-specific analyses since market shares of building products based on example sites do not yield quite accurate market shares for all construction products and, consequently, their accurate annual demand.

When alternative forecast futures are used instead of statistical data, the development of sectors over the strategic term can be examined based on alternative development scenarios. The results of this kind of analysis are very useful in strategic decision making. As the case study 1 shows growing share of renovation can be attractive as business area.

System can also be applied to individual project to show the money flows. For example via results can be analysed how one big public project effects regionally.

2.2 Case studies

Case 1: Impact of construction boom, new construction slump, and changed regional structure of Finland on the demand for building products

Changes in the demand for construction products can be viewed from several angles. The focus may be the markets of companies operating in Finland – both domestic and international construction markets – or domestic demand for imported construction products and domestic deliveries of the Finnish products industry.

The following equation yields the demand for construction products companies operating in Finland:

$$\begin{aligned} &+ \text{deliveries to domestic markets} \\ &+ \text{imports to international markets} \\ &= \text{total demand for domestic (Finnish) construction products industry} \end{aligned}$$

The demand by domestic construction, again, can be derived from the equation below:

$$\begin{aligned} &+ \text{deliveries to domestic markets} \\ &+ \text{construction product imports} \\ &= \text{domestic (Finnish) demand for construction products} \end{aligned}$$

Changes due to construction activity (chart 2) and the resulting changes in demand for services have also been calculated to serve as reference figures.

Construction Output by Sectors in Finland

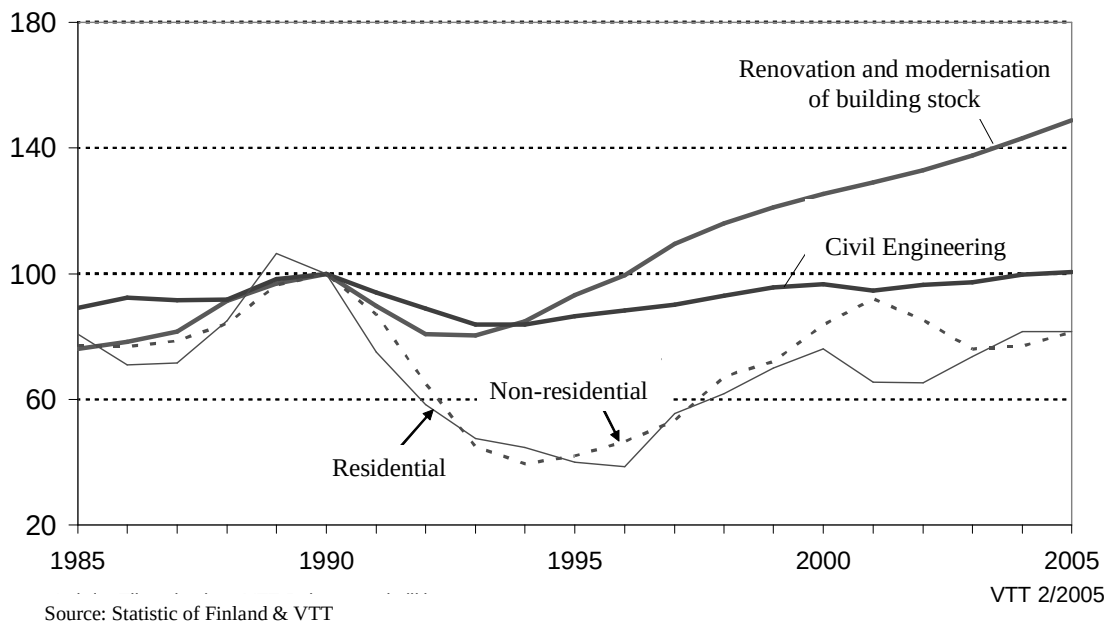


Chart 2. Volume of construction sectors in Finland.

The analysis showed that the construction products industry rode out the slump in demand for construction in the early 1990s better than construction proper. The non-metallic mineral industry is the industrial sector most tightly connected to domestic new construction which is why demand for its products fell more than in other branches. The metal industry that supplies the construction sector was least affected by the recession and was able to profit from the emphasis on renovation in building construction as well as exports.

Case 2: Revenue from construction

Construction brings revenue to several sectors and parties. The recipients can be determined by tracing the flow of money through different phases of the process all the way to those who produced the basic inputs. Money tied in basic inputs may accrue to an economic unit either directly as primary income or through income transfers. Income transfers are effected by taxation, and their share of primary income is determined by tax scales.

The primary income of construction-sector companies, as well as those of other sectors, consists of interest and operating surplus, part of which accrues to the public sector via taxation. Interest and operating surplus are subject to corporation taxes.

Households earn wage income, of which the pension insurance contribution, social security contribution and income tax are deducted and transferred to the public sector.

Official input-output calculations omit taxes. When the scope is widened to include sector clients, the value-added tax included in the sale price paid by dwelling buyers and the construction products purchased by independent builders enters into the picture. The buyers of new dwellings also pay a capital transfer tax in connection with the sale.

The revenue of the state and municipalities consists of taxes in the form of income transfers, other product taxes, social security and pension contributions by employers and employees, income and corporation taxes, and value-added and capital transfer taxes paid by households. The revenue of the public sector is reduced by the product subsidies it pays.

A third of the money used for construction ends up in the coffers of the public sector as tax revenue and social security contributions. If the value-added and asset transfer taxes connected to new building construction are factored in, the public sector's share of the revenue is significant. Household's share of the revenue is one quarter independent of the sector of construction. As an example there is outcome that finally gets the money from residential construction (chart 3).

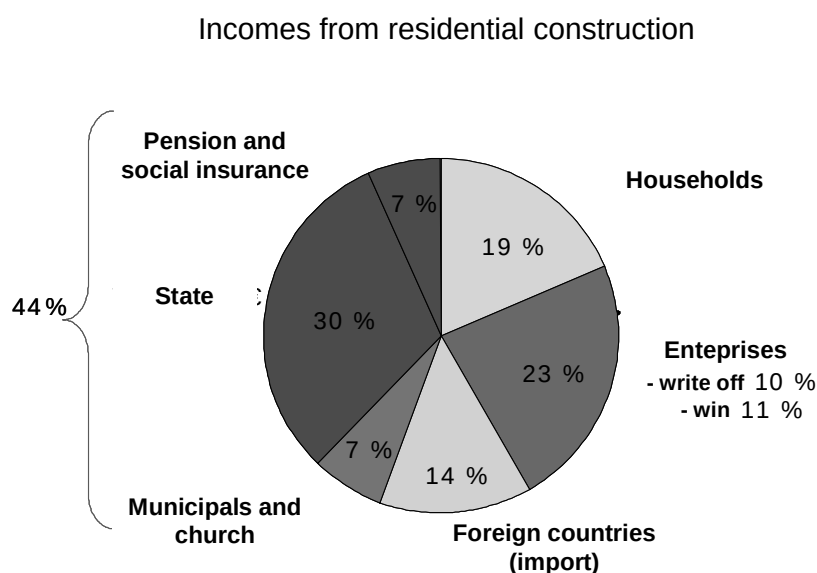


Chart 3. The outcome from input-output analysis of money flow in residential construction. The target is apartment in multifamily house, built by contractor [2]. Doesn't include site value.

3. Conclusions

The study describes how the volume and content of money flows change as investment in new building construction and infrastructure are replaced by investment in maintenance and renovation that maintains usability. The entire process from the clients to the implementers is going to change.

The basic assumption is that construction's role gets smaller in developed society. Yet, recent developments have shown that in the case of non-residential construction the level of advancement of a society is not as important a factor as the pace of change of the industrial and commercial base. In housing production, on the other hand, the basic assumption has proven correct. Since the year 2000 the European Union member states have invested more in renovation of housing than in new building. The structure, operations and value networks of building construction are changing.

The most essential variable is the amount of money invested in building construction. Whether the money is used to make an investment or to maintain a structure or building has little significance, for instance, as concerns the need of labour. This is central since our attitude toward construction is strongly affected by the "investments as share of GDP" variable which projects an image of a "declining industry".

Renovation is tied to place and local activity, but yet more closely linked to international markets than new building. New building uses local, heavy materials. Renovation largely involves products typically made by multinational giants. Renovation consists of small one-off projects that demand special skills of companies and workers. The roles learned in new construction do not serve implementation of renovation projects – they are driven by totally different parties.

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The Development of a Contractual Framework for Disaster Reconstruction

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Abstract

Disaster reconstruction management requires a different response to ordinary construction. One of the key factors to consider is the development of a fast and efficient contractual framework, or procurement system, for rebuilding following a disaster event. The objective of this paper is to explore the most efficient construction framework for reconstruction following such an event. The methodology for this research consists assessing different procurement options commonly in use for current effectiveness and then using this data to suggest the most suitable framework for use both locally in New Zealand and internationally for any given disaster event. The results will show how the current common procurement frameworks in use can assist with post-disaster reconstruction.

Keywords: Contractual frameworks, procurement, reconstruction, disaster, New Zealand

1. Introduction

Following a disaster, one of the requirements for reconstruction is the establishment of a comprehensive procurement framework for reconstruction. Without this, reconstruction and new development will be carried out on an ad-hoc basis with little regard for the needs of the society needing reconstruction. Current normal procurement mechanisms used in the construction industry need to be assessed for their suitability to deliver the best economic outcome in the event of a disaster. It is likely that without a comprehensive reconstruction

procurement framework, rapid reconstruction will be significantly hampered. This research examines current common procurement types to assess their suitability for reconstruction following a disaster. Particular focus is made on the question of which is the best procurement option for this reconstruction.

2. Procurement Systems for Disaster Reconstruction

There have been changes in the forms of contract and other types of project relationships used in some sectors of construction in recent years [1], and these may be more suitable for reconstruction projects than traditional contracts. Procurement strategies such as traditional, design-build, partnering and alliancing can be judged against, amongst other things, time, cost, quality, industry familiarity, communication and management. Procurement systems are the organisational structure adopted by the client for the implementation of the project process and eventual operation of the project [2]. Procurement can be seen as a strategy designed to satisfy the client's development needs [3]. For disasters, the client is likely to be the government of the country undergoing disaster reconstruction. They will require guidance on the most useful strategy for reconstruction. The common purpose for all the procurement systems and the inherent part of a procurement system is to achieve the clients' objectives [4]. In an emergency situation reconstruction is required rapidly, and this should be at the forefront of the client's objectives. Cheung [5] suggests procurement is critical as it determines the overall framework embracing the structure of responsibilities and authority for participants within the building process. In all projects, but particularly in a crisis situation, clear structures need to be determined and responsibilities and authority for rebuild established.

Initially all projects were procured by using the traditional procurement system and even today a large number of projects are carried out by using the same procurement system Cheung [5]. Recent changes in the construction industry such as changes in the type of client and development of construction techniques have produced differentiation within construction processes and changes in organisational structures to satisfy a variety of clients' objectives [4]. This has led to the development of variety of procurement systems. Both Sanvido & Konchar [6] and Walker [7] comment on the relationships of the parties to the project. As Walker [7] points out, '...for the purpose of accomplishing a construction project an organisation can be said to be the pattern of interrelationships, authority and responsibility that is established between the contributors to achieve the construction clients' objective'. Hence the key to the management of construction project is the way in which the contributors are organised to use their skills effectively. Effective use of skills is an essential element to rebuilding after a

disaster. Where large loss of life occurs, skills are lost and it is the need for the procurement system used to recognize the skills shortage and respond to it.

Commonly used procurement systems can be categorised as either traditional, integrated or management [4]. The traditional system is where the project process is separate and sequential in nature (construction follows design and tender) and is the oldest form of construction procurement [3]. An integrated system, as described by Al Khalil [8], is where single organisation is responsible for design and construction of the project and the involvement of the client is at a single point. Common examples of these procurement systems are design and build, built-operate-transfer (BOT), built-operate-own-transfer (BOOT), turnkey and package deal. The management approach is where an additional role of construction manager (CM) or project manager (PM) is added in the organisation to look after the project objectives. These systems as described by Walker & Hampson [9] are the combination of traditional system of procurement and integrated approach because in this kind of system a separate entity, often called project manager, acts in a management role and the project manager is responsible for all clients' objectives through one point of contact with the client. Few recently developed systems under this category are project alliancing and strategic partnering which are largely based on the ethics of the project participants [10].

In a disaster, the ability of a governing organization to quickly establish an adequate procurement system for rebuilding is crucial. For reconstruction following a disaster event it is hypothesized that the procurement framework needs to have the following:

- Short time for rebuilding
- Low cost
- Use of local material, labour and plant
- Well developed communication links between the parties
- Local industry familiarity with the framework
- Well developed relationships between the parties (including trust and respect between the parties)

The following sections assess the different common procurement options for their suitability against the above factors.

2.1 Usefulness of the Traditional Approach for Disaster Reconstruction

The traditional procurement system is known as the system with separated design and construction organisation. Walker and Hampson [9] describe this'... approach to procuring

project involves discrete design development, tender, contract award and construction phases. Each phase is, in theory, separate and distinct.’ In this system the client appoints a designer such as an architect or design engineer who fully designs the project and helps the client in selecting the contractor by inviting the tenders [11]. In this system the architect or designer acts as a team leader and has functional relationships with other project participants. Masterman [12] suggests that for the small or medium size projects where complexities and uncertainties are not high this form of procurement proves economical. Masterman [12] further points out that the organisation structure of this system is fragmented and sequential in nature and procurement participants are separated and have separate responsibilities. The fragmented nature of this system makes a complex network of communication. Shockley-Zalaback [13] suggest that effective communication is important for successful delivery of project as it has been linked to team effectiveness, the integration of work units across organisational levels, characteristics of effective supervision, job satisfaction and overall organisational effectiveness’.

McGeorge and Palmer [14] refer to the main disadvantage of this system as one which ‘...removes the contractor from the design development phase and thus much management and contractual information is lost’. The traditional system of procurement has a noted advantage over the other procurement systems as Masterman [12] suggested ‘...provided that the design has been fully developed and uncertainties eliminated before tenders are invited... proper competition is ensured...and the selection of bid that is more advantageous to the client will present little difficulties’.

In a disaster, the ability of a traditional framework to quickly respond to rebuild could be a disadvantage. If a short time for rebuilding is required then using the traditional system may be a disadvantage. As Wilkinson & Scofield [11] suggest the traditional system usually results in a longer time period for the whole construction project mainly because the design is often fully completed before tendering and construction. They further point out that usually the longer the time period, the higher the cost, hence the traditional system is often associated with higher costs [11]. A higher cost product would be a disadvantage in a disaster rebuild situation, as financial resources will already be stretched. However, with full design documentation at tender stage, the total cost of the project should be known which might introduce some clearer measure of reconstruction costs. The traditional system is associated with design by a design professional and a quality product. Administration of the project by a design professional usually means high quality as the design professional is often focused on quality. Care should be taken that, following a disaster, quality is not taken to mean importing expensive material at the expense of getting local infrastructure and material supply businesses functioning. The traditional system is a well understood, tried and tested procurement system making it attractive from a familiarity

viewpoint. If the parties have worked together with the framework on previous projects then there is likely to be well-developed relationships between the parties. However, the fragmented and sequential nature of the systems tends to mean that communication becomes complex. This is a disadvantage when working in a crisis situation where clear and easily understood communication systems are required. On balance, the main impediments to this system for reconstruction following a disaster are the time, cost and communication factors. The main advantages for reconstruction following a disaster are familiarity with the system and receiving a quality product.

2.2 Usefulness of the Integrated Approach for Disaster Reconstruction

In an integrated procurement system, design and construction are integrated and become the responsibility of one organisation. The design and build is an arrangement where one contracting organisation takes sole responsibility for the design and construction of the client's project [12]. Design and build is the main member of the integrated system, other types include package deal, built-operate-transfer (BOT), built-operate-own-transfer (BOOT), novation and turnkey are also examples in the category. Cheung [5] describes the popularity of these systems in the construction industry '...these options become fashionable when more and more contracting organisations are armed with a design function. In fact, for those with financial capability, their service can be extended to build-operate-transfer.'. Masterman [12] suggests that design and build gained popularity because there was '...heavy demands upon the construction industry and shortage of construction resources, coupled with claims by contractors of greater efficiency and lower cost when using this method...' Wilkinson & Scofield [11] suggest that these systems are good for typical construction where standardised techniques and materials are to be used. This system proves useful only when the client's brief and detailed design are properly communicated to the organisation responsible for the construction [12]. Masterman [12] further points out that systems like BOT and BOOT are more common for infrastructural projects than buildings because the concession allows for toll or other payments to be made by end users to cover the cost of both procuring the facility and its operation. Smith et al, [15] describes that the BOT entity undertakes financing, design, and construction as well as operation and so the client is taking no direct cost risk other than the possibility that the facility does not meet its need or that the concession agreement is unsatisfactory. For design and build suitability in disaster reconstruction consideration should be given to the reduction of time and cost which is of significance when rapid rebuild is required and financial resources are

limited. As design and construction are the overlapping activities, this can reduce the overall time of project completion. Design and build also permits the incorporation of constructability information during design, so following a disaster, local knowledge of material availability and other resources can be incorporated into the project. Concern is expressed in the use of design and build because of the lack of checks and balances leading to a lower quality [16]. Quality may not be such a priority in a crisis situation, as recovery needs are more likely to focus on time and cost. Mulvey [17] summarises that the design and build approach is especially successful in the case where the scope of project is clearly defined, the design is a standard, repetitive design, and the schedule is tight. In a disaster, design and build procurement could be suitable because of this short time and low cost focus. This coupled with a local contractor's likely knowledge of the local construction industry such as fast access to local material, labour and plant make it an attractive option. The design and build system has uncomplicated and therefore it is easy to establish well-developed communication links between the main parties, contractor and client. In many countries internationally, design and build also scores on local industry familiarity with the framework. The only caution to be noted is in the reputation of the design and build framework to be focused on repetitive, simple constructions and some concerns about the reliance on one company to be able to undertake all the work effectively – hence trust becomes a major factor.

2.3 Usefulness of the Management Approach for Disaster Reconstruction

The common characteristics of all management oriented procurement systems are that in these systems a person or organization is contracted to manage the design and construction. Masterman [12] suggests that these systems can more readily respond to the client's needs, especially accelerated commencement and completion. Walker [7] describes project management as a procurement framework where the project manager generally coordinates the design and oversees those responsible for the work packages. In the case of a pure project management arrangement the project manager has management authority for both design team and construction team. The project manager acts as the executor and is the only entity to interact directly with the client [7]. Whereas in the construction management system where the project manager is usually a contractor, the expectation is that construction expertise of the contractor is encouraged in the design. In this system construction manager is a consultant hired by the owner to oversee the project process on the behalf of owner. Walker and Hampson [9] state about this expertise that '... this build-ability or constructability advice is crucial to the

development of design solutions that maintain value in terms of the quality of product as well as providing elegant solutions to production problems.’

Having a management tier in a project could be advantageous during disaster reconstruction as the sole focus of the project management or construction management organisation is management of the project. The skill of the managing organization is critical to its success, more so in a disaster scenario where quick and efficient decision making is required. Wilkinson and Scofield [11] discuss the advantages and disadvantages of the project management system. They suggest that when a project manager is employed, then the programme may be shortened due to the project manager using increased knowledge of project planning. By concentrating on management, the project manager can focus on reducing the overall time. This could be good for disaster reconstruction management. Where skilled local project managers can be used for managing reconstruction then the expectations of project success are high. As with design and build, the project manager or construction manager, using existing communication links between the parties would be able to facilitate rapid rebuild – especially if the project manager has a well developed sense of the local material, plant and labour situation. However, there is a need to check for local industry familiarity with the system and in particular the value of having another management tier in the project increasing the lines of communication between the parties.

2.4 Usefulness of the Partnering Approach for Disaster Reconstruction

Wilkinson and Scofield [11] suggest that partnering is not technically a procurement system, rather it is a framework which overlays any of the procurement frameworks in operation. Masterman [12] concurs, suggesting, ‘Partnering does not supersede the process used by the procurement system chosen to implement the project but rather acts as a framework within which the selected system operates more beneficially’. The definition provided by Construction Industry Board [18] describes partnering as: ‘...a structured management approach to facilitate team working across contractual boundaries. Walker [7] asserts that it ‘...is based essentially upon team spirit. The interesting aspect of this simple model is that all three essential elements require trust, commitment, honesty, integrity, good communication skills and technologies between parties’. In partnering there are three essential features; mutual objectives, continuous improvement and problem resolution [19]. Mutual objectives are the objectives that establish for everyone that their interests are best served by concentrating on the overall success of the project [19]. The second aspect, continuous improvement, involves team and individual feeling

safe in measuring performance to learn from their experiences. This requires openness and honesty hence trust and commitment are major issues for improvement. In continuous improvement- performance is measured and analysed to provide knowledge about how improvement can be achieved continuously. There must be a commitment to learn from experience and to apply this knowledge to improve performance [19]. The third aspect, problem resolution requires the resolution of problems with an escalation strategy to solve them at the lowest organisation level possible [19]. Partnering is a voluntary arrangement made between all of the project participants, has no legal standing and imposes no contractual obligations upon any of the parties [10]. But, as Egan [20] and Latham [21] discuss, the partnering approach can prove useful in that construction process and in improving construction practices. For disaster reconstruction, partnering may be a suitable option to overlay other frameworks. As a focus on relationships and trust are likely to be crucial in such a situation, partnering might provide a vehicle for reconstruction. If local companies in a reconstruction zone have an established long-term relationship, as a system based on trust requires, then using partnering might be viable. Internationally, familiarity with partnering concepts may still not be high, but could be quickly learnt, especially given the needs of the parties to face the common objective of rebuilding communities.

3. Conclusion

In this paper analysis has focused on the most suitable procurement systems for reconstruction following a disaster. The analysis has focused on some key factors such as time, cost, quality, industry familiarity, communication and management and how these factors change with different procurement systems and hence their usefulness for reconstruction. What is not in doubt is that following a disaster, one of the requirements for reconstruction in the establishment of a comprehensive procurement framework for reconstruction. How this is achieved depends upon how the various factors interplay and what requirements and facilities exist in the local communities. Concluding, it appears that all procurement systems have specific attributes useful for disaster reconstruction. It is the weightings of these attributes to specific circumstances that are more critical.

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Efficiency Improvement through Procurement Innovation in the New Zealand Construction Industry

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Key words: construction, procurement, innovation, collaboration, demonstration

Abstract

An initiative engaging clients and the construction industry supply chain has been established in New Zealand, to publicise the benefits and encourage wider adoption of procurement and project delivery innovations throughout the industry. Innovative projects have been engaged as ‘demonstration projects’ to increase the knowledge base in the industry and, to prove the business case for change, a set of industry key performance indicators is being established to measure the benefits of innovation. Research has been carried out to support the initiative, including analysis of the significance of the construction industry to the New Zealand economy and an investigation into the range of procurement approaches currently used in the industry, together with case studies of a range of relevant construction projects.

1. Introduction

The following paper describes an initiative that aims to facilitate efficiency improvements and a culture change in the New Zealand construction industry. The various activities associated with this initiative are described and the results obtained so far are discussed.

1.1 Characteristics of the construction industry in New Zealand

The construction industry in New Zealand is similar to the traditional industry of the UK, in terms of the roles of the various supply-chain members, the forms of contract used, the types of relationships that are formed and the levels of efficiency in delivering projects. Recent research commissioned by BRANZ (2003) shows that the New Zealand industry has a major influence on the national economy. Whilst the construction sector’s direct contribution to GDP is only around 5%, a 10% improvement in construction efficiency will result in a 1% change in GDP due to multiplier effects and gains in related sectors. Despite the importance of an efficient construction

industry to the economy, the government has not intervened to encourage efficiency improvement but sees the responsibility lying with industry.

New Zealand, like the UK, experiences a range of construction procurement approaches, from traditional lowest price, lump-sum, competitive tendering to target cost and alliancing arrangements. The small size of the construction industry in New Zealand has facilitated a greater proportion of cooperative relationships between the various stakeholders to construction projects, particularly in civil engineering. In some cases the cooperative relationships have been formalized in partnering arrangements, in other cases collaborations have been more ad hoc and have been the result of the involvement of enlightened individuals in particular projects. Research undertaken to support the innovation initiative described in this paper (Henderson and Le Masurier, 2005) has shown that traditional contractual relationships are by far the most commonly used in New Zealand construction, with almost three quarters of all construction in New Zealand undertaken using either traditional design-bid-build or traditional design and construct. The use of partnering is however well established in the industry and is used in some form in approximately a quarter of all construction projects, see Figure 1.

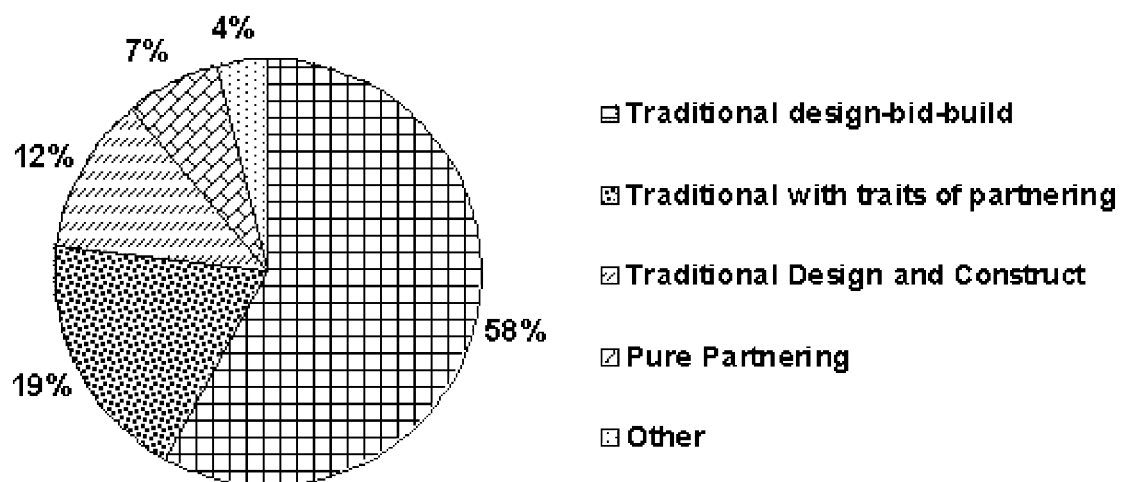


Figure 1: Proportions, by number of projects, of the most commonly used contractual relationships in the New Zealand construction industry (Henderson and Le Masurier, 2005)

1.2 Promoting innovation in construction project procurement and delivery

Recently the industry has experienced new levels of collaborative procurement arrangements, adopted by state owned enterprise client bodies as well as local and central government clients. A high level of interest in innovation was demonstrated at an industry conference on new forms of contract and procurement (Henriod and Le Masurier, 2002) and it was clear that there was a movement for change underway in parts of the industry. However, the efforts of a few

enlightened clients and construction companies were dispersed, without a coordinated ‘critical mass’ of innovators or process for knowledge-sharing which could benefit the industry as a whole. It was therefore proposed that an industry owned initiative, similar to the UK’s Construction Excellence, could help facilitate wider adoption of innovation, in particular innovation in procurement which was considered to offer the greatest potential for efficiency improvement.

2. Methodology

2.1 Steering Group

The Centre for Advanced Engineering (CAE) at University of Canterbury has a track record in facilitating expert groups and providing technology transfer and is recognised as an effective independent voice on engineering and technology-related matters. CAE fulfils the role of a knowledge broker and integrator across a number of engineering disciplines and since CAE already had an infrastructure programme it provided the ideal platform from which to establish a construction industry innovation initiative.

Key industry players involved in procurement innovation were invited to form a steering group to guide the initiative. The steering group has representatives from the whole construction supply chain including clients.

The initiative, known as Best Practice in Construction Procurement and Delivery, has a two-pronged approach: bottom-up focussed on processes and top-down focussed on policy, with the former leading and facilitating the latter.

2.2 Demonstration Projects

A fundamental part of the bottom-up initiative has been a programme of demonstration projects. Current projects using innovative procurement approaches (alliancing, partnering, integrated supply chains, etc) have been engaged in a peer review process. The purpose of the demonstration project process is to share experience and knowledge among the teams involved in the projects and to provide tangible evidence of the benefits derived as a result of the innovation. At the end of each project a case study is produced and seminars organized to showcase best practice and innovation to the wider industry.

The demonstration project process is based on that used by UK’s Constructing Excellence, and follows the steps shown in Table 1. The peer review panel is made up of representatives from current and past demonstration projects, so stages 1-5 are confidential among the panel members. This process provides a ‘safe’ environment for panel members to share their knowledge and experience with like-minded people and ensure that the benefits are proven before going out to a wider audience at stage 6.

Stage	Process
Stage 1	Outline of the project innovations and anticipated benefits through meetings with the project team and submission of an application form.
Stage 2	Presentation by the project team to a peer review panel where the project is judged on its suitability for inclusion in the demonstration project programme.
Stage 3	Presentation and discussion by demonstrating projects to the peer review panel on the key performance indicators (KPIs) that will be used to demonstrate the tangible benefits specific to the innovation.
Stage 4	Collection and processing of KPI data and benchmarking with other demonstration projects.
Stage 5	Summarising and evaluating lessons learned and evidence of the benefits derived from the innovation in a final presentation to the peer reviewers.
Stage 6	Publication of a case history and dissemination to wider industry.

Table 1. Demonstration project process

2.3 Benchmarking

Whilst the demonstration projects use project-specific key performance indicators (KPIs) to benchmark internally, much of the evidence of the benefits from innovations is anecdotal. Without standard performance metrics to enable direct comparisons between projects and clear guidance on how to measure performance, it is difficult to prove the business case for innovation. Therefore, another underpinning element of the initiative has been to develop a national set of industry KPIs. A KPI steering group was set up to pursue this particular area and a set of KPIs was chosen based on what were considered to be the main areas for performance improvement in delivery of construction projects. The KPIs chosen are shown in Table 2 and use similar definitions to the UK's Constructing Excellence (2005) headline KPIs.

The project to establish and run a pilot trial of these KPIs has been carried out with funding from BRANZ and is nearing completion. The pilot results will be presented and the KPIs will be launched nationally at an industry conference in May 2005. Once established the national KPIs will provide a means of differentiating the better performing players from those who rely on traditional lowest price procurement processes and will allow industry players to measure their current performance and gain feedback on the potential for performance improvement. A process for regular industry benchmarking against the national KPIs will help to make the business case to industry and policy makers to do things differently, for the benefit of both individuals and the economy as a whole.

KPI

- 1. Customer Satisfaction – Product**
- 2. Customer Satisfaction – Service**
- 3. Quality – Defects**
- 4. Accidents**
- 5. Predictability – time**
- 6. Predictability – cost**
- 7. Turnover and Profits**

Table 2. National Key Performance Indicators

3. Case study – Auckland Airport Runway

3.1 Introduction

Auckland Airport runway refurbishment works is one of the demonstration projects and the description below provides an example of the type of procurement innovation and resulting benefits that are being promoted through the initiative.

The Auckland airport runway was built in the 1960's and by 2000 was nearing the end of its service life. Whilst the runway has been lengthened to accommodate the requirements of larger aircraft, the concrete slabs under the original central section of the runway were not designed to carry the loads imposed by modern aircraft and needed replacing. The first stage of the refurbishment works required the conversion of the main taxiway into a temporary runway to allow closure of the main runway. The risk of disruption to operations and the thousands of people that travel through Auckland's airport daily was minimised by thorough planning for the refurbishment, considering an extensive array of potential operational impacts. Planning took two and a half years to complete. Risk in the delivery of the project was further minimised by selecting and partnering with contractors that demonstrated a customer focussed culture and a proven ability to perform well on such projects.

As the runway is critical to the core operation of the airport, the refurbishment works had to be carried out with minimal operational disruption and no delays. All specifications had to be met correctly first time, as passenger safety could not be compromised.

3.2 The Solution

Communication and detailed planning was the key to delivering this project successfully. An integrated delivery team was formed at the earliest stages of the project with the designers and

contractors working together from the start. People working on the project at all levels participated actively in progress meetings. Clear and constant communication gave management the flexibility to optimise the work programme through faster decision making processes and allowed them to “design out problems”. There were daily meetings to discuss past, present and future progress and to ensure all phases of the project were integrated with one another. Planning involved all those actually responsible for the site works together with feedback from extensive stakeholder consultations. A risk consultant was employed to perform a detailed risk analysis involving all stakeholders, as a result of which the project team was able to prepare contingency plans for a wide range of potential outcomes.

3.3 The Benefits

The benefits of the integrated delivery team were measured against the key performance areas of time, cost, quality and safety and the project was a success in all areas as follows:

- Time – construction was completed five days ahead of the tight 30-day planned schedule; this was the result of the extensive planning process and the use of backup plant to speed up construction
- Cost – prices were negotiated up-front with the contractors so there were very few variations and claims
- Client Satisfaction – the client was very satisfied with the end result and early completion was a bonus for the end users
- Work Continuity – there were no programme delays and no accidents.

4. Results

The Best Practice in Construction Procurement and Delivery initiative has developed steadily, from the ‘bottom-up’ over the past 2 years. Several of the larger construction and consulting companies and major clients in New Zealand have supported the initiative both financially and through the steering group. Five demonstration projects have been completed, covering a range of project types, scales and procurement approaches and several further demonstration projects are currently underway. All projects are demonstrating excellent levels of performance in the industry KPI areas. Progress on the initiative overall has been slow however, due to lack of resources. The initiative is beginning to make some headway now in the ‘top-down’ policy area. Once the national KPI project has produced the first round of results there will be an opportunity to demonstrate to policy makers in government the benefits that can be obtained from improved procurement processes. Although applications for government funding to support the initiative have been unsuccessful previously, it is hoped that the government will see the benefit to the national economy resulting from a more efficient construction industry and support this initiative,

in collaboration with industry. A lesson to learn from the experience to date is that establishing an industry-owned initiative is hard work with limited resources and no prime funding. This is in contrast to the initiatives in UK and Australia which have received significant public funding from the start, the former now moving towards greater industry ownership and less public funding. A barrier encountered, due to the lack of capacity of industry to cope with the current workload, has been getting the key people to spend their time in meetings and in the peer review process. The irony is that during the buoyant times when innovation could be thriving, companies do not have the spare resources to consider and implement new ideas. However, the number of new projects using collaborative relationships in the industry is steadily increasing.

5. Conclusions

From a historical perspective, it has been proposed that innovation in construction procurement in New Zealand has occurred organically through the involvement of various enlightened individuals. Though the industry in New Zealand is small and new ideas and ways of working can spread relatively easily, traditional approaches to procurement are dominant in many sectors, with associated inefficiencies often in evidence. In order for innovation to spread more rapidly, a coordinated approach was needed and the paper has described the various aspect of an initiative to facilitate innovation in construction procurement. The initiative was established in collaboration with industry and used as its foundation the evidence available from existing best practice projects. A process has been described by which the learning from such projects is captured. The KPI results from a national benchmarking initiative will further underpin the business case for procurement innovation and help towards achieving the overall objective: improving the efficiency and culture in New Zealand construction.

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Targeting Constraints and Improving Performance in Singapore Construction

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Abstract

The construction industries in many countries are besieged with constraints such as low productivity, lack of cost control, low level of standardisation, low quality control, lack of training and the inability to meet schedule. The main constraints in Singapore's construction industry need to be identified, so that appropriate actions may be taken to improve the industry. The objectives of this research are (1) to identify issues that cause constraints and challenges to companies, and affect their ability to improve their business activities; and (2) to investigate whether different players in the construction industry, viz. clients, consultants, main contractors, specialist contractors, subcontractors and suppliers, face the same problems. An industry wide survey revealed that all the 41 issues identified in the study significantly affect them. The industry has, collectively, also identified top main constraints to be 'client focus on lowest price at tender stage' and the 'narrow profit margins in construction business activities'. It is recommended that solutions be found to overcome many constraints in the construction industry, especially those relating to benchmarking performance, corporate development, and improving relationships and profitability.

Keywords: challenges, construction industry development, problems, constraints

1. Introduction

The main constraints in Singapore's construction industry are low productivity, heavy reliance on foreign workers, multi-layered subcontracting, and the industry's poor safety record [1]. The industry's productivity growth rate is also very low: it recorded negative productivity growth rates from 1995 onwards. The productivity problems are attributed to factors including a heavy reliance on an unskilled foreign workforce. Another influencing factor is the multi-layered subcontracting system adopted in the industry where over 91% of registered firms in 1998 employed less than 50 people. A third factor is the segregation of design from construction owing to the predominance of

the traditional system of procurement. The lack of involvement of contractors in the design process often leads to less buildability, maintainability and safety, as well as reworks and increased costs.

The objectives of this research are (1) to identify issues that cause constraints and challenges to companies, and affect their ability to improve their business activities; and (2) to investigate whether different players in the construction industry, viz. clients, consultants, main contractors, specialist contractors, subcontractors and suppliers, face the same constraints. The importance of this paper is that the results provide some insights into the actions that should be taken in improving the construction industry.

2. Possible constraints and challenges

A literature search was undertaken to identify the issues that cause problems and challenges to companies operating in the construction industry. For brevity, only some of these issues are discussed below. In many countries, the main constraint that the construction industry faces is low productivity. In the USA, construction productivity has been on the decline since the 1980s [2]. As a consequence, the cost of construction has increased by 50% over the inflation rate [3].

A world-wide phenomenon in the construction industry relates to an ‘obsession’ with the lowest cost. Many studies through the years have pointed out that tender price or initial capital cost dominate the final contractor selection decision, and less attention paid to other contractors’ attributes [4, 5]. Other constraints faced by the construction industry include lack of cost control, low level of standardisation, low quality control, lack of training and the inability to meet schedule [6].

From the literature review and collective experience of the authors, 41 possible issues that are likely to cause constraints and challenges to companies, and affect their ability to improve their business activities were identified. There is a need to ascertain to what extent these constraints affect Singapore’s construction industry and from there, suggestions to overcome the constraints may be given.

3. Research Methodology

A questionnaire was designed, to find out to what extent the issues identified were significant. The first part of the questionnaire comprised introductory questions for data classification. The second part of the questionnaire consists of statements regarding the possible constraints and challenges that prevent companies from achieving significant improvements in their business activities (see Appendix 1). Respondents were asked to indicate the effect of these constraints on a seven-point Likert scale, where 1

represented ‘strongly affect company’s ability’, 4 indicated ‘neutral’, and 7 stood for ‘no effect at all’.

In this study, there were six population frames comprising: clients, consultants, main contractors, specialist contractors, subcontractors and suppliers. The different groups were studied because they occupy different positions in the construction chain, and have different power and influence in the development process. They are also subjected to different sets of problems and challenges.

The samples were selected randomly from published directories and websites. The survey package comprised a cover letter, the questionnaire, and a pre-stamped and self-addressed envelope. A pilot study was conducted prior to the full-scale industry-wide survey.

4. Results

A total of 1815 questionnaires were sent out and 200 (response rate of 11%) usable returned questionnaires were received. The characteristics of the respondents are summarised in Table 1.

Table 1 Summary of characteristics of respondents

Characteristics	Number	Percentage (%)
DESIGNATION		
Upper management	86	43%
Middle management	72	36%
Professionals	23	11.5%
Others	19	9.5%
TOTAL	200	100
CONSTRUCTION EXPERIENCE		
≤ 6 year	32	16%
7-15 years	62	31%
> 15 years	106	53%
SIZE OF CONSULTANTS		
Professional staff	Median= 5 staff	
Technical staff	Median= 12 staff	
SIZE OF GENERAL CONTRACTORS		
Paid up capital ≤ US\$3 million	32	76%
Paid up capital > US\$3 million	10	24%

From Table 1, it can be concluded that the survey captured the interest of people who play major roles in the construction industry. They were also holding senior positions in their firms, and had practised in the construction industry for a long period of time.

Mean ratings were calculated from the feedback received (see Table 2). Statistical t-tests of the mean were carried out to check the entire population's (construction industry participants in general) likely response to the issues raised in the questionnaire, based on the sample's ratings. The results showed that all 41 issues significantly affect the companies' ability to improve their business activities (see Table 2, at $p \leq 0.05$)

Besides the overall mean, the mean ratings were also calculated for the six different categories of respondents. Analysis of variance (ANOVA) was carried out to ascertain whether different construction industry participants have different views about the issues presented, at 0.05 significance level. The ANOVA revealed that seven issues were not rated in the same manner (see Table 2). Even though the different groups have different objectives, this small number of differences shows that for the majority of the issues the different groups of respondents had perceived the constraints and challenges in a similar manner.

The issues that were not rated in the same manner could be divided into two groups. In the first group, clients and consultants felt that the issues affected them, but main contractors, specialist contractors, subcontractors and suppliers (collectively known as contractors) felt that these issues affected them to a lesser extent. The issues that fall in this group are as follows: high number of unskilled foreign workers employed by contractors and sub-contractors (H24); low level of use of IT in your company (H32); lack of standardised system of classifying and sharing of information to allow increased usage of IT (H33); and high start-up cost of IT implementation in the company (H34).

In the second group, contractors felt that the issues prevented them from achieving business improvements, but clients and consultants were affected to a lesser extent. These issues are as follows: client focuses on lowest price at tender stage (H16); current standard conditions of contracts do not create positive working relationships on projects (H9); and allowing too many companies to tender for any single job or project (H14).

The above shows that different respondents in the construction chain are more concerned about their immediate needs, and have thus focused on problems that affect them directly. This meant that concerted effort to improve the construction industry may be difficult, as parties are still unwilling to adopt holistic approach to solving problems.

5. Discussion

5.1 Benchmarking performance

Six constraints were classified under the 'benchmarking performance' heading. From

the ratings, the third most serious issue in the construction industry is the relative ease for poor performing companies to enter the market (H4). Currently, unskilled workers, and poor performing contractors and consultants are allowed to operate in the construction industry. The fact that poor performers are in the industry is because clients allowed them to be in there, when they emphasise low cost, at the expense of quality.

In the absence of benchmarks, clients would not have proper standards to judge the quality of these players and may not know if they will be getting value for money when engaging them. Another constraint faced is the relative ease for poor performing companies to enter the market. The low barrier of entry would mean that incompetent firms continue to operate in the industry. To overcome lack of benchmarking problems in the construction industry, it is recommended that the Building and Control Authority starts a performance measurement system.

5.2 Relationship

The survey revealed that there is a lack of collaborative culture in contracting. Organisations are reluctant to develop long-term business relationships. Clients have the tendency to call fresh tenders for every new project, and subject contractors whom they have prior business relationships with, to competitive tenders. Hence, there is no incentive to develop long-term business relationships. It was also found that the current standard conditions of contract do not create positive working relationships on projects. Adversarial relationships are known to affect overall productivity negatively [7].

To transfer risks to contractors, clients are introducing modifications to standard conditions of contract to reduce their risks. This makes it difficult for contractors to improve their business activities. The modifications may increase the adversarial relationships which are already present in many projects. C21 has therefore recommended that there should be minimum modification to the standard contracts, and this addresses the worry of the respondents about this matter.

5.3 Profitability

The two most significant constraints in the construction industry relate to monetary matters: client focuses on lowest price at tender stage (H16) and narrow profit margins in construction business activities (H17). Tender evaluation that focuses on lowest tender would mean that other contractors' attributes such as quality delivery, are overlooked. The narrow profit margins arise because of fierce competition from many tenderers. The successful contractor may thus not have the resources to deliver the results that would satisfy the client and end users.

From the result, it is not encouraging to know that construction firms find it difficult to make a profit. While tendering gives the client the advantage of competitive pricing and also forces contractors to control cost and maintain a profitable position [8], the client's quest for the lowest price caused profit margins to drop to unrealistic levels, leading to a compromise in project quality.

5.4 Working conditions

Poor working condition is another serious constraint in the construction industry. Arditi and Mochtar [6] found that in the USA, it is becoming more difficult to employ qualified labour. Foreign workers from developing countries, looking for a source of income, would have to be hired. The dirty-dangerous-dreadful (3-D) image of the construction industry can to some extent be improved by using more prefabrication and nurturing a pool of local workers in selected areas by suitable promotion and training programmes [1].

5.5 Productivity and quality

Construction sector's low productivity, as compared to other sectors of the economy, is well known. Arditi and Mochtar [6] found that it is necessary for designers to minimise on-site activities, by increasing the use of prefabricated and precast components. This also leads to easier management of quality and project control. Buildable designs can be achieved through constructability reviews [9] and design reviews [10]. Recommendations to increase construction productivity include hiring skilled workers, setting a minimum buildability level, having incentive schemes to encourage prefabrication and encouraging modular dimensions [1].

The results also show problems with low quality, arising mainly due to the use of unskilled labour. The presence of unskilled and untrained workers in Singapore is not unique. In the USA, unskilled labour abounds, and proper trained labour is becoming scarce, leading to a crisis in the quality of the work performed [6]. Substandard works and frequent reworks arise due to the use of semi-skilled workers [11]. These quality deviations may account for up to 12.4% of total project costs [12]. The government's tightening of entry of unskilled foreign workers together with levying a high tax on these unskilled workers will force contractors to employ skilled workers.

5.6 Innovation and IT

Studies have shown that R&D is important to improve business activities. However, there is still a low level of investment that companies give to R&D. In particular, Singapore companies may still have the mindset that R&D activities and funding should

come from the government.

The results show constraints relating to low IT usage (H32), the lack of standard system of classifying and sharing information (H33) and high start-up cost (H34). Many firms in the construction industry use IT for simple word processing and spread sheet functions, and do not exploit its other potential such as e-commerce, Internet and emails. The use of IT is important, especially in projects of high complexity, in order to ensure that there is proper control system, with accurate and timely input data [13].

5.7 Corporate development

The respondents felt that they do not have the ability of develop long-term business strategies (H38), and there is a lack of objective measures that can allow the monitoring of progress within the business (H39). Finally, there is a lack of strong leadership from major clients to improve performance of the construction industry (H40). There is a need to return to the fundamental question ‘why should the industry improve its performance?’. The reason should not be because ‘the government says so’ or ‘because it is good for the economy’. Consultants, contractors and suppliers must be put in a situation that they want to improve their performance because it is demanded by the clients, i.e. it makes commercial sense to improve. Therefore, clients should take the lead to demand for better performance from construction industry players.

Due to Singapore’s small construction market, respondents are aware of the need to undertake more overseas projects. The survey shows that what the players need are access to reliable information about the international construction markets (H35), and helping them to compete in overseas markets (H36) in order to clinch more overseas projects. Besides encouraging firms to form consortia to compete overseas [1], there is a need for private firms to take the plunge and rely less on the Singapore government to help them thrive overseas.

6. Conclusion

The research revealed that the construction industry in Singapore faces many constraints. These issues cause challenges to companies’ ability to improve their business activities. The three most significant issues are: client focuses on lowest price at tender stage; narrow profit margins in construction business activities; and relative ease for poor performing companies to enter the market.

While Singapore already has a construction blue print in the form of C21 report [1], the recommendations in C21 do not address all the constraints uncovered in this study. The implication of this finding is that there is still some way to go, to solve the other

problems in the construction industry. Singapore may need another blue print to complement C21, in order to bring the construction industry to a world class standard. However, while the Singapore government can provide some assistance, ultimate, the initiative, drive and direct action must come from the firms themselves.

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Appendix: Possible problems and challenges

Ref	Problems and challenges
BENCHMARKING PERFORMANCE	
H1	Lack of ranking for <i>contractors</i> according to their performance and quality of work.
H2	Lack of ranking for <i>material suppliers and component manufacturers</i> according to their performance and quality of work.
H3	Lack of ranking for <i>professional advisers</i> according to their performance and quality of work.
H4	It is relatively easy for poor performing companies to enter the market.
H5	Lack of licensing system for contractors.
H6	Lack of formal code of conduct for contractors, developers and some professionals in industry.
RELATIONSHIP	
H7	Lack of effective involvement of the client during the design process.
H8	Lack of effective involvement of the client during the construction process.
H9	The reluctance of organisations involved in construction projects to develop long-term business relationships.
H10	Current standard conditions of contracts do not create positive working relationships on projects.
H11	Modifications to standard conditions of contract by clients and developers.
H12	Lack of cooperation and understanding among professionals.
PROFITABILITY	
H14	Allowing too many companies to tender for any single job or project.
H15	Extensive use of competitive tendering in construction contracts.
H16	Client focuses on lowest price at tender stage.
H17	Narrow profit margins in construction business activities.
H18	Domination of large/ complex projects by foreign firms.
WORKING CONDITIONS	
H19	Image of the construction industry as being dirty, demanding and dangerous.
H20	Difficulty of providing a safe and decent working environment for workers involved in construction activities.
H21	Difficulty of attracting and retaining Singaporean workers.
PRODUCTIVITY & QUALITY	
H13	Moves to encourage increased use of DB contracts.

Ref	Problems and challenges
H22	Productivity of the construction industry compares unfavourably with the rest of the economy.
H23	Current building designs do not allow for high buildability.
H24	The high number of unskilled foreign workers employed by contractors and sub-contractors.
H25	Number of foreign workers (skilled and unskilled) employed by the contractors and sub-contractors.
H26	High level of tolerance towards defects in construction.
H27	Low level of satisfaction of the company's clients and customers.
H28	Low quality of graduates joining your company.
INNOVATION & IT	
H29	Lack of a national body to spearhead R&D effort in industry.
H30	Low level of investment and priority the company gives to R&D.
H31	Lack of incentives to encourage creativity and innovation in construction.
H32	Low level of use of IT in your company.
H33	Lack of standardised system of classifying and sharing of information to allow increased usage of IT.
H34	High start-up cost of IT implementation in the company.
CORPORATE DEVELOPMENT	
H38	Ability of construction companies to develop a long-term business strategy.
H39	Lack of objective measures that can allow the monitoring of progress within the business.
H40	Lack of strong leadership from major clients to improve performance of the construction industry.
H41	Lack of impetus for change in construction.
H35	Access to reliable information about the international construction markets.
H36	Ability of your company to compete in the overseas markets.
H37	Potential of construction companies to be world-class.

Table 2 Statistical analysis of the problems

No.*	Overall Mean				Means of individual groups of respondents						ANOVA	
	All respondents N= 200	Rank	t-value	Sig.	General Contractor N= 42	Sub-contractor N= 26	Specialist Contractor N= 33	Supplier N= 24	Consultant N= 48	Client N= 27	Sig.	F-value
H16	2.14	1	-17.999	0.000	1.825	1.8	1.813	2.043	2.295	3.2	0	4.26
H17	2.45	2	-15.222	0.000	2.5	2.375	2.219	2	2.558	3	0.19	1.51
H4	2.46	3	-16.513	0.000	2.357	2.654	2.576	2.435	2.455	2.308	0.92	0.29
H14	2.49	4	-14.658	0.000	1.952	2.692	2.273	2.652	2.652	3.038	0.04	2.45
H15	2.62	5	-13.309	0.000	2.4	2.48	2.594	2.478	2.659	3.2	0.35	1.12
H21	2.7	6	-11.618	0.000	2.714	3.154	2.636	2.739	2.467			
H40	2.72	7	-12.974	0.000	2.625	2.542	2.781	2.609	2.721	3.08	0.76	0.52
H24	2.79	8	-10.845	0.000	3.05	2.64	3.25	3.174	2.432	2.2	0.04	2.45
H31	2.83	9	-12.607	0.000	2.333	3.077	3.182	3	2.756	2.923	0.07	2.11
H6	2.85	10	-11.988	0.000	3.143	2.269	2.576	3.217	2.822	3	0.07	2.12
H38	2.88	11	-12.428	0.000	2.85	3.167	2.75	2.652	2.805	3.12	0.61	0.72
H10	2.9	12	-10.803	0.000	2.714	2.28	2.848	2.522	3.311	3.52	0.01	3.37
H22	2.91	13	-11.429	0.000	3.024	2.958	2.727	3.087	2.87	2.808	0.91	0.31
H12	2.93	14	-11.016	0.000	2.69	2.923	2.758	3.13	3.152	3	0.61	0.73
H19	3.05	15	-8.439	0.000	2.846	3.125	3.063	3.045	3.4	2.64	0.44	0.96
H18	3.07	16	-7.738	0.000	2.821	3.04	2.656	3.304	3.295	3.44	0.36	1.11
H11	3.12	17	-9.645	0.000	2.952	2.833	3.063	3.087	3.182	3.68	0.21	1.45
H25	3.13	18	-8.822	0.000	3.167	2.731	3.364	3.652	3.152	2.654	0.09	1.94
H41	3.14	19	-9.617	0.000	3.095	3.48	3.03	3.609	3.043	2.808	0.18	1.54
H9	3.15	20	-8.261	0.000	3.048	2.92	3.031	3.273	3.279	3.36	0.83	0.43
H39	3.2	21	-9.076	0.000	3.275	3.25	3.031	2.913	3.326	3.28	0.75	0.53
H2	3.22	22	-8.389	0.000	3.286	3.28	3.394	2.913	3.261	3	0.74	0.55
H3	3.24	23	-8.224	0.000	3.214	3.192	3.424	3.087	3.217	3.308	0.95	0.22
H1	3.25	24	-7.799	0.000	3.143	3.08	3.545	3.174	3.261	3.269	0.8	0.46
H30	3.27	25	-7.479	0.000	3.333	3.28	3.545	3.435	3.065	3.038	0.62	0.71
H34	3.27	26	-7.272	0.000	3.381	3.231	3.061	4.304	3.022	2.923	0.01	3.52

No.*	Overall Mean				Means of individual groups of respondents						ANOVA	
	All respondents N= 200	Rank	t-value	Sig.	General Contractor N= 42	Sub-contractor N= 26	Specialist Contractor N= 33	Supplier N= 24	Consultant N= 48	Client N= 27	Sig.	F-value
H7	3.28	27	-7.187	0.000	3.119	3.28	3.061	3.348	3.364	3.64	0.66	0.65
H23	3.3	28	-8.042	0.000	3.262	3.115	3.727	3.522	3.222	2.923	0.15	1.65
H37	3.33	29	-6.42	0.000	3.2	3.5	3.25	3	3.279	3.84	0.4	1.04
H29	3.4	30	-5.332	0.000	3.05	4.083	3.194	3.478	3.578	3.167	0.12	1.76
H20	3.43	31	-5.46	0.000	3.095	3.731	3.531	3.636	3.4			
H8	3.43	32	-6.032	0.000	3.262	3.4	3.29	3.739	3.511	3.48	0.77	0.5
H26	3.46	33	-4.794	0.000	3.381	3.84	3.303	3.87	3.478	3.04	0.38	1.07
H5	3.47	34	-5.162	0.000	3.667	3.44	3.455	3.522	3.4	3.308	0.94	0.26
H33	3.47	35	-5.776	0.000	3.429	3.76	3.394	4.217	3.333	2.923	0.01	3.06
H35	3.5	36	-4.287	0.000	3.025	4.25	3.323	3.565	3.622			
H13	3.5	37	-4.436	0.000	3.049	3.52	3.813	4.043	3.435	3.44	0.18	1.54
H28	3.53	38	-4.781	0.000	3.714	3.615	3.394	3.565	3.4	3.48	0.9	0.32
H27	3.53	39	-4.519	0.000	3.548	3.423	3.394	4	3.432			
H36	3.66	40	-2.838	0.01	3.55	3.8	3.656	3.304	3.864			
H32	3.67	41	-3.509	0.000	3.667	3.615	3.727	4.217	3.867	2.808	0.01	3.4

* The problem numbers correspond with those shown in the Appendix.

Effect of severe acute respiratory syndrome on the construction industry

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Abstract

The objectives of this research are: (1) To find out the preparedness level of the construction industry during the Severe Acute Respiratory Syndrome (SARS) outbreak in Singapore; (2) To assess the threat pose by SARS on the construction industry during the SARS outbreak in Singapore; (3) To evaluate the effectiveness of the anti SARS measures that were implemented in the construction industry; and (4) To recommend other possible effective measures that can be implemented in the future to guard against SARS. The research methodology employed in the study consisted of a questionnaire survey. Data were collected from contractors, consultants and clients. Results showed that the preparedness level of the construction industry was good and the precautionary measures implemented were effective. Recommendations on possible precautionary measures that can be adopted in the future to guard against SARS are provided to allow the construction industry to have better preparation for future SARS invasion.

Keywords: Severe Acute Respiratory Syndrome, precautionary measures, epidemic.

1. Introduction

Singapore was plagued by the severe acute respiratory syndrome (SARS) between March and May 2003. A total of 205 contracted SARS and 33 people died of it [1]. Singapore reported the fifth largest number of SARS cases after China, Hong Kong, Taiwan and Toronto. This unexpected epidemic outbreak wreaked havoc in Singapore, causing a direct impact of 2% drop in its gross domestic product (GDP) [2] and creating a greater uncertainty to the already dampened economy.

Since there has not been any report on the effects of SARS on construction industry, it is not known whether SARS has posed a threat to the construction industry and how prepared the construction industry was towards SARS. Even if the preparedness level is sufficient, it is not

known if the precautionary measures that they have taken to prevent the spread of SARS were effective. There may be more effective measures, which have not been explored. Therefore, it is vital to investigate the impact of SARS on the construction industry, the preparedness level of the construction companies and the effectiveness of the current precautionary measures implemented as well as the potential precautionary measures that may be feasible.

The objectives of this research are: (1) To find out the preparedness level of the construction industry on SARS during the SARS outbreak in Singapore; (2) To assess the threat pose by SARS on the construction industry during the SARS outbreak in Singapore; (3) To evaluate the effectiveness of the anti SARS measures that have been implemented in the construction industry; and (4) To recommend other possible effective measures that can be implemented in the future to guard against SARS.

2. Research method

A sample survey was used to gather the necessary information required for this study. In order to obtain an overall view of the effect of SARS on construction industry, four groups of target respondents were selected for the study. They included the contractors, consultants, clients and other construction-related services participants (e.g. facilities management).

The contractors were selected through personal contacts and from the Building Construction Authority (BCA) Contractors Registry website using the purposive sampling technique. In the case of the non-contractors (consultants, clients and other construction-related participants), they were selected through personal contacts and from Singapore Yellow Pages 2003 using purposive sampling method. A total of 120 survey forms were sent to the various participants to gather the required data for analysis. These comprised 60 contractors, and 20 each of consultants and clients. The distribution pattern of the sample ensured that equal attention was paid to both the contractors and non-contractors. Questionnaires were sent by post or emailed to the firms, and returned via the same routes. The survey was conducted from September to October 2003, and respondents were given one month to complete the questionnaires.

The questionnaire design consisted of four sections to facilitate data collection. Section A asked general questions to determine the characteristics of the respondents. Section B asked respondents about the level of preparedness of various companies in construction industry. On a scale of 1 (which represents poor) to 5 (which represents outstanding), the respondents were requested to indicate the preparedness level of his company during the SARS out break in Singapore. In the second part of this section, the respondents were requested to rate the impact of SARS as a threat to construction industry, on a 5-point scale where 1= totally agree and 5= totally disagree. Section C provided a list of precautionary measures implemented in construction industry during SARS outbreak and respondents were asked to indicate their effectiveness on a 5-point scale where 1= totally not effective and 5= very effective. In Section

D, the respondents had to rate new precautionary measures to guard against SARS in construction industry in future on a 5-point effectiveness scale.

3. Data Sample Characteristics

120 survey questionnaires were posted or emailed to the various participants in the construction industry. A total of 63 forms were returned, giving an overall response rate of 53%. Among these, 58 responses were usable. The profile of respondents is shown in Table 1. Contractors formed the majority of respondents.

Table 1 Characteristics of respondents and their firms

Respondents' characteristics	Frequency	Percentage*
Nature of firm (predominant)		
Design and consultancy	13	22.4
Construction	33	56.9
Client	12	20.7
Designation		
Top management	2	3.5
Middle management	22	37.9
Professionals and supervisors	34	58.6
Years in Industry		
Up to 5 years	23	39.7
6-10 years	17	29.3
11-15 years	7	12.1
16-20 years	5	8.6
> 20 years	6	10.3
Presence in Singapore during SARS outbreak		
Yes	58	100
No	0	0
Involved in projects during SARS outbreak		
Yes	58	100
No	0	0
Experience with Home Quarantine Order		
Yes	12	20.7
No	46	79.3
You or your staff contracting SARS		
Yes	1	1.7
No	57	98.3

* Rounding off error may have occurred.

The respondents were considered knowledgeable to respond to the survey. All of them were in Singapore and managing projects during the SARS outbreak. Their involvement in construction projects would allow them to have a clear account of the activities that happened in the construction sites during the SARS period and strengthened the reliability of their responses.

4. Results and Discussion

The one-sample t test was first used to test the four areas in concerned: whether the preparedness level is adequate, whether SARS is a threat to construction industry and whether the precautionary measures implemented or suggested for the future are effective.

4.1 Preparedness of construction industry for SARS

The one-sample t test is first conducted on the preparedness level of construction industry on SARS. The preparedness level of companies on SARS has a high mean value of 3.897 (out of 5.0), at $p = 0.000$. This infers that the preparedness level of the construction industry on SARS is well above an adequate level. However, this finding differs from Loosemore's [3] finding that many construction companies have a low state of crisis preparedness.

One of the reasons for such good preparation is the intervention of Government. As Leung and Ooi [4] explained, the Government has launched intensive public education and awareness campaigns nationwide via the media such as newspaper, television and radio stations to raise the public awareness about this new respiratory illness. In addition, with effect from 16 June 2003, the Ministry of Manpower (MOM) had required employers to ensure daily temperature-taking for all workers at construction worksites employing more than 25 workers and foreign worker dormitories. It has also introduced a series of precautionary measures to keep workplaces free from SARS [1]. Ministry of Health, on the other hand, has too disseminated critical information about the disease to all workplaces. With proper education on SARS through different distribution channels, employers know that they have a role to play in containing this modern epidemic. Hence, they will spare no effort in maintaining the highest level of vigilance against SARS by taking precautionary measures at the workplace to prevent any import or export of the disease and raise the construction industry preparedness level as a whole.

4.2 Impact of SARS on the Construction Industry

Respondents were requested to rate the impact of SARS on the construction industry on SARS (see Table 2). All the eight test variables have $p > 0.05$. It is concluded that SARS has not posed a negative impact on the volume of construction demand, work flow of construction sites, productivity and quality of construction works and finally, the morale, motivation and absenteeism of the workforce.

In addition to the economic repercussions from the Iraq war, the Asian economy is dealt a further blow with the outbreaks of SARS. As such, investment analysts and economists have slashed economic growth and prospects of Asian countries. Some have even described the SARS outbreak as the biggest crisis since the Asian Economic Crisis in 1998 [4]. Without a doubt, Singapore economy suffered as well. However, the respondents felt that SARS did not

aggravate the already weak construction industry, which was already suffering negative growth before, during and after SARS outbreak.

Table 2 One-sample t Test on possibility of threats imposes by SARS.

SARS was a threat to company as:	Mean	t	Rank	p (1-tailed)
The volume of the construction project to tender reduced	2.569	-2.916	4	0.998
The work flow on site and office was affected, causing delay in construction works	2.966	-0.231	2	0.591
The work flow on site and office was affected, causing cost increase in construction works	2.793	-1.369	3	0.912
The quality of the construction works reduced	2.052	-7.801	7	1.000
The productivity of the workforce reduced	2.793	-1.318	3	0.904
The morale of the company workforce reduced	2.397	-4.211	5	1.000
The motivation of the company workforce reduced	2.310	-5.019	6	1.000
The absenteeism of the company workforce increased	3.172	1.166	1	0.124

The reason for such finding could be because Singapore had kept a close watch on SARS and responded fast to counter and contain this epidemic disease. As commended by Dr Jody Lanard and Dr Peter Sandman, risk communication consultants in Princeton, New Jersey, “In terms of managing urgent health problems, Singapore was the master of this in the SARS crisis.” [5]. Furthermore, Singapore’s actions also alleviate public’s fear for SARS and even injected more confidence into investors doing business in Singapore. Singapore then Prime Minister Goh Chok Tong also praised Singaporeans for their ‘fearless effort’ to fight SARS and they should take pride in how they had impressed the investors and the rest of the world [6].

As a result, the main parties in construction industry, and the building developers, did not lose confidence in Singapore building economy too. The construction companies and investors went ahead with their planned schedules or projects on hand. Most of the employees also went to work as per normal. Hence, the demand did not fall, sentiments of the construction workforce were not affected significantly and the productivity and quality of the construction works remained satisfactory. On the whole, the construction industry has not been significantly affected by the SARS outbreak.

As the survey was conducted only a couple of months after SARS had hit Singapore, the full impact of the SARS outbreak on construction sector may not yet be felt. There may be delay effects of SARS outbreak on the construction industry.

4.3 Precautionary measures implemented

Respondents were asked to rate the effectiveness of the precautionary measures implemented in construction industry (Table 3). All the precautionary measures have $p = 0.000$. It is concluded that all the precautionary measures taken are effective.

Among the top four most effective precautionary measures, three of them are related to temperature-check. This finding is accordance with the current most effective method of early detection of suspected SARS cases acknowledged by Government [7]. The effectiveness of informing and educating employers and employees to help prevent the spread of SARS at the workplace is self-explanatory. Proper education of both employers and employees on the disease can certainly serve to allay fear, thwart misleading rumors and prevent panic among the workforce, as well as help foster better understanding of the disease [4].

The three least emphasized precautionary measures identified are: urge employers not to send staff for work assignments or training in SARS-affected countries, urge employers to temporarily hold back rotation of staff from Singapore to SARS-affected countries and vice versa and introduce a system to facilitate contact tracing.

Table 3 Results on effectiveness of precautionary measures implemented

Precautionary Measures implemented in construction industry	Mean	t	Rank	p (1-tailed)
Inform and educate employers and employees to help prevent the spread of SARS at the workplace	4.138	15.917	3	0.000
Guard against the import of SARS through foreign workers who stay in Malaysia but commute to work in Singapore daily	3.931	9.218	6	0.000
Quarantine for 10 days all new Work Permit holders and Employment Pass holders entering Singapore from SARS-affected countries	3.897	7.489	7	0.000
Quarantine for 10 days existing work permit holders and Employment Q-pass holders who visit SARS-affected countries on their return to Singapore	3.966	8.191	5	0.000
Work with employers to isolate, ring-fence and contain infection in the event of an outbreak of SARS at the workplace	3.879	8.185	8	0.000
Take the temperature of all workers at construction worksites employing more than 25 workers, at least once a day	4.414	16.569	1	0.000
Maintain a temperature log of all workers	4.345	15.433	2	0.000
Ensure that workers are housed in dormitories which have instituted temperature-taking procedures and keeping of temperature logs	4.052	9.462	4	0.000
Urge employers not to send staff for work assignments or training in SARS-affected countries	3.879	7.979	8	0.000
Urge employers to temporarily hold back rotation of staff from Singapore to SARS-affected countries and vice versa	3.810	7.284	9	0.000
Introduce a system to facilitate contact tracing	3.707	4.724	10	0.000

The respondents felt that holding the staff from going overseas or holding back rotation of staff may not be as effective as the rest of the measures because this will further disrupt the work routines of the companies. Instead of holding the staff back, the respondents advocated that the individual going overseas should play a more active and responsible role in maintaining his vigilance in his daily lives by leading a healthy lifestyle and practicing good personal and public hygiene. This will be a more effective measure to guard against SARS.

Introducing a system to facilitate contact tracing is the least emphasized precautionary measure because the construction industry still relies heavily on subcontracting [8], and that it is especially difficult to keep track of all these personnel entering and leaving the construction sites. To enable the optimum utilization of each worker during each working day, the labor subcontractors' workers are transferred quickly from site to site. Hence, personnel entering and leaving the site may not be same everyday and this makes it difficult for contact tracing.

4.4 Possible precautionary measures for the future

Nine precautionary measures that are practiced in other industrial sectors to guard against SARS or other epidemic diseases are suggested by the author (see Table 4) as potential anti-SARS measures that can be adopted by the construction industry in the future. The respondents were requested to rate these measures using the same scale as the precautionary measures implemented. Among the nine possible precautionary measures suggested, all except two have a $p < 0.05$. Hence, it is concluded that these seven precautionary measures suggested to guard against SARS in the future are effective.

To encourage workers on site to have a healthy diet is not considered effective as most respondents commented that they have no control over the food consumed by the workers. Moreover, the construction workers in Singapore are of different nationalities and each may have different preferences for food. Hence, it will be difficult to set a standard of healthy diet for each of them.

Some Japanese contractors in Singapore conduct morning exercises as a warm-up for the daily routine work. This study showed that conducting morning exercises for the workers and staff to reduce their chances of contracting SARS is also not effective. Hence most respondents do not consider morning warm-up exercises as a viable mean to strengthen an individual's immune system and makes him healthier.

The most effective precautionary measure that the respondents hope to implement in the near future is to conduct routine checks on construction sites' hygiene level more than once daily. With a cleaner working environment, the site management and workers not only can safeguard their own health; it also helps to minimize any adverse impact on construction operations if they

have to stop work due to poor hygiene or sanitation. The neighborhood will also feel assured, knowing that the construction site and its workers followed strict hygiene standards [9].

Table 4 Results on effectiveness of possible precautionary measures in the future

Possible precautionary measures to be implemented in the future	Mean	t	Rank	p (1-tailed)
Introduce a system to facilitate contact tracing that is specially tailored for construction contractors	3.414	2.507	6	0.008
Produce a detail manual on the procedures for handling suspected SARS cases	3.569	3.747	4	0.000
Include SARS prevention precautionary measures in the planning stage of a new project	3.483	3.569	5	0.001
Send pamphlets regarding SARS matters regularly to sites	3.655	5.270	2	0.000
Conduct routine checks on construction sites' hygiene level more than once daily	3.810	6.530	1	0.000
Encourage workers on site to have a healthy diet	2.983	-0.131	8	0.448*
Encourage workers on site to wash their hands more frequently	3.345	2.351	7	0.011
Conduct morning exercise for the workers and staffs	2.517	-3.404	9	1.000*
Issue personal thermometer to every personnel on site	3.638	4.017	3	0.000

5. Summary and Conclusion

Severe acute respiratory syndrome (SARS) has plagued Singapore for the first few months of 2003. It has affected the daily routine and working progress of the construction industry. Although there have been studies on the effects of SARS on Singapore on a nationwide basis, there has yet been a study that examines the effects of SARS on the construction industry. It is not known if SARS has posed a threat to the construction industry and whether the construction industry has prepared itself against SARS. Even if the construction industry is prepared, it is not known if the precautionary measures taken are effective. There may be more effective measures, which have not been explored. In view of this, this study is conducted to investigate the four issues mentioned above.

Using a structural questionnaire, data were collected from contractors and consultants, clients and other construction related services participants (non-contractors). The locality of respondents and their involvement in construction project during the SARS outbreak period in Singapore were first sought to ensure the relevance of the data gathered for this study. Secondly, their awareness level towards SARS was also investigated.

Next, the preparedness level towards SARS, the impact of SARS as a threat to construction industry and the effectiveness of current precautionary measures practiced and potential measures recommended were investigated. The one-sample t test was conducted to test these four issues in concerned.

The results of the one-sample t test confirmed that the preparedness level of the construction industry is sufficient and adequate. One of the main reasons is the intensive public education and awareness campaigns launched nationwide by the government through the media such as newspaper, television and radio stations. In response to the effort made by the government, the employers spared no effort in maintaining the highest level of vigilance against SARS by taking precautionary measures at the workplace to prevent any import or export of the disease and raise the construction industry preparedness level as a whole.

Secondly, the one-sample t test showed that SARS has not posed a threat to the construction industry. The reason for such finding could be because Singapore had kept a close watch on SARS and responded fast to counter this epidemic disease. As a result, the main parties in construction industry, and the investors, did not lose confidence in Singapore. They went ahead with their planned construction schedules and projects. Most of the employees also went to work as per normal. Hence, on the whole, the SARS outbreak has not appeared to dampen the construction industry activities significantly. However, there are concerns that it is still too early to gauge the impact of SARS on construction industry. The full impact of the SARS outbreak on construction sector may have yet to be felt. There may be delay effects of SARS outbreak on the construction industry. Hence, more studies have to be conducted to further ascertain that SARS has not posed a threat to construction industry.

One-sample t test also confirmed that all the current precautionary measures implemented to keep the workplaces SARS free are effective. Conversely, seven out of nine possible precautionary measures recommended are rated effective. Most of the respondents felt that it is difficult to encourage workers on site to have a healthy diet as they have no control over the food consumed by the workers. Furthermore, it is not viable to set a standard of healthy diet for the workers who came from different countries and have different preference for food. Similarly, the respondents disagree that doing morning exercise would help, as this served as a warm-up for the daily routine work only. It is not possible to strengthen ones health and reduce his chance of contracting SARS through this morning exercise.

This study is beneficial in three ways. First, the study has shown that SARS did not pose a threat to the construction industry. This may be because it the syndrome was only in Singapore for three months. Secondly, it provides a better understanding of the crisis preparedness of the whole construction industry during the SARS outbreak period. The study has shown that construction companies were responsive to adopt additional measures and were well prepared for the SARS crisis.

Lastly, this study has also confirmed that the current precautionary measures are effective in preventing SARS. In addition, other possible precautionary measures that have been practiced in other sectors to deal with SARS or other epidemics are also feasible in construction sector. Should SARS strike again, the construction industry will have better and more effective measures to defend itself against SARS.

Based on the findings, it is recommended that contractors increase their routine checks on the construction sites' hygiene level at least twice per day. This is to ensure that the construction sites maintain a high standard of hygiene and sanitation to prevent the transmission and spread of infectious diseases within the premises. In addition, designing of SARS posters and pasting them on construction site will raise the SARS awareness level among workers. This will help to keep the construction site SARS free as well.

It is also recommended that clients include SARS prevention precautionary measures in the planning stage of a new project. This will enable the consultants and contractors to have better preparation for any suspected SARS case that occurs during the planning or construction stages. Both the clients and consultants are also encouraged to aid in raising the awareness level of the construction workers and operation staffs by sending pamphlets regarding SARS matters and updates to construction sites.

It is also suggested that the relevant organization within the construction industry (for example BCA) should introduce a system to facilitate contact tracing that is specially tailored for the construction contractors. It should produce a detailed manual on the procedures for handling suspected SARS cases in construction sites. This will benefit the construction industry, as the parties in construction sector will have adequate understanding of the necessary procedures required.

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Challenges of Best Practices for Constructability Implementation: North Cyprus Construction Industry

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Abstract

Constructability can be defined as the optimum use of construction knowledge and experience in planning, design, procurement, and field operations to achieve overall project objectives. Constructability, the integration of construction expertise into all phases of a project, can benefit cost, schedule, quality, and other key objectives. Most organizations participating in the construction industry informally integrate construction knowledge and experience in their planning and design activities. In developing countries, many owners that do not apply formal constructability programs on projects are unaware of the potential savings that are being lost by unnecessary rework, reduced quality, lower construction productivity, and increased schedule durations. Our research focus is to investigate the challenges and opportunities of best practices for constructability implementation in a developing country, the case of North Cyprus Construction Industry. We aim to 1) determine current constructability implementation practices and identify elements that contribute to successful implementation, 2) assess the existence and severity of barriers to constructability implementation and 3) propose methods for overcoming common barriers to constructability in the construction industry of a developing country and develop a framework of best practices for constructability implementation in North Cyprus construction industry. Our research includes review of background literature, interviews with managers on building projects, analysis of this information to develop findings, and extending these to develop a framework of best practices for improving constructability implementation in a developing country, North Cyprus. By carrying out an effective constructability review process in a framework of best practices, the owners and contractors will be able to optimize construction costs, time, quality and safety whilst ensuring minimum interference to existing site operations. This will assist with maintaining consistently high construction performances in North Cyprus construction industry.

Keywords: Constructability, best practices, performance improvement, North Cyprus.

1. Introduction

1.1 Background

Constructability has been defined as ‘the extent to which the design of a building facilitates the ease of construction, subject to the overall requirements for the completed building’ [1]. Constructability is the optimum use of construction knowledge and experience in planning, design, procurement, and field operations to achieve overall project objectives. Constructability concept is an important tool in improving the quality of a product by controlling for better constructability implementation. Product, being in desired quality is reflected in the growing demands placed on building. The built environment must be constantly developed so that the targets set by residents and the community is attained and the building expresses cultural and environmental values. The importance of the quality of the completed project is growing all the time. The constructability concept encompasses the fulfilment of developer expectations, cost and time savings, ease of construction, functional and technical durability. The owner is responsible for the end product. A good building is the one that will remain serviceable for as long as possible, it will be economic to maintain, and as energy efficient as possible during both construction and use.

Many research efforts have investigated different aspects of constructability analysis. Some researchers have focused on identifying broad constructability concerns and developing constructability improvement approaches and programs [2,3,4,5,6,7]. Others have focused on identifying design-relevant constructability knowledge to automate constructability analysis of 3D models similar to this research [8,9,10,11]. Fischer developed an automated decision support tool that provides feedback to designers on how well a designed structure considers the requirements of construction methods [8]. Fischer presented a Construction Knowledge Expert (COKE) that guides designers towards designing structures that are more constructable [12]. Patty et al. presented a computer tool that utilizes a multimedia to give the designer the capability of accessing constructability information at the point of design [13].

Constructability is increasingly becoming a major requirement in building practice. The industry’s clients are continuously demanding the best value for money, in terms of the efficiency with which the building is carried out. Most organizations participating in the construction industry informally integrate construction knowledge and experience in their planning and design activities. In developing countries, many owners that do not apply formal constructability programs on projects are unaware of the potential savings that are being lost by unnecessary rework, reduced quality, lower construction productivity, and increased schedule durations. Recognizing constructability issues early in the project delivery process can help to identify design constraints that limit a constructor’s ability to plan and perform construction operations effectively resulting in suboptimal project performance and increased construction costs. Today, project teams often perform constructability reviews during the design phase to ensure that construction knowledge is incorporated in the design process and constructability problems are minimized.

1.2 Constructability Reviews

Constructability Review is the phase of construction project management where an independent and detailed analysis of all of your contract drawings and construction documents is conducted before their release for construction. This critical process evaluates the “ability to construct” the project. The purpose to conduct a constructability review is simply because, during a typical construction project, the design phase can take months or even years to complete in developed countries, while the design phase takes shorter time in developing countries. The problem is that, a contractor’s level of expertise and knowledge is introduced at the end of the design phase, mostly by the end of procurement phase, during the time when you bid and award projects to the contractors in order to commence the construction phase. Delaying this vital and project critical review until the later stages of the project can lead to inefficiencies. At worse this will lead to cost overruns, time overruns, substandard building quality, or even structural failure. By the aid of the review, opportunities may arise to perform a framework of best practices for constructability implementation.

1.3 Best Practices for Constructability Implementation

Application of the Constructability Concepts to a capital facilities project can be expected to reduce project costs and schedule while improving quality and project safety. Returns on investment of greater than 10:1 were widely reported. Constructability implementation tools and the roadmap for a corporate or project constructability program were shown in Construction Industry Institute (CII) Special Publications 34-1-*Constructability Implementation Guide* and RS34-2-*Preview of Constructability Implementation* [14]. As demonstrated in the case studies summarized in the publications, when methodically implemented, front-end constructability efforts were an investment that results in a substantial return. Documentation of constructability efforts showed that owners accrued an average reduction in total project cost and schedule of 4.3 percent and 7.5 percent, respectively. These savings represented a 10 to 1 return on the owner’s investment in the constructability effort.

In order to commence a formal constructability program, the owners, clients or employers should be acknowledged by professions about the necessity of a formal comprehensive system and enforce them to seek a formal constructability approach. Constructability review conducted in the early stages of a project is useful in detailed analysis of all of the contract documents and construction project drawings and documents before their release for construction. The process involving a constructability implementation should be commenced with the beginning of the design phase of a construction project, sometimes even before the design phase may be useful to assess feasibility of the project in an earlier stage (before the design is commenced) and should be implemented during the construction phase until the delivery of the project. Benefits of early involvement in constructability implementation should be known by the owners in order to obtain a good performance in terms of time-cost quality triangle. Applicability and improvement of constructability approaches are directly related to the approach of the project stakeholders to the constructability concept. For improvement of constructability approaches commence of

constructability practices by the involvement of all project stakeholders is of great importance. On the other hand, cost of constructability practices for a specific project should be predicted in order to select the appropriate method or model for constructability implementation.

1.4 The Case: Overview of the North Cyprus Construction Industry

Construction industry in North Cyprus is aware and recognizes the need to modernize in order to tackle the severe problems it is encountering, namely, Profitability, Research and Development, Training, Price and Cost, Dissatisfaction of Clients and Fragmentation. The necessary conditions for competitiveness for the North Cyprus construction industry include strong and sustained levels of productivity growth, openness to innovation and new technology and a commitment to delivering value for clients' money. There is growing interest in the role of innovation within the North Cyprus construction industry [15]. Compared with other industries, there are constraints placed on innovation within construction because of the characteristics of the industry. These include the adversarial culture and fragmentation of the different participants in most construction projects, the project based nature of construction. Projects are discontinuous and temporary and there are often poor linkages between project and business processes. Also the environment within which most organizations operate is changing rapidly. Organizations failing to adapt and respond to the complexity of the new environment tend to experience survival problems, sooner or later. In this climate of change, the development, implementation and use of adequate performance measurement and management frameworks is one of the major challenges confronting organizations but can play an important role in their success.

Contractors typically hire subcontractors, who do not have contracts with the owner - even if the owner pays a high price, the subcontractor may still have to work with inadequate budgets, often compromising quality as a result. Communication tends to be via the contract. Essentially, the designer is paid to produce a design expressed in the form of specifications and drawings. The contractor is expected to use these as a means of communication, and produce the completed facility. This communication often does not work as well as it should have. Innovation is adopted very slowly. Contractors often lack the expertise or financial resources to adopt technological advances - adoption is inhibited further by fear and uncertainty. Few large companies and virtually no small companies have implemented the concept of a quality or productivity manager – the traditional approach is to depend on the experienced staff to run projects efficiently; such staffs are rarely if ever trained in optimization techniques. Profit margins are low and discontinuous in construction industry. Research and development activities carried out by contractors are insufficient. In-house training is not meeting the requirements of firms. Most of the clients are not aware of the difference between price and cost. Thus at the bidding process the lowest offers submitted are preferred by most owners. Projects are unpredictable in terms of timely delivery, within budget and to the required quality standards.

2. Objectives of the Study

Most organizations participating in the construction industry informally integrate construction knowledge and experience in their planning and design activities. In developing countries, many owners that do not apply formal constructability programs on projects are unaware of the potential savings that are being lost by unnecessary rework, reduced quality, lower construction productivity, and increased schedule durations. Our research focus is to investigate the challenges and opportunities of best practices for constructability implementation in a developing country, the case of North Cyprus Construction Industry. We aim to 1) determine current constructability implementation practices and identify elements that contribute to successful implementation, 2) assess the existence and severity of barriers to constructability implementation and 3) propose methods for overcoming common barriers to constructability in the construction industry of a developing country and develop a framework of best practices for constructability implementation in North Cyprus construction industry.

3. Research Phases

The research includes review of background literature, interviews with managers on building construction projects, analysis of this information to develop findings, and extending these to present the key strategic issues that could be targeted for continuous improvement within construction firms in North Cyprus Construction Industry in terms of constructability. The empirical data was collected through structured interviews within the main large private sector construction organizations. The paper deals with the results of a questionnaire survey conducted by research members of European University of Lefke (EUL) Department of Civil Engineering MSc. in Construction Management Program. Main topics in the questionnaire were as follows:

- i. General information about organizations
 - § General functions of service areas
 - § Size of organizations
 - § Work capacity
 - § Firms' turnover
 - § Work force information
- ii. Establishment of Corporate Constructability Program
 - § Identifying constructability sponsor/champion
 - § Establishing functional support organization and procedures
 - § Developing lessons-learned file
- iii. Planning Constructability Implementation
 - § Developing constructability team
 - § Identifying and address project barriers
 - § Consulting applications matrix and lessons-learned file
 - § Developing constructability procedures and integrate into project activities
- iv. Implementing Constructability
 - § Applying constructability concepts and procedures
 - § Monitoring and evaluating project program effectiveness
 - § Documenting lessons learned

- v. Updating Corporate Program
 - § Evaluating corporate program effectiveness
 - § Modifying organization and procedures, updating lessons-learned databases

3.1 Literature Review

This stage involves a thorough review of literature about the implementation of performance measurement systems that include measures adapted to constructability and that can be a real driver for continuous improvement of project processes. The intensive literature review resulted in the identification of constructability concepts affecting the phases of *Planning* (Strategic Plan/Preliminary Feasibility/Final Feasibility), *Design* (Program or Conceptual Phase/Pre-Schematic Phase/Design Development Phase/Construction Document Phase), *Construction* (Site work/Shell/Interior), *Procurement* and *Occupancy* [14]. The concepts are;

- (a) Constructability program is an integral part of project execution plan
- (b) Project planning involves construction knowledge and experience
- (c) Early construction involvement in development of contracting strategy
- (d) Project schedules are construction-sensitive
- (e) Basic design approaches consider major construction methods
- (f) Site layouts promote efficient construction
- (g) Project team participants responsible for constructability are identified early-on
- (h) Advanced information technologies are applied throughout project.
- (i) Design and procurement schedules are construction-sensitive
- (j) Designed to enable efficient construction
- (k) Design elements are standardized
- (l) Specifications are developed for construction and procurement efficiency
- (m) Designed for modularization & preassembly to facilitate fabrication & transportation
- (n) Designed for accessibility of personnel, materials and equipment
- (o) Designed for construction in adverse weather and remote locations
- (p) Design and construction sequencing should facilitate system turnover and start-up.
- (q) Contractor use of innovative construction methods

3.2 Data Collection

The second stage involved the collection of data. A questionnaire survey, which was administered to almost all the firms, which are registered to the Association of Building Contractors, has been used in conducting the survey. The survey includes four main types of information involving *Organizational Structure*, *Establishment of Corporate Constructability Program*, *Planning Constructability Implementation*, *Implementing Constructability* and *Updating Corporate Program*.

1. Organizational structure: General company characteristics were sought which include the general functions of service areas of the organizations, size of the organizations involving the production, firms' turnover, number of permanent employees, human resources and development and target group of customers.

2. Establishment of Corporate Constructability Program: This portion of the questionnaire was used to address the steps necessary in establishing a corporate-level constructability program for contractor organizations. The three steps are *Identifying constructability sponsor/champion, Establishing functional support organization and procedures* and *Developing lessons-learned file*.
3. Planning Constructability Implementation: This portion of the questionnaire was aimed to analyze the steps leading to effectively planning for constructability implementation. The four steps are *Developing constructability team, Identifying and address project barriers, Consulting applications matrix and lessons-learned file, and Developing constructability procedures and integrate into project activities*.
4. Implementing Constructability: This portion of the questionnaire was aimed to study the steps for implementing constructability. The three steps are *Applying Constructability Concepts and Procedures, Monitoring and Evaluating Project Program Effectiveness, and Documenting Lessons Learned*.
5. Updating Constructability Program: This portion of the questionnaire was aimed to investigate the steps for updating a corporate program. The two steps are *Evaluating corporate program effectiveness* and *Modifying organization and procedures, updating lessons-learned databases*.

The questionnaire was designed using a nominal scale for the real values of the independent variables. In evaluating the dependent variables, a scale of 4 intervals (with a '0' value given to no effect, '2' to a middle value, and '4' given to maximum effect). The respondents were asked to check a number on the scale, which reflects their assessment regarding the different factors (constructability concepts and barriers). A list of all contractor organizations within the construction sector was obtained from the Association of Building Contractors. The list consisted of a total of 30 organizations. An attempt was made to contact every single organization. In this particular survey, the sample size $n = 20$. During the survey 30 organizations were contacted and 20 (66%) of these questionnaires were evaluated. Contact personnel in the companies for the questionnaire survey were either the top management or senior management in their respective departments, therefore their level of knowledge expected to provide responses was acceptable for the purpose of validity of the survey results.

4. Findings

This section of the study discusses the opportunities and challenges of the implementation of constructability implementation considering construction firms' strategic planning as well as to the conditions for the North Cyprus construction industry to lesser the barriers for constructability implementation.

4.1 Determination of Importance Indices

The participating contractors provides numerical scoring concepts expressing their opinions on the significance of each concept in determining the establishment, planning, implementing and updating the constructability program and presenting the key strategic issues that could be targeted for continuous improvement within construction firms in North Cyprus Construction

Industry. The weighted average for each factor was calculated and then it was divided by the upper scale of the measurements in what is referred to as “important index” therefore the level of importance of the fourteen factors of the seven phases of the constructability implementation process were calculated using the formula [16]:

$$\text{Level of Importance (Index)} = [\Sigma(aX) \times 100] / 4$$

a= the score given to the factor by each organization (varying from 0-4)

X= n/N

n= Frequency of organizations

N= Total number of participant organizations

						PLANNING			DESIGN					CONSTRUCTION			PROCUREMENT		OCCUPANCY	

Table 1. Matrix showing the variations in the level of Importance Indices of the factors

Table. 1 shows a matrix of variations in level of important indices of the factors (constructability concepts and barriers) during the constructability implementation phases. The X-axis of the matrix indicates the processes categorized into five phases. The three concepts believed to have influences on the constructability implementation process were listed in the Y-axis of the matrix with their index values. The matrix also includes the calculated sum, mean and the rank orders of

all the phases of the process listed at the bottom of X-axis with their index values. Studying the matrix the first three concepts carrying the highest level of importance are; *Advanced Information Technologies are applied throughout project*, *Project planning involves construction knowledge and experience* and *Project team participants responsible for constructability are identified early-on*. In observing the three highest ranked phases of the processes, it can be noted that all these phases belong to the “Design” process and carry almost similar level of importance. These are; *Design Development Phase*, *Schematic Phase* and *Program or Conceptual Phase*. The Level of Importance Indices for the concept “Advanced Information Technologies are applied throughout project”, the Level of Importance Indices for the concept “Project planning involves construction knowledge and experience” and the Level of Importance Indices for the factor “Project team participants responsible for constructability are identified early-on” are shown in Figure 1., Figure 2. and Figure 3. respectively.

4.2 Discussion of the Survey

The concept “Advanced Information Technologies are applied throughout project”, is ranked #1 and is found to have an influence on the “Pre-schematic Phase” considerably with a value of importance index, 57. This indicates that there must be an efficient utilization of Information Technology tools for the storage of historical data. These data are stored by computerized databases. These databases must include lessons learned from the constructability program as part of the project control system (e.g. budget amounts, change orders, and purchase orders).

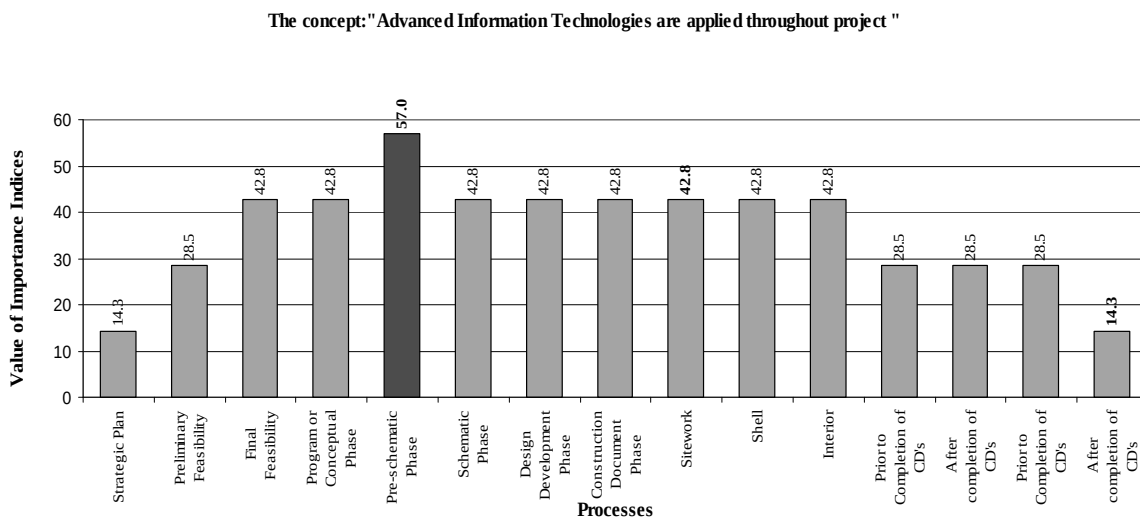


Figure 1. Level of Importance Indices for the concept “Advanced Information Technologies are applied throughout project”.

The concept “Project planning involves construction knowledge and experience”, is ranked #2 and is found to have an influence on the “Program or Conceptual Phase” considerably with a value of importance index, 57. This indicates that gaining knowledge from past experience is essential to any successful constructability program. Lessons learned are usually communicated

by project kick-off meetings, informal conversations, project meeting notes and post-project review meetings.

The concept “Project team participants responsible for constructability are identified early-on”, is ranked #3 and is found to have an influence on the “Schematic Phase” considerably with a value of importance index, 57. This indicates that at the design phase an organizational chart must be drafted identifying the constructability team participants and delineating their roles.

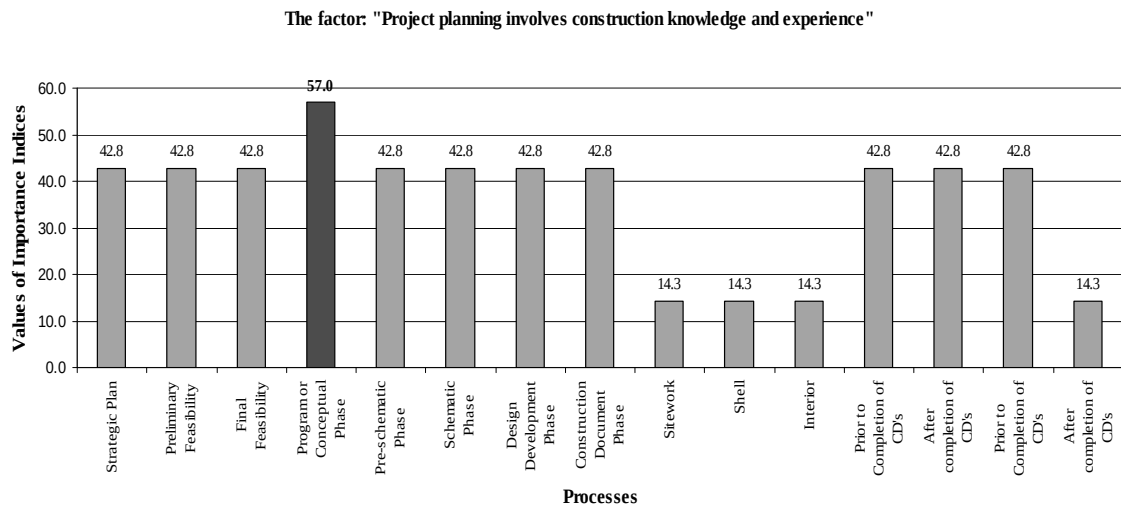


Figure 2. Level of Importance Indices for the concept “Project planning involves construction knowledge and experience”.

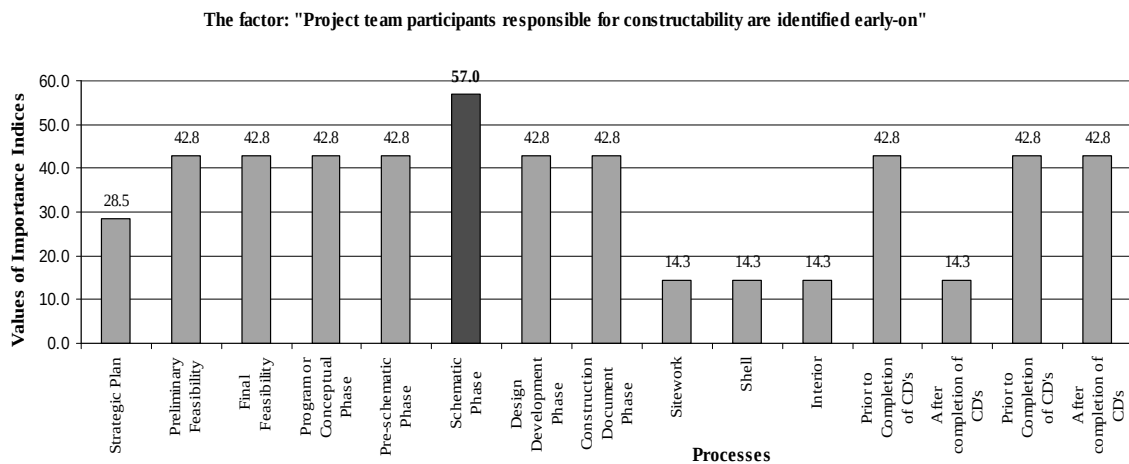


Figure 3. Level of Importance Indices for the concept “Project team participants responsible for constructability are identified early-on”.

The survey verifies that the *design* sets the pattern for all that follows. A ‘good’ design will mean that a ‘good’ project will follow but a good fabrication and installation cannot compensate for a poor design. It needs to be recognised that design goes through various stages, i.e. concept,

scheme, feasibility, detail and production drawings. Furthermore, between each of these stages there is often a break in time, sometimes a change in responsibility and there can even be a change in philosophy and priorities. What has to be achieved therefore is a transition between these various stages without a break, or at the very least with strong links and ties, whilst clearly identifying the responsibilities within each stage. It is important to identify those areas, which, the design must take cognisance of if maximum efficiency is to be obtained.

5. Conclusions

This paper investigates the challenges and opportunities of best practices for constructability implementation in a developing country, the case of North Cyprus Construction Industry. The findings verify that by carrying out an effective constructability review process in a framework of best practices, the owners and contractors will be able to optimize construction costs, time, quality and safety whilst ensuring minimum interference to existing site operations. This will assist with maintaining consistently high construction performances in North Cyprus construction industry. It is found that the concepts “Advanced Information Technologies are applied throughout project”, “Project planning involves construction knowledge and experience” and “Project team participants responsible for constructability are identified early-on” hold the highest level of importance. From the phases point of view, “*Design Development Phase*”, “*Schematic Phase*” and “*Program or Conceptual Phase*” are the three phases of the “Design” process to be highly affected by the concepts mentioned above.

In North Cyprus, clients are increasingly becoming aware of the benefits of constructability review. They require buildings to be completed on time and within the tender price. These buildings should be of sufficient quality and easy to operate and maintain. Good constructability has been shown from experience to speed up construction, improve standards and lower costs. The time or cost ‘saved’ in the design process by inadequate attention to constructability is, lost over and over again during construction. Poor constructability can lead to lower standards of construction. The more complex the assembly of the structure is, the greater the number of operations and specialist trades required. New developments in the construction industry highlight the importance and continued relevance of constructability.

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Section II

Shaping Companies with
New Managerial Solutions

Best practices – development and implementation

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Abstract

The construction sector deals with huge possible combinations in the use of materials, construction methods, contractual forms, involvement of partners, expertise, etc. The management team in a construction process will be challenged to both satisfy the client demands and to fulfil the operations with a positive return on invested resources. The key to success in such complicated processes would be to minimize expedient options by standardization of processes and structural parts including educational activities for all involved disciplines. Skanska is developing best practices for the purpose to improve the professionalism within the company and to guide involved management levels in awareness and procedures of both “doing the right things” and “doing things right”. Dissection and risk assessment of common used materials and structural parts could undermine basic platforms for industries, designers, expertise, etc and would require trustworthy, unassailable expertise and the necessity of involvement from both top management and the academic intellectual capital. The report describes essentials from the identification process of moisture induced problems in construction development processes ending in implementation of results and a moisture plan for business managers, designers and contractors.

Keywords: Standardization, best practice, implementation, moisture induced problems, guidelines, method statements, moisture plan.

1. Introduction

Mould is not a new problem. The incidence of mould has been discussed over many decades and the expression “Sick Building Syndrome” is still in use when the construction sector fails. Moisture is considered to be the main mechanism behind the deterioration of building materials and the cause for mould growth. The mould problem has increased significantly due to shift from robust systems with inorganic materials to more complex systems with many layers of organic materials applied in structures.

Systematic sub optimizations have resulted in a wide range of products in the construction market. The continuous insignificant exchanges of materials in a system as an exterior wall would induce a higher risk exposure. Theoretical considerations would be accurate nevertheless should small defects occur, would materials moisture sensitivity be of great importance.

Analyses of the risk exposure in modern construction of buildings, use of different materials of various degree of moisture sensitivity, the imperfection in weather forecasting, complexity of assembling products under weather shield and resulting in an implementation of more robust products have been a great challenge that will be described in the report.

The management team in a construction process will be challenged to both satisfy the client demands and to fulfil the operations with a positive return on invested resources.

2. Analysis of risk exposure

A Skanska task force with internal and external experts for analyzing the risk exposure for moisture-induced problems in buildings was established 2002. Expert groups were formed for specific studies and focal points appointed from business units involved in the study. The focal points were addressed to handle all contacts to projects and to propose implementation of results from the project.

The first step was to develop a suitable enquiry. All building projects in a construction phase were requested to define used systems in exterior walls, wet rooms, roof structures, basements, basement walls and floor structures. A parallel analysis was set up for detail discussions with site managers about conditions at site, such as planning and control of possible moisture problems.

A probabilistic analysis was performed where the principles of buildings codes were used with the lower 5% fractile as the limit for a low risk structure, see table 1. The assessment took into account both production risks and degradation of materials during the service period. The principle was that building sections should resist mould growth or degradation of organic materials in a 50 year perspective without extraordinary maintenance.

The analysis was focused on moisture mechanics, damages by high moisture load, decrease in material properties, estimated impact on air quality, etc. Material properties were generally lacking nevertheless basic results by Viitanen (1) have been utilized in the categorization of products, see figure 1. Many conditions especially inside structures have been predicted by physical calculations and assumed material properties. The principles for classifying structures were formed by an expert group by description of many typical structures including motivation of the judgment in all sub evaluation steps. Senior experienced engineers were hired to execute the main assessment procedure of enquiries. The results were finally discussed with the expert group for the certification of general findings and for the adjustment of results.

Table 1: Defined risk exposure and principle for estimation of total risk exposure by the combined impact on structural design and sensitivity to moisture during production.

Classified risk exposure	Probability of damage
Low risk	< 5 %
Medium risk	5 – 25 %
High risk	> 25 %

Produktion risk	Estimated total risk exposure in bold			
Low	L * L = L	L * M = M	L * H = H	
Medium	M * L = M	M * M = M	M * H = H	
High	H * L = H	H * M = H	H * H = H	
	Low	Medium	High	Service phase

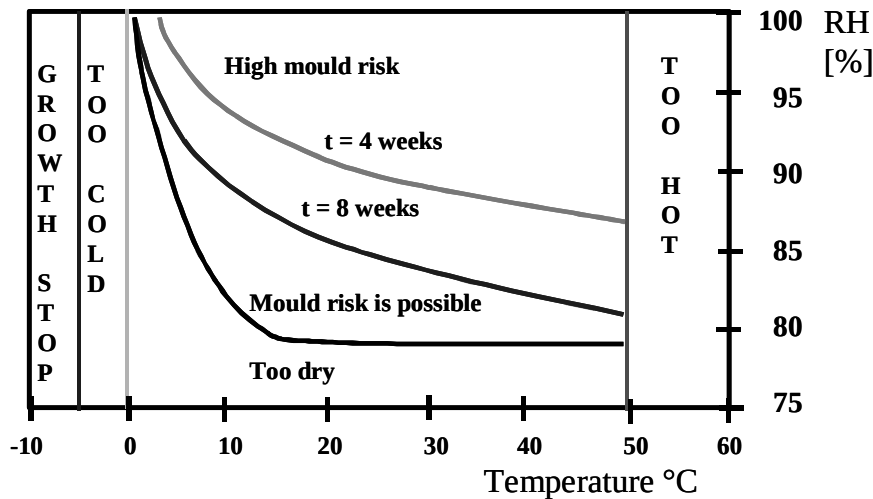


Figure 1: Schematic sketch of possible mould development on painted wood as a function of temperature, relative humidity and exposure time (t). Viitanen (1)

Surprisingly simple structural sections as by way of example exterior wall systems could be varied in more than 250 types even if not all systems were identified. The typical structures of various risk exposures are schematically expressed in figure 2. Cultural differences were observed where the lowest risk exposure was identified in Finland due to their utilization of robust structural systems and materials.

Bathrooms or other wet rooms were generally in the high-risk zone because usages of complex systems with many layers combined with the extremely watery sensitive gypsum plasterboard. The water barrier could consist of various types of membranes some with low ductility properties that would break even with normal movements in structural materials.

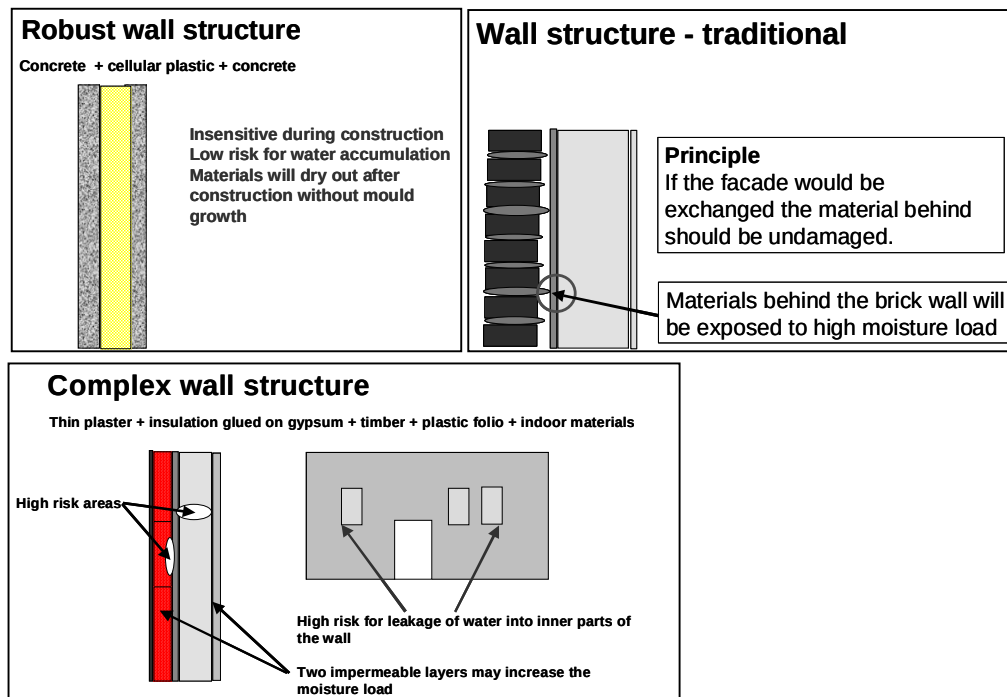


Figure 2: Typical exterior wall structures representing the tree risk exposure grades low (robust), medium (traditional) and high-risk structure (complex).

Theoretically these wet-room structures would be functioning properly conversely the many possibilities to fail would increase the risk exposure significantly. The Finnish system of certification on a personal level for assembling wet rooms with focus on control of membrane thickness, surface slopes etc has been very successful. Arguably assembling both vapour barriers and water membranes, which will encapsulate some materials between two impermeable layers. Detail design for this extraordinary sensitive structural part is normally lacking and enforces construction sites to take decisions and develop details.

Crawl spaces under houses have been in focus later years and many failures have recently been reported in the literature. Earlier when the thermal insulation was moderate these structures were dryer caused by the higher air temperature in the crawl space. The new energy standards have resulted in lower temperatures in these areas and increased relative humidity especially during the summer period. The moisture threshold value for mould growth appears to be exceeded. The recommendation would be to increase the temperature in the crawl space or installation of air-drying equipment.

Roof structures would also suffer from the new energy standards as the increased thermal insulation has resulted in colder attics. Condensations at cold areas are a general problem in new buildings and use of inorganic materials will be constructive.

Basements were earlier storage for household materials and tough processes as building heating systems. The surrounding materials were of the robust type as concrete and stone with excellent functionality in wet and harsh conditions. A change to sleeping and relax rooms in basement

usage has introduced more moisture-sensitive materials in these areas. The recommended structure is of open character with the possibility to dry out even after flooding that would be expected few times in the lifetime. Few designers are skilled in building physics and therefore considerations involving the lifetime perspective would not be handled accurately.

Concrete ground slabs structures have been studied over tree decades and the importance of proper thermal insulation has been implemented in the construction sector. New introduced systems as floor heating would change the moisture load properties negatively and the recommendation would be to study these systems thoroughly before a more general introduction to market. Moisture plan

3. Moisture plan

Development of society as areas of buildings have been disintegrated in several disciplines such as business considerations in the sales and negotiation phase, architecture constructive design in predesign, cost predictions in the tender phase, purchasing and construction in the production phase and finally documentation and delivery to client. Lacking awareness of moisture-induced problems in buildings would trap the possibility to select optimal material alternatives to structural sections. A moisture plan was developed for implementation of existing know-how improved inducement of standardized systems and optimal materials, see figure 3.

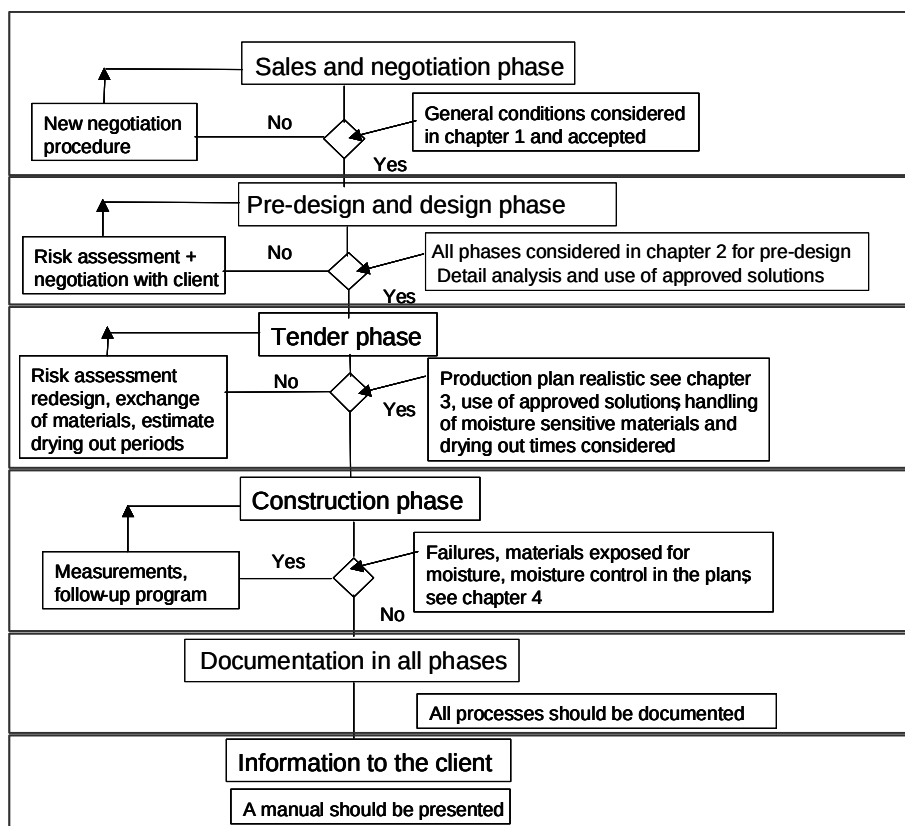


Figure 3: Flow chart of a moisture plan for increased awareness in the construction sector.

4. Implementation

The implementation of technical issues into business-focused employees was a great challenge, especially if the requirement was to reject client proposals in design. The construction market has been totally convinced in that designers would select proper materials with functional properties. On the other hand designers expect the assembly to be carried out in dry conditions, which illustrates the interface problems we have to consider in development of construction systems.

Site managers are also trapped in a cost limit range where exchange of materials would result in higher costs and impossible to achieve. The culture for many years has not accepted interferences from top management to construction sites. Management levels at corporate functions, business operations, purchasing offices and construction site managements have been focused in their optimizations that have resulted in a sub optimization in the holistic view.

In the implementation process the choice was to inform most of the employees of the findings and the risk exposure that would be expected in projects. The aim was to establish a successively change in the production and in business operations. Nevertheless, the transformation to a lower risk exposure was insignificant and a decision was taken to forbid use of specific materials and systems.

A component in the implementation procedure was to develop used best practices. The best practice system has been split in guidelines and method statements. Guideline is a professional information tool for increased awareness and support in selecting procedures aiming in “doing the right things”. Method statements would decrease the efforts in development of manuals and working procedures aiming in “doing things right”. The positive outcome of a best practice system would be the opportunity to focus on prioritized actions as planning of critical steps in the construction process by use of existing know-how.

5. Conclusions

The construction business is acting on a matured market. However, many systems would have been transformed to less moisture robust with increased risk exposure in the endeavour to minimize production costs. A systematic analysis and evaluation of used products and systems have demonstrated the need of increased awareness within the construction sector including all steps from architectural design to assembly of materials. Best practices and standardization would be a tool to improve existing systems and development of products.

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Management of Architects Within Architectural Businesses – Cross Case Study Results

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Abstract

The research formed part of a PhD thesis into the behaviour of architectural businesses and the way the industry reacts to change. The thesis divided this research problem by segregating architects' businesses from the whole industry. The problem was further sub-divided by focusing on architectural businesses that were a particular 'culture'. This sub-division led to the research focusing on four specially selected architectural firms. These firms form the basis for the Case Studies. The research further was limited to an exploration of expectations influencing patterns of behaviour of qualified architects: individually, as a group (as interpreted by the Royal Institute of British Architects (RIBA) Strategic Study) [1] and as a business. This framework modelled the emerging propositions, drawn originally from the RIBA Strategic Study, and enabled the qualitative collection of information from the Case Studies. The RIBA Strategic Study identified a need for architects to change their 'way of thinking', in fact to think more strategically. The RIBA Study was brave enough to suggest the USA model for the industries' future, where architects were developers closing the circle from design through to build. The RIBA Study pointed to some drastic changes that were necessary, (namely the separation of architecture into signature, concept, executive, and construction architects) in the strategic thinking of architects' businesses. The RIBA Study was based around a popular theory, relating to the behaviour of firms, based on work by Coxe et al (1980) [2] in the UK supported the work of Maister in the USA which suggested that firms which superposition are more efficient than firms that stay in the centreground. Coxe's work went on to speculate that there was a design technology continuum that ran from the practice centred businesses (strong ideas) towards the business centred practice (strong delivery) (Maister, 1987. [3]) Maister added those firms that superposition concentrate on a narrow band of technology. The inference being that firms would tend to superposition along the continuum towards being a business centred practice strong on delivery. Rather than adopt the predictive approach used by the RIBA Study a diagnostic approach was preferred by this research. A model of a firm was developed based in Social Learning Theory describing the firm as a human activities system. The object of the model was to explain patterns of behaviour found in firms. This research collected the perceptions of the firm and the perceptions of individual architects within the firm. The intangible nature of this research problem required a sensitive approach by the researcher to correctly interpret the information collected. Social learning theory was used to identify patterns of beliefs within a firm (Denzin 1970) [4] This paper reports on the findings of the cross case study analysis of those four architectural practices using the technique

of social efficiency mapping. Triangulation of the results, using established research techniques identified any patterns that might emerge from the results and assisted in explanation building.

Keywords: Congruence, social efficiency, expectancy theory, superpositioning

1. Introduction

Mapping Social Efficiency was developed in this research and described in detail in, Thompson (2002) [5]. The technique adapts Expectancy Theory to capture the perception and belief individuals attached to goals. The model is based around a matrix of goals, drawn from the application of a fulfilment model of human behaviour and of business behaviour based in the literature. The vertical axis of the Social Efficiency Map includes a hierarchy of typical goals. The horizontal axis is the expectancy of achieving these goals.

2. Modelling Firms' Behaviour

Coxe (et al)'s [2] model distinguishes three main ways in which architectural firms execute their projects (design technologies) and two types of cultures or ethos, which motivate practices (organisational values). This leads to a matrix of six core positionings each characterised by a different mix of appropriate management requirements. In terms of design technology their model distinguishes three types of firm: strong delivery, strong service, strong ideas. In terms of organisational values the model distinguishes, practice centred businesses, business centred practices. "Many (but not all) of Coxe's findings based on their US research are supported by our own UK observations" RIBA (1992) [1] Two main weaknesses were identified by the RIBA of Coxe's model; first it assumes that for any one box only one set of factors will suit; and second it confuses a useful device for reflecting internal or peer group perceptions with a mapping or positioning matrix based on client needs and perceptions.

Winch and Schnieder's (1993) [6] Strategic Model of a business indicates four generic strategies for better than average performance in architectural practice. The first dimension is that of project complexity. This measures how demanding the project is in terms of the sophistication of specification, its size, the rapidity of the work required, or other special client requirements. The second is the client's preference for quality – whether the client chooses to emphasise conception or realisation in determining quality. These two dimensions yield four generic strategies, which articulate particular distinctive competencies. They are; strong delivery, strong experience, strong ideas, strong ambition. Few practices within the industry develop the competence to sustain one of the three main generic strategies – the vast bulk, earning average fees or slightly below, are stuck in the middle, with little ability to distinguish themselves from their competitors.

Georgopoulos' Model (1973) [7] developed a systems approach in terms of an input-output model. In terms of output, organisations are classified into three main types: output is some physical product; output is some service; and those whose output is information. Complex

organisations export all three kinds of output, but rarely to the same degree or in equivalent amount. On the input side organisations import a variety of material and non-material resources and facilities from the environment. A simple input-output model would not be sufficient to explain the critical processes of resource allocation, of co-ordination of effort, of social and psychological integration, and of organisational strain and its management that occur within, the collective level and individual level in an organisation. An organisation may have excellent inputs in terms of quality cost and amount, but a very poor output because these social-psychological processes may be generating dysfunctions and problematic outcomes for the organisation. According to the model it is necessary to examine the problems at the collectivity level, if we are to learn what they mean for the total organisation as a system. It is also necessary to examine them at the individual level in order to understand and explain member behaviour in the system.

Social Efficiency Mapping Thompson (2002) [5] involves mapping the interviewee’s perceptions of reality rather than the reality itself.

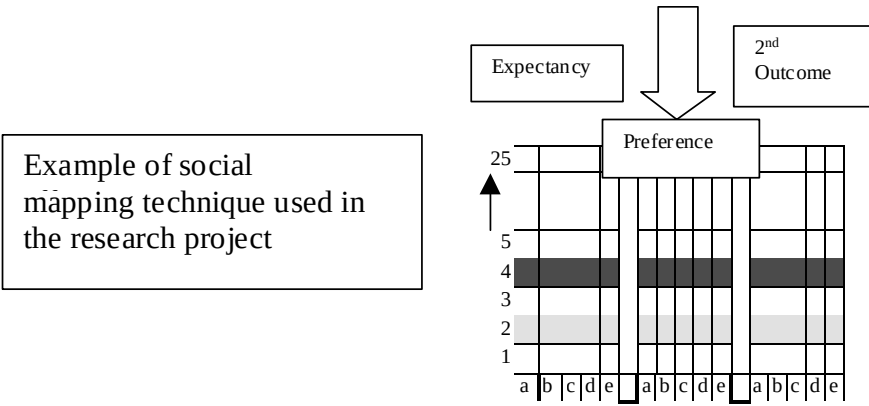


Figure 1 Social Efficiency Map Thompson (2002)

Architects (RIBA) form a homogeneous group of individuals who it is proposed may have a common view of the world, which can be collected, identified and categorised to explain in some part their approach towards business. The effort individuals are prepared to invest in achieving the multiple goals found in organisations has not been mapped previously. This new technique captures individuals’ high level goals and maintenance level goals McGregor (1960) [8] and business goals Barnard (1981) [9] A questionnaire was developed comprising two stages. First, semi-structured interview with a representative of the firm to identify the goals of the firm. Second, a semi-structured interview with the architects in the firm, to establish, first, are the goals of the firm possible, second, do the architects prefer these goals, and third if the firm's goals affect any individual goals of the architects interviewed (Table 1). The researcher carries out an interpretation process developed from Vroom’s (1964) [10] work. Answers collected from the interviews can be positive or negative. The answers are plotted on the Social Efficiency Map (Figure 1). The yellow plots are maintenance goals and the green plots are the motivator goals.

The columns marked a, b, c, d, e are the interviewee's. Where a line appears across the map this is indicative of congruence in the firm about a goal. Where a yellow line forms across the Social Efficiency Map maintenance goals are congruent and where a green line forms across the Social Efficiency Map Motivator goals are congruent.

Case Study A – Traditional Architectural Practice. The firm's skills core is to provide small-scale generalist advice for a wide range of buildings, working in a variety of market sectors. The legal entity of the firm is a partnership, comprising six partners, one of which is the financial manager partner. All partners share equal equity. The line on the Social Efficiency Map (Figure 2) illustrates that goal 12 develop employees potential, merits further investigation as follows:

- The perceptions (expectancy) by individuals of the firm's goals demonstrated conflicts between partners, and between architects. A negative goal was identified for goal 12. The partners were in favour of training but felt threatened the workforce would leave once trained. Lack of policy and structure in training within the firm led to dissatisfaction in the people giving the training and the people who were trained.
- The preference of individuals for the goals of the firm demonstrated how much effort individuals are prepared to contribute to the goal 12, the training policy was not being implemented or leading to advancement in the firm. This lack of commitment by the partners was reflected by the architects 'getting what they can' and leaving.
- Comparison between an individual's secondary outcomes and the goals of the firm identified a conflict arose here regarding goal 12. The partner responsible for training 'had enough' and wanted to design. The architects who had received additional training were concerned this was not recognised. The architects' goals for praise were not being satisfied.

Case Study B – Multidisciplinary Architectural Practice. The firm provides a fully integrated in-house service using in-house specialists comprising project management and co-ordination of the design of highly complex serviced buildings and providing structural and quantity surveying services. They also act as a developer. The legal entity of the firm is a partnership. The lines on the Social Efficiency Map (Figure 2) illustrates that goal 6 gross profits, merits further investigation as follows:

- The perception (expectancy) by individuals of the firm's goals demonstrated uncertainty between partners, and architects. A negative goal was of particular interest for goal 6. A clash arose between partners and the architects because of the policy of not telling staff if the firm makes a profit or not. Architects are not told about any financial matters of the firm.
- The preference of individuals for the goals of the firm demonstrated how much effort individuals are prepared to contribute to goal 6. The partners want the firm to make a profit but it is not, moreover they do not know what to do about it. The secrecy means staff are unaware of the situation and cannot help.
- Comparison between an individual's secondary outcomes and the goals of the firm identified that a conflict arose between competing goals of the firm and the individuals regarding goal

6. The poor financial performance was hidden through partners cutting their personal income. This was kept a secret, perhaps in order to maintain a secondary goal of the partners, which was that of maintaining their image of success.

Case Study C – Named Architectural Practice. The firm's skills core is to provide highly innovative specialist designs. The firm spends a lot of time designing and co-ordinating the design of highly complex serviced buildings and private houses. The line on the map (Figure 2) illustrates that goal 19 completion deadlines, merits further investigation as follows:

- The perception (expectancy) by individuals of the firm's goals demonstrated uncertainty between partners and architects. A negative goal was identified for goal 19. All the architects knew the firm had to hit deadlines and worked very hard to achieve this, working excessive overtime particularly during design competitions.
- The preference of individuals for the goals of the firm demonstrates how much effort individuals are prepared to contribute to goal 19, the need to win competitions was taking a toll on the associate (b) and architect (d). They realised winning these competitions was the only way the firm had to survive. The adrenaline rush after winning the competition was addictive but the requirement for the architects to be personally responsible for the job to completion of the building was very demanding.
- Comparison between an individual's secondary outcomes and the goals of the firm identified all the interviewees felt the strain attached to goal 19. This reduced their capacity to work effectively due to exhaustion. They had no social lives but were beginning to redress the imbalance between work and private life.

Case Study D- "Commercial" Architectural Practice. The client base is commercial type clients acting as project managers and architects for a supermarket chain store. The firm has four directors and is a Limited Company. As this was the only identifiable commercial practice in the RIBA Directory in the correct location this firm was of particular interest. The Social Efficiency Map (Figure 2) initially appears to be of little use. The firm employs two architects, one of which refused to participate in the study. The line on the map (Figure 2) illustrates goal 2 earnings, is investigated as follows:

- The perceptions (expectancy) by individuals of the firm's goals demonstrated conflicts between the manager (f) and the firm. A problem was identified for goal 2. The firm could not be any more efficient. The firm does not employ competent staff at a lower level so could not give them more responsibility and the firm will not pay 'decent wages' to get better staff.
- The preference of individuals for the goals of the firm demonstrated how much effort individuals are prepared to contribute to the goal 2. The firm's policy of cutting overheads in order to maintain profit in a falling market was seen by staff as making them work harder for no reward. Commitment of staff was therefore low.

- Comparison between an individual's secondary outcomes and the goal 2 of the firm to move into new markets was supported, but the idea that the firm was able to compete in this new market was questioned. The new work would be difficult to learn and the firm was not geared up to train people. Initially this would cause earnings to drop. Management would then cut overheads, would not invest more capital in retraining staff and the firm would be back in crisis mode. It is best to 'wait and see' if things don't improve it is best to leave the firm.

3. Triangulation

The research model needs to be validated in order to compare contrast and interpret the results gathered in the semi-structured interview process by multiple sources of evidence. The advantage gained is by using converging lines of enquiry through a process of triangulation Yin (1994) [11]. Any finding or conclusion in the case study is likely to be much more convincing and accurate if based on several different sources of information.

- Categorisation of the firm, a study by the RIBA (1993) [12] used Maister's framework to identify the many cultural and operational differences found in architectural practices. The study also categorised firms into stages of development.
- Testing by means of standard questionnaires developed for identifying: personality type; creativity; locus of control and leadership style.
- Perceptions collected by a semi-structured interview developed by this research.
- Participant Observation: contact with the informant is so brief and perhaps superficial and the informants may be misunderstood by the observer. This is minimised by following three stages of analysis, the selection and definition of problems, concepts and indices, the frequency of the phenomena and the incorporation of the findings into the case study.

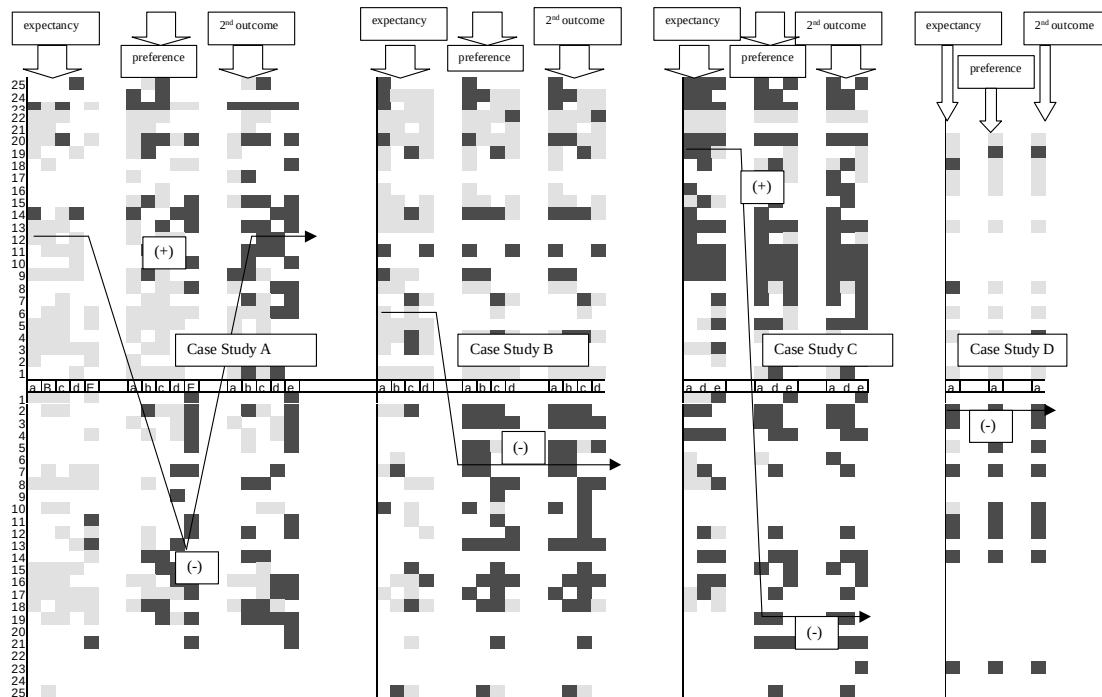


Figure 2: Case Study Results Thompson (2002)

4. Cross Case Study Analysis

A process of triangulation was carried out to identify patterns that emerge from the case studies, and a summary and general conclusion about each case study was made. The proposition is then introduced and the same sequence is followed. pattern matching and explanation building are used to support or question the validity of the proposition.

Case Study A₂ General observations of the Social Efficiency Map (Figure 2), indicate the motivator (green) goals are distributed unevenly between positive and negative goals at the higher levels of goal-seeking behaviour. The maintenance level goals (yellow) predominate at the lower levels of goal-seeking behaviour. A brief analysis of the Social Efficiency describes the firm as chaotic internally with a lot of negative goals held by the architects within the firm. Deeper analysis illustrates the firm thrives on this chaos but contains the stresses and strains generated by the conflict through a high staff turnover. The hold the partners have on the definition of 'good design' acts as a barrier preventing the architects winning any challenge they may have to the partners' supremacy. The consequence of this uneven battle is high staff-turnover, as increasingly confident architects become frustrated with the partners' attitudes to design and move on. This is positive to the firm as it draws in new ideas from the environment through churning staff, rather than strategic thinking by the partners. Social efficiency between the partners is strong but this is not allowed to over-spill into the remainder of the firm because management is strictly retained at partnership level.

Case Study B. General observations of the Social Efficiency Map (Figure 2), indicate the motivator (green) goals are distributed predominantly negatively and occur at the higher levels of goal-seeking behaviour, the maintenance level goals (yellow) only occurring as positive goals. A brief analysis of the Social Efficiency describes the firm as approaching a crisis or revolution point in its life. The senior partner's position is undermined by a lack of belief by the architects in the firm's goals, and a strong secondary belief that the firm should change. This unanimity amongst architects anticipating change constrained individuals acting independently and leaving the firm en masse, so much so that the phenomena of a special language had developed amongst this growing clique. The language had grown out of the stifling of individual expression within the firm through a large number of meetings and an inability to make decisions independent of the meeting. The senior partner keeping secret any financial matters from the rest of the firm compounded this practice of cossetting the staff. The trigger to initiate change is the crisis of falling profits. The policy of partners subsidising the firm by continually reducing their earnings from the firm was undermining the partnership's faith in the senior partner's abilities. The focus for change fell on the partner (b) who interestingly had the most effective management style and very different goals to the senior partner. The pattern of the Social Efficiency Map indicated a firm that was not very socially efficient in terms of a business. The individuals did not feel the goals of the firm were achievable or resulted in any secondary outcome that they wanted. But the very unanimity of this negative perception meant that within the firm was a very Socially Efficient clique, in effect the firm was negatively very Socially Efficient.

Case Study C. General observations of the Social Efficiency Map (Figure 2), indicate the motivator (green) goals are distributed predominantly positively and occur at the higher levels of goal-seeking behaviour. Few maintenance level goals (yellow) are apparent in the firm. A brief analysis of the Social Efficiency describes the firm as very united regarding the higher level self-actualisation goals in the firm while the more common business goals were ignored. The beliefs of the architects appear to be copied from the principal. The language used in the firm meant phrases used like 'quality building' had definite meanings. The principal was considered to be a master and the architects were learning the craft from him. The questionnaires identified all the architects as type A competitive individuals but with an external locus of control. This indicated they believe forces beyond their control are responsible for success. The combination of these forces mixed to form a powerful cocktail of united thought and actions.

Case Study D. General observations of the Social Efficiency Map (Figure 2), indicate the motivator (green) goals are distributed predominantly negatively and occur at the lower levels of goal-seeking behaviour. Few maintenance level goals (yellow) apparent occur positively at the higher levels of goal-seeking behaviour within the firm. A brief analysis of the Social Efficiency describes the firm's goals as contrary to those of the architect's secondary goals. The architect had developed a coping mechanism to divorce himself from the dehumanising environment of the workplace. Only an active life outside work enabled him to survive in the workplace throughout each day. The architect's higher level needs seemed to be satisfied by his Christian beliefs and involvement with the Church, and indeed this may have substituted completely the architect's original motivation to be an architect.

5. Pattern Matching

Systems theory was used to understand the behaviour in the firms and explain its reasons by using the input - transformation – output model Kast & Rosenzweig (1980) [13]. The identification of key characteristics of organisational systems provides a link between the environment and the firm. A set of behavioural patterns can be identified and the outcome of predicted behaviour established. This set of behavioural patterns provides a suitable framework for modelling business behaviour. While not dismissing the validity of other approaches towards modelling business behaviour, the integrated framework offered by the systems theory approach provides a set of behavioural patterns that have been established in previous research. Behavioural patterns identified by systems theory comprise subsystems or components. A system is composed of interrelated parts or elements. This is true for all systems. Every system has at least two of the following elements: Holism, Open systems, Input-transformation-output model, Systems boundaries, Negative entropy, Steady state dynamic equilibrium, Feedback, Hierarchy, Internal elaboration, Multiple goal-seeking, Equifinality. A pattern was seen across all the case studies identifying a relationship between market position and Social Efficiency.

Table 2: Abstract of Goal-Seeking Behaviour and Services Offered, Thompson R F (2002)

Case Study A	Case Study B	Case Study C	Case Study D
Traditional service	Traditional service	Specialist in design	Specialist in design construct
Practice Centred Strong Service	Business Centred Strong Delivery	Practice Centred Strong Ideas	Business Centred Strong Delivery
Multiple goal (Chaotic Negative Entropy)	Multiple goal (Revolutionary Negative Entropy)	Single goal (Entropic)	Single goal (Entropic)

The firms that exhibited multiple goal-seeking behaviour had a very different pattern of goals than those with single goal-seeking behaviour. The input-transformation-output model is used to explain the process in each case study. The outputs are considered as services and identified in terms of strong service, strong delivery or strong ideas. The professional or business culture of the firm is considered as located within the transformation process. The inputs are the jobs that come into the firm.

Case Study A: the firm has varying inputs but maintains the output of a strong service by retaining the transformation process of a professional culture. This leads to chaos internally and a lot of negative goals held by the younger architects. The firm thrives on this chaos containing the stresses and strains generated by the conflict through a high staff turnover. This continual churning of staff at the level of 'architect' draws in new ideas which equip the firm to undertake varying inputs but retains its professional culture giving a strong service to clients.

Case Study B: the Senior Partner is attempting to shift the outputs from strong delivery to strong service and move from a business to a professional culture. The result is a firm approaching a crisis or revolution. The lack of belief by the staff in the successful outcome of the firms' goals supports a strong secondary belief that the firm should return to its established business culture. The situation is manifest in the unanimity amongst architects anticipating change at the top rather than leaving the firm en masse.

Case Study C: inputs are limited to 'enlightened clients'. This is necessary to guard the professional culture which the firm believes enables its output of strong ideas. The firm was united regarding the higher level self-actualisation goals, while the more common business goals were ignored. These strong beliefs appear to be copied from the principal. The firm was totally committed to this way of working, with architects preferring to leave architecture altogether rather than entertain change.

Case Study D: the Managing Director is attempting to shift the outputs from strong delivery to strong service but retain the existing business culture. An inability to attract more of their established inputs is driving the firm towards accepting varied inputs. The architect is sceptical about the firm's ability to learn a new type of work because of the rigidity of the existing transformation process. The architect had disassociated himself from gratifying any higher level goals through work and had developed a coping mechanism to divorce himself from the dehumanising environment of the workplace.

6. Explanation Building

The traditional firm in Case Study A attempted to provide a traditional service to a broad client base. The partners were committed to multiple goal-seeking but limitations in their management skills meant goals were capped to a goal to tackle any job that comes along. The firm avoided entropy because of new ideas drawn into the firm by the continual churning of staff. Social Efficiency of the partners is good, all the partners have the same beliefs and goals. The firm seemingly harmonised its professional culture by its concentration on strong service. The multi-disciplinary firm in Case Study Bs' advantage gained by its multi-disciplinary service was being eroded by the senior partner's reluctance to modernise the firm's working practices. The firm did not appear to be socially efficient and moving towards entropy. Closer examination of the Social Efficiency Map however identified a negative Social Efficiency at secondary level within the firm. The Social Efficiency of this group in isolation is good: the entire group has the same beliefs and goals. The firm has a history of coup d'état and it would appear this is part of a long-term cycle. The conflict between the firms established business culture and the introduction of a professional culture by the senior partner, was compounded by a confusion in output between strong on service and strong on delivery. The named firm in Case Study C was very united regarding the higher level self-actualisation goals, while the more common business goals were ignored. The firm was incapable of displaying the internal elaboration required in a growing firm because of the principal's involvement in every scheme. Inputs were limited to those obtained from

'enlightened clients' and their transformation process was rigid indicating a firm incapable of multiple goal-seeking behaviour. The firm being very much a professional culture strong on ideas. The commercial firm in Case Study D was very defined in the market place but the effect of the Social Efficiency Map was limited as only one architect participated. The internal elaboration of the firm was complex but had grown around a specialist input and the requirement for a specialist output. The firm had become entropic because of its overspecialisation and inability to exhibit multiple goal-seeking behaviour. The result was that the architect had disassociated himself from work. The firm was the opposite of Case Study C. All the goals were at the lower levels and none at the higher levels. The firm was desperate to move towards a strong on service output but retain its business culture. The inflexibility of its transformation process was becoming apparent. Proposition: firms that superposition, are more efficient than firms that stay in the centre ground. The proposition is not supported. Firms may appear on the basis of one measure to be more efficient if they superposition towards strong service, strong ideas or strong delivery. Examination of the Social Efficiency Maps and analysis using the systems theory indicate that those firms that do superposition do not have an even spread of goals preferring to concentrate on higher level goals or lower level goals. The effects of a concentration on higher level goals, typically design, has an effect on stress levels, typically excessive working and fatigue in the staff, an avoidance of multiple goal-seeking behaviour and resulting in a move towards entropy. The effect of a concentration on lower level goals is boredom and a disassociation from work by the employees. The resulting deconstruction of their skills' base combined with an avoidance of multiple goal-seeking behaviour compounds this move towards entropy.

7. Summary and Conclusion

The pressure on management is readily apparent as firms resist the pressure to move along the continuum identified by Coxe towards a business culture. All the firms chosen in the case studies seemed to be crippled by management's inability to exhibit multiple goal-seeking behaviour. Analysis of the spread of goals at strategic level gave them the appearance of mutations of firms rather than the well-balanced well- managed firms one would expect to see. The effect of the proposition was to give an insight into thinking at the strategic level in a firm. Comparing the position of the RIBA Strategic Study in 1993 and the thinking of architects in this study illustrated they had not changed and were not going to change. Architects' businesses remain impermeable to change. Architecture remains a strong professional class separate from the remainder of the industry. This group exhibits strong signs of projecting its own goals into the wider environment in the form of beliefs. This is reinforced by the tradition of design competitions as a method of allocating work within the industry. The initial selection of architectural firms in this way reinforces architects' expectancy of approval from their peers in the world of architecture. The effect of the proposition is to point towards a group of individuals who have a tendency toward group-think.

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Improving Innovation Diffusion: A case study approach to strategy development

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Abstract

The construction industry constantly faces new challenges, which emerge at an ever increasing pace. At the same time, the world of business is full of new management and improvement paradigms, each of which has merits, but which tend to be rapidly replaced with new ones. How can a small/medium organisation find the time and expertise to understand these models and respond accordingly? One solution may be that in future successful diffusion of innovation will be facilitated by positive engagement between higher education institutes and industry and the development of knowledge transfer partnerships (KTPs). The objectives of this paper are to identify activities and processes which facilitate diffusion of innovation in the industry, through engagement, and use experience from examples to develop a strategy for improving innovation diffusion. The paper reviews case studies of successful engagement and knowledge transfer partnerships to develop the model of successful innovation diffusion. The main contribution is a proposed strategy to improve innovation diffusion through the use of “innovation sets”.

Keywords: Knowledge Transfer, Innovation, Diffusion, Industry Engagement, Partnership

1. Engagement & Knowledge Transfer

1.1 Global and Industry Drivers

The ability to foster innovation is frequently cited as the key to a successful modern economy. In the UK, for example, the Department of Trade & Industry (DTI) has stated ‘We find that the competitiveness agenda facing UK leaders in Government and business reflects the challenges of moving from a location competing on relatively low costs of doing business to a location competing on unique value and innovation. This transition requires investments in different elements of the business environment, upgrading of company strategies, and the creation and strengthening of new types of institutions’ [1]. The DTI has developed an innovation strategy in

response ‘Competing in the global economy: the innovation challenge’ [2]. In this it is stated that ‘Innovation, the exploitation of new ideas, is absolutely essential to safeguard and deliver high-quality jobs, successful businesses, better products and services for our consumers, and new, more environmentally friendly processes.’

Given this emphasis on innovation it is worthwhile considering what the key drivers are for change in the construction industry and what are the associated implications of these drivers? If it is true that innovation is necessary for a successful economy and for the competitive advantage of the companies that shape it, it will be those companies that can adapt to these changes that will be successful. In an attempt to analyse the ways in which construction companies have to change, and how this might be accomplished, a review of ‘Constructing Futures and SCRI Strategy’ [3] has been conducted by the Salford Centre for Research & Innovation at the University of Salford. This report considers seven construction future studies from the UK, Sweden, America and Australia. The reports contain many common drivers and implications for the industry as shown in the table below:

Table 1: Most commonly cited drivers and possible implications for the Construction Industry

Drivers	Implications
Ageing Population	Smart Buildings & Material
Flexible Working & Living	Sustainability Agenda
Rise of the Individual	Pre-fabrication/Offsite Manufacture
Globalisation	Mass Customisation
Move to Service Industry	e-Everything
Increased Use of ICT	On-Site Automation
Demand for Lifelong Learning	Customer Focus
Sensors & Communication Technology	House building/Infrastructure
Automation	PFI/PPP
<i>Note: Implications in the right hand column are not necessarily directly linked to the Drivers in the left hand column</i>	Self-Build
	Refurbishment
	Planning Restrictions
	Global Competition
	Investing in People
	Professional Judgement

In considering the need to improve innovation diffusion it is necessary to match the knowledge base of issues in the above table that exists in the University sector with the immediate business needs of companies. In an attempt to test these drivers and implications ‘on the ground’ a futures workshop [4] was run in the NW of England in conjunction with SCRI, Constructing Excellence and nCrisp. The Futures event, which was attended by 13 regional industrialists and 7 academics,

came to broadly the same conclusions as the reports considered in the literature review. The event provided abundant evidence of companies having to adapt to legislation and regulations that are being enacted in response to these drivers. Furthermore, there was agreement that the rate of change required from companies is also increasing. It is against this background that this paper considers the need to improve innovation diffusion from the university as one mechanism that can be used to aid companies in facing up to this challenge.

1.2 The need for Knowledge Transfer

In an increasingly knowledge oriented business environment around the world there is the need for both industry and “knowledge” intensive organisations such as universities to work together to help solve and overcome the problems and challenges that being in business in the 21st Century present. As noted by an executive director of Hewlett-Packard [5], there is a growing opinion in the worlds of academe and industry that the last remaining source of competitive advantage is the development and implementation of new knowledge. Assuming that universities are one location for the development of new knowledge then in order to diffuse this into the world of business where that knowledge will be implemented there is a clear need for industry and universities to engage with each other for mutual benefit.

As has been identified above there are multiple factors driving change in the global economy. What must also change is the relationship which exists between industry and universities. There is a long history of many forms of collaboration – what is required now may be to strategically and deliberately seek relations that will permit the transfer of knowledge and diffusion of innovations. This bringing together of industry and academia will help innovation diffusion but may need to be facilitated through brokerage [6]. In addition, the concept of industry and academia being part of the same supply chain, brought together by an innovation “broker”, is something which has driven the development of the ideas presented in this paper.

1.2.2 Multiple Forms of Engagement

So, engagement between industry and higher education institutes (HEIs) takes a number of different forms and each one may be driven by a different purpose, objectives and ultimately, outcomes. There is an increasing amount, and many different types of engagement that occur which facilitates knowledge transfer between the higher education sector and industry, particularly from a UK perspective [7]. Types of engagement identified by Lambert include:

- personal contacts and staff exchanges such as visiting professors / guest lecturers or industry secondments;
- business support and consultancy;
- collaborative and contract research;
- establishment of joint ventures, licensing agreements and spinout companies

Indeed, a stated desire within this report was to encourage increased engagement between industry and HEIs as this would benefit both research and teaching activity; and would provide other spin-off benefits for individual academics and teams of academics.

1.2.3 Some benefits from engagement

In addition to facilitating knowledge transfer through closer relationships, another reason for industry / university engagement is to assist with the development of skilled undergraduates and postgraduates and this also provide a mechanism for improved future knowledge transfer between the two parties. Lambert also identified possible positive outcomes of engagement which will include industry access to the following:

- A supply of skilled graduates and post-graduates;
- Highly skilled scientists and researchers;
- The latest research and cutting-edge technology;
- International networks of academics; and
- Continuing professional development opportunities for employees

In addition, three main themes relating to the supply of skilled graduates and post-grads which must be addressed in encouraging future engagement included matching the skills provided by universities and the needs of business; increasing industry influence upon the curriculum; and developing strategies for industry to recruit and retain the best talent. Developing the 'learning society' and an increasing focus upon 'knowledge' will also increase the emphasis upon Continuing Professional Development (CPD) activities and this is an area where collaboration between universities and industry is currently limited [8]. Here, there is potential to increase professionals' interactions with academia in the future especially if academic qualifications become more practical and relevant [9].

In the built environment sector, a recent study [10] considered different forms of engagement primarily from a teaching and learning perspective, but also identified examples of post-graduate work-place training. The main conclusions that can be drawn from this study is that from a teaching and learning perspective engagement can take many different forms and exist upon a spectrum of informal engagement at one end to more formal, planned interventions at the other extreme. Moving from a teaching perspective, there is also a need to understand more clearly the benefits of engagement in research. Having acknowledged that knowledge transfer can take place in a variety of ways this paper now considers how engagement activity can be fine-tuned for innovation diffusion purposes from a research perspective. The first stage in the development of a strategy for this is to consider lessons learned from two examples of innovation diffusion. Both of these examples commenced in an ad hoc way but resulted in strong partnerships, and interesting outcomes for both university and industry.

2. Case Studies of Knowledge Transfer

The case studies in this paper illustrate two examples of knowledge transfer and innovation diffusion between university and the construction industry. It is in part a response to these case

studies that the strategy detailed in the next section was developed. Neither of the case studies involves a startling innovation that is new to the industry or region, nevertheless they both illustrate how a company has successfully worked in collaboration with a university for mutual benefit. They also illustrate how, once a common understanding has been developed, innovation can work as a ‘pull’ from industry rather than as a ‘push’ from the university side.

The first case study considers a formal Knowledge Transfer Partnership (KTP), whilst the second presents the development of a relationship in a more informal, yet ultimately also productive manner. A KTP is a UK Department of Trade and Industry scheme designed to help businesses to develop and grow by accessing expertise in the UK's universities, colleges and research organisations [11]. Under the KTP scheme the DTI funds approximately half of the cost of employing a recent graduate (known as the KTP Associate) who would normally have specialist knowledge in the problem area identified by the company. The KTP Associate is supported by a KTP Supervisor based in a local university. The supervisor adds their expert support to the scheme which can last between one and three years.

2.1 A KTP in a Medium Sized Painting & Decorating Company



The Group Chief Executive initiated the scheme as a response to a changing market need. The Egan report [12] with its emphasis on partnering had resulted in key clients developing new collaborative ways of working. Realising that the Group needed to respond to the changing market the company initially proposed the appointment of a best practice manager to modernise the company's approach. However, recruitment consultants were approached to assist in the search and it was these consultants that suggested the use of the KTP scheme.

The Business School of a local university was contacted and the process of recruiting a suitable KTP associate started. Support and expertise was given from the University in the form of a Senior Lecturer in Marketing and the Director of the School of Business Information. It is interesting to note here that the skills required were not construction specific.

The initial work indicated that the group would need to adapt to an industry-wide up-take in partnering. The remainder of the KTP was spent in addressing this need. It was clear that to enter into true partnering arrangements the company needed to gain a deeper insight into their clients' needs. A clients' needs analysis was conducted and in response a benchmarking and Key Performance Indicator system was introduced into the company. This in turn led the company onto a path of trying to adopt a culture of continuous improvement.

As a result of the strategy, the company are now part of the Construction Management Frame Work Community with the UK Highways Agency, as well as establishing several other

collaborative contracts with Registered Social Landlords. This success means that the company now only seeks to work collaboratively as part of partnering and framework agreements. The KTP Scheme is now complete and the KTP Associate is employed as a permanent member of staff, as Best Practice Manager. The Scheme enabled the Group to take a fresh look at its future and draw upon external expertise in deciding its way forward. The results have made a real difference to the way the company operates and, indeed, its future strategy and success.

2.2 Informal Knowledge Transfer Arrangement between a University and a Small Heating/Plumbing Installation Company

The previous case study details a knowledge transfer partnership under a formal UK government scheme. This second case study details the knowledge transfer that has taken place under what was initially an informal relationship between the University of Salford and a local heating and plumbing installation company. The original contact between the company and the university occurred at an event under the banner of Constructing Excellence's [13] Best Practice Club network. In the NW of England these events are co-ordinated by the Centre for Construction Innovation [14] which is an enterprise centre of the University of Salford. These events include 'networking' time before and after the event and it was here a discussion took place about business challenges facing the company and some of the possible solutions that the HE sector could offer.

At the time no further action followed, other than the exchange of business cards. However, two months later when a PhD student was seeking small specialist sub-contractors to interview in order to study the take up of best practice and innovation in these type of companies, the idea of making contact with the company again with a view to taking an action research approach to the subject occurred. The company was happy to agree to this. During the two month period of the action research the student was present at high level strategy meetings and gained a good knowledge of the company. Progress meetings between the University and the Managing Director of the company resulted in a specific piece of work being commissioned. The company was part of a framework agreement as a sub-contractor on the local housing refurbishment programme and was under pressure to introduce a performance measurement system. This was an area the university had expertise in. Taken together with the working knowledge that the PhD student had of the company it was a comparatively simple task to put a performance measurement system in place. So successful was this piece of work that the company have now accepted a second student as part of the Chevening Technology Enterprise Scheme (CTES) [15]. The student is working with the company to assist them in the implementation of a wireless asset maintenance and job allocation scheme.

The case study is informative in a number of ways. Firstly it shows again that often the initial collaboration can come about in an unplanned fashion. Only if academics are actively involved and network in industry based activities and events can this chance association occur. Secondly, if the initial discussion had involved the need for the company to implement a performance measurement system it is unlikely that the University would have taken this further. It is not

possible to implement a key performance indicator system without a good knowledge of the factors that are critical to the company for business success. The initial action research had enabled this knowledge to be gained and so the implementation of the measurement system could be done with this knowledge already gained. Lastly the current work that the company are undertaking under the CTES scheme is indeed innovative for the sector and size of company. It is only after building the 'common understanding' that is discussed by Johnson [5] that this type of work would be envisaged by both sides.

2.3 Case Study Summary

Both case studies detail university/company collaboration that resulted in significant impact in the way that the companies work. In seeking solutions to their problems neither company had initially considered the university sector. It was, to an extent, by chance that the contacts were made. Neither of the solutions could have been implemented without an initial period of in-company work that enabled a common understanding of the company and its needs and the university and its expertise to be developed. The next section of this paper considers the development of a strategy to deliberately create a situation where this common understanding can be developed coming from either formal or informal beginnings.

3. A Future Strategy: Innovation Sets

So, is there a way in which we can create a situation where this common understanding can be developed more often and in an organised way? The current construction innovation strategy of the UK government is based on two main ideas, firstly, that innovation arises from the ongoing production and exchange of knowledge, and, secondly, that the existing diffusion of knowledge from HEIs to the construction industry needs to be improved. Yet, as the previous section has illustrated, despite the effort put into dissemination of research findings it would seem that more could be done. Reports are published, events are held and websites are created but does the knowledge and innovation diffuse effectively?

Perhaps to make research knowledge transferable, researchers must understand companies and their needs better, and vice versa. Perhaps the best way of doing this is through direct, personal contact. It is with these ideas in mind coupled with the Action Learning (AL) and innovation literature [16-23] and this current UK Higher Education Innovation Fund (HEIF) project [24] that the strategy below, of creating 'Innovation Sets' has been developed. Innovation Sets bring together two developments in the field of business support: AL, with its emphasis on finding solutions to real business problems, and the rationalisation and integration of business support.

3.1 Innovation Sets: What are they, and how will they work?

Typically an innovation set will consist of 4 to 8 people who will come together in order to help each other identify, address and solve real business problems. The sets can be project teams, expert groups, professional development groups, general business improvement (or orientation) groups, or other groups, operating within construction or related industries. They can also be inter-enterprise or intra-enterprise. The level and scope of knowledge sharing and knowledge production will vary from case to case, although the potential for real business improvement is present in each of them. In the case of a project team, consisting, say, of consultants, contract managers, and clients, the level of learning is likely to be collective and the scope is likely to be project specific. In the case of expert groups, which originate in common knowledge, such as PFI or off-site fabrication, rather than common projects, the purpose will be not so much efficient exploitation of opportunities and resources, but exploration of novelty in certain professional areas. Accordingly, the scope of learning is likely to be individual and enterprise specific. Professional development groups usually coalesce around generic themes, such as the norms and values of the profession. Thus, the scope of the learning will tend to be individual and enterprise-specific. The intention of general business improvement (or orientation) groups is to improve the performance of the collective, such as the individual enterprise or a collection of collaborating enterprises. They often do this by developing a shared sense of direction and aligning their structures, capabilities and motivations

The innovation sets will use the principles of AL to ensure that action is taken to put ideas into practice, so that learning generates real business benefits. Sets will meet regularly and at convenient times. Typically, there will be monthly meetings over a period of six months, with the frequency of meetings being higher in the initial formative phase. In some cases, the sets may become self-sustaining, or spawn offshoots. Each group will be supported by a set facilitator with appropriate knowledge and interest in learning in the particular field. The set facilitator will give the group focus, provide administrative support and help the members make use of the network of support provided by HEIs and other business support agencies.

The development of an innovation set will progress through a number of stages, such as those envisioned in Figure 1. The purpose of the first stage is to identify the problem or opportunity and gain a real business-focussed understating of the issue (usually something simple and easy to solve). As the set develops members will begin to identify the ways in which they can tackle the issue. The facilitator will encourage each member to develop and implement an action plan. If individual actions are successful, this will help in solving the problem, and the member can, with the help of other set members, specify the learning and develop areas for further improvement – if not then the member will have learnt more about the problem and the action plan, which can be shared and investigated further at the next meeting.

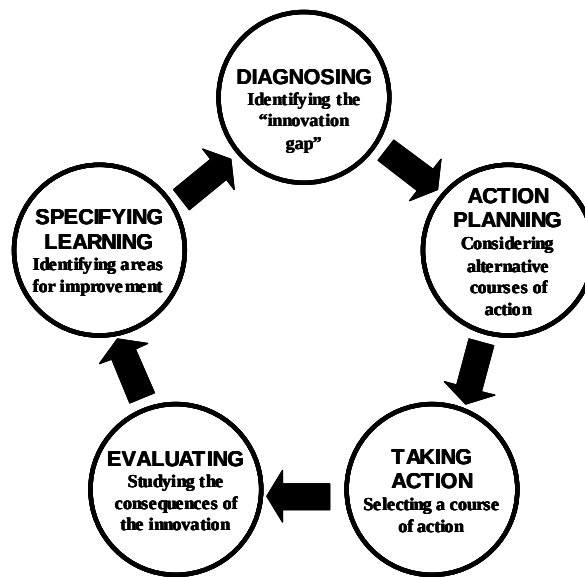


Figure 1: The cyclical process of learning

Unlike traditional action learning sets, each innovation set will be supported by a network of HEIs and other business support agencies. The Construction Knowledge Exchange, as it is known, currently comprises a core membership of regional HEIs and regionally-focussed national agencies. The national agencies are Constructing Excellence (CE); the Construction Industry Council (CIC); the Construction Industry Training Board (CITB), which together with CITB Northern Ireland and CIC forms Construction Skills, the new Sector Skills Council of the construction industry; and the Centre for Education in the Built Environment (CEBE). The network is being managed and co-ordinated by University of Salford with five partner Universities. The partners will work with other regional HEIs and FE colleges; regional centres of the national agencies, local business communities and trade associations; and other bodies to deliver a broad range of business support. This will be available through a web-based knowledge and information portal.

As members of innovation sets, businesses can expect to gain competitive advantages in the areas of overall business performance, individual and business capabilities, internal and external business relationships, and individual and business motivation. Different problems will be tackled by different sets. For those businesses that wish to implement a change process, in response, say, to a change in market structure, innovation sets, in the form of business improvement groups, offer a means to identify the problem and enact suitable solutions, drawing on support from the CKE, including KTPs. For those businesses that want to learn about and engage with generic developments, such as smart building, innovation sets will offer a means for participants to explore ideas and develop their own, business-specific responses.

3.2 Who will benefit? Some important considerations

Studies indicate that action learning sets tend to work best when there is a real business problem; an ability and willingness to act on the problem; and ability and willingness to reflect and learn. Typically, the individuals and the businesses they represent will be seeking to change. This is most likely to occur where futures and choices are unclear. There must also be the ability and willingness to act. Accordingly, the innovation sets must be peopled by senior management or other decision-making bodies. They must also be relatively risk free, in terms of their impact on the psychological and personal career safety of the members, and in terms of the ease with which core-knowledge can spill over and members can free ride on the production of knowledge. Finally, the members must be willing and able to reflect and learn. This presumes independence of thought as well as practice, and a certain degree of competence.

With this in mind, innovation sets are likely to prove beneficial for certain types of business and individuals. They are likely to prove most valuable in developing higher-level professional and managerial competences, such as judgement, and less valuable in developing basic skills, where instruction and practice hold their own [21]. In other words, they promote personal, situational and emergent learning rather than highly transferable, skill-based and programmable learning. They are likely to prove most beneficial in those cases where the prevailing or desired culture of the business is congruent with that of the action learning set. The members must value a questioning approach, respect personal development, trust employees with a fair amount of autonomy, be supported by line managers, and encourage the generation of new ideas. Above all, there must be commitment to implement ideas; action alongside learning.

By placing ability and willingness to act in the forefront of what is learned and knowledge that would help in the background, the innovation sets will, in the words of Revans, help members to “Learn better to manage with and from each other in the course of tackling the very problems that it is the proper business to tackle” [22]. The members will put knowledge into practice and learn how to put knowledge into practice, so they can achieve real and sustained improvements in the performance of their business.

4. Conclusions

Innovation is as a key element of a successful modern economy and by implication for those companies that comprise that economy. At the same time, and reinforcing this idea, the construction industry is faced by a whole range of challenges which occur at a relentlessly increasing pace. As a response to the above, an increased emphasis is now placed on beneficial relationships between HEIs and industry. Given that in the knowledge economy, universities are a key source of new knowledge, it is the contention of this paper that for some construction companies their future success will depend on their being an effective part of this knowledge supply-chain. The case studies illustrate the potential for such collaborations with companies that have previously had little or no involvement with the university sector. The studies further illustrate that real benefits can accrue once a common understanding has been gained.

The strategy of creating innovation sets is intended to help establish this condition on a more regular basis. They are based on the principles of action learning and so start from the concept of defining need and then working together to mutually solve that need. This is an ambitious attempt to strengthen the knowledge supply chain and will provide much useful research material over the coming years. This proposed strategy presents the opportunity to learn more and better about the needs of construction SMEs and to reflect on future courses of action. Evaluation will be undertaken as the different learning sets will be characterised in terms of their knowledge and learning, their motivation and their structure, and to compare this with the corresponding characteristics of the participating business organisations [18].

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Strategies of Roofing Contractors who Develop New Equipments

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Abstract

The aim of this paper is to analyse the strategies of roofing contractors who were awarded for developing new equipments. The case studies confirm that the owners of small enterprises are at the core of the innovation process. Each of the four managers developed products to improve safety on the building site but they followed different development and commercial strategies. One cooperated at the development stage, another at the production level and a third one established a commercial agreement based on trust. The last manager who runs the subsidiary of a large group did not market the innovation. The implication for policy aiming at stimulating the diffusion of innovation in the construction industry is that initiatives should focus more on the commercial stage. Indeed many small enterprises lack human and financial resources to promote innovation at a larger scale.

Keywords : Innovation, construction, small firms, contractors

1. Introduction

The building and construction industry is characterised by a high number of very small firms. In France, in 2000, among the 276 721 firms of the industry, 269 585 (more than 99.9%) employed less than 200 employees and contributed to 79% of the production [1]. Among these enterprises, there is a bulk of very small enterprise. As in countries such as Canada [2] and Australia [3], the majority tends to show little or no innovation. The advantages of large firms are usually ascribed to their greater financial resources and their ability to benefit from complementary resources (technical, financial and commercial).

Firms' positions along the value-added supply chain affect their innovative behaviour. For example, contractors and manufacturers adopt different innovative strategies:

- Contractors tend to innovate by focusing their resources on the effective management of the building site which is considered as their core activity. Most innovations aim at circumventing bottlenecks which, once corrected, enable improvements in productivity and safety of the building site.
- Manufacturers of building components undertake applied research tasks. They focus mainly on extending the range and the performances of existing components. Many innovations are introduced to respond to problems which appear in the implementation

process. Contractors who are their clients want to have products less expensive and easier to install to improve their productivity on the building site.

The fragmentation of the building and construction industry is supposed to inhibit innovation. The use of subcontracting prevents the continuity of teams that is essential to learning and innovation [4]. Because of the fragmented markets, it is also difficult to identify all innovations since most are developed at a local level and result from personal initiatives.

To circumvent this problem and to promote innovations at a larger scale some initiatives have been launched.

Most large French companies created internal contests to promote the best approaches developed within subsidiaries. Their aim is to codify the learning from problem-solving on projects and to disseminate these approaches on future projects [5].

Small to medium enterprises (SMEs) cannot benefit from similar networks and be aware of innovations introduced by similar companies. So national institutions such as the national federation of contractors, the federation of small contractors and the French innovation agency have initiated a national contest to award the most innovative contractors. The aim is to promote the image of the construction industry and the diffusion of innovative approaches and products within the industry.

The aim of this paper will be to analyse the strategies of roofing contractors who were awarded at the national level for their innovative approaches. To fulfil this goal, we will recall some facts about innovation within SMEs. Some elements concerning strategic management will be discussed. This conceptual framework will help us to analyse four case studies of contractors recently awarded. The findings will allow some recommendations concerning the role of institutional networks aimed at supporting the innovation activity.

1. Innovation in small construction firms

1.1. Definitions of innovation

In their paper about innovation in small construction firms, Sexton and Barrett [6, p.626] define innovation "*as the effective generation and **implementation** of a new idea, which enhances overall **organizational** performance*".

- The implementation aspect shows that innovation differs from invention. "*The invention concerns the creation of a new equipment. The innovation also requires a commercial or practical application of this new equipment*" [7, p.41]. According to its effects, innovation is usually categorized as radical or incremental. However this distinction appears sometimes artificial and arbitrary. For example, the performance improvements caused by the accumulation of minor technological changes may be stronger than the changes caused by radical innovation. Moreover, the difference between incremental and radical innovation is sometimes just a matter of perspective. Certain innovations may be considered as radical from an economic point of view but they rest on minor technical improvements [8].
- The organizational aspect indicates that the innovation concerns either the individual firm or the other elements of the supply chain. This shows that to appreciate the real impact of an innovation, a systematic approach is necessary. It widens the scope of the

analysis by focusing on the firm and its competitive environment. Relationships between the components of the system appear important to understand how actors “generate, diffuse, and utilize technologies (physical artefacts as well as technical know-how) that have economic value” [9, p.235].

One way to integrate the links between the components of the building and construction innovative system is to classify innovations according to their impacts on “core concepts” and on “linkages between core concepts and components” [10, p.12]:

- Innovations are incremental when the core concepts are reinforced and the linkages unchanged.
- On the opposite, innovations are radical when the core concepts are overturned and the linkages are changed.
- Modular and architectural innovations are intermediary. When there is no change in the linkages but a reversal of core concepts, innovation is modular. “The essence of an architectural innovation is the reconfiguration of an established system to link together existing components in a new way” [10, p.12].

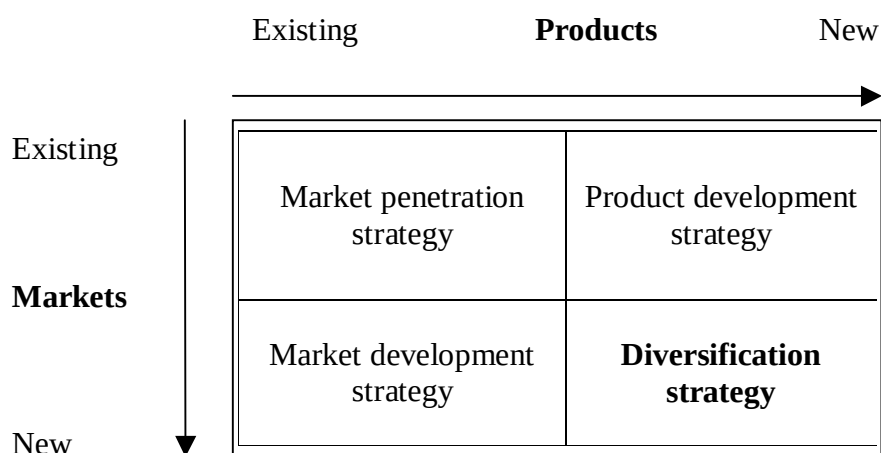
The approach shows that an innovation that is incremental to the innovator may be radical to other members of the building site. This means that the implementation and diffusion of the innovation will require defining appropriate commercial and marketing strategies to circumvent the resistance of the users.

1.2. Innovation and strategic management

We will use Ansoff' growth vector' matrix [11] as a framework to describe the position of contractors who developed new roofing equipments.

According to Ansoff matrix, companies can adopt four different strategies:

- maintain their market share without innovation,
- develop new products for their actual markets,
- create new products for unknown markets,
- develop their existing products on new markets.



A contractor, who develops and markets new products for the building site, adopts a diversification strategy which is the most risky among the four. He moves away from his position within the production chain by producing goods "*for an anonymous market*"¹ where the production depends on the client. This means that the price and performances of his product will be compared with competitive solutions. This change of business orientation raises several issues. This company needs to define an appropriate strategy and to balance the site activity and the industrial activity.

To mitigate the commercial risks associated with a diversification strategy and a new market, enterprises may cooperate with a commercial partner who has already built an appropriate network. Generally, co-operation is sought when activities are closely complementary and dissimilar. Conversely market forces are chosen when "*there is no attempt to match complementary activities ex ante by deliberately co-ordinating the corresponding plans*" [13, p.891].

1.3. The dominant role of the manager during the innovation activity

In SMEs, the manager bears the responsibility of taking the decisions regarding all aspects of technical change. Thus risk adversity may impede the innovation process. Two types of behaviour are usually applicable to managers [14]:

- In the first category, one finds managers who look for the stability and independence of their company and consider that innovation represents a large financial risk. So they only innovate under the pressure of their environment. They limit their contacts with the external environment to suppliers and clients. The management style is centralised.
- The second kind of entrepreneurial managers encourage rapid growth of their company. They accept risk and try to take advantages of every new opportunity. To enhance the performance and the growth of their company, they forge external technical and scientific linkages with educational establishments, research associations and other public agencies. They know that the success of their company is based on the quality of their employees and on their commitments to networks of innovators. In this prospect the managers' educational level influences the scope of the network. Highly educated managers tend to rely more on research and advisory agencies and less on informal contacts. Networks allow SMEs to decode and appropriate flows of information. They reinforce SMEs' competitiveness by providing them with a window on technological change, sources of technical assistance, market requirements and strategic choices made by other firms.

The dominant role of the owner in small construction firms is a source of flexibility and adaptability to any changes in market conditions and client demands. But it "*can constrain innovation activity if the owner does not have the necessary vision and systemic thinking when diagnosing and progressing innovation activity*" [6, p.631-632].

¹ "*One of the peculiarities of the construction industry as compared to the manufacturing industry, which produces goods for an anonymous market, is that in construction industry the production is depending on the client*" [12].

2. The case studies

2.1. Characteristics of the national award scheme for innovative construction companies

The national Innovation Award dedicated to firms working on the building site was launched in 2000. Since this date, every two years, companies are invited to present innovations that have been successfully implemented. Applications are judged by a jury of people working for the Ministry of Housing, the national federation of contractors, the federation of small contractors, the French innovation agency, CSTB, a journal dedicated to the building and construction industry, regional delegation of the Ministry of Construction...

About 200 applications were submitted in 2000 and 2002. Most came from small construction firms. The most promising innovations were awarded (less than 30 in 2000 and about 40 in 2002). The aim of the organizing committee was not to be elitist but to promote the image of the construction industry and the diffusion of innovative approaches.

Four types of innovations have been identified by the organizing committee:

- Building techniques,
- Safety and work conditions,
- Methods and organizational schemes,
- Environmental approaches.

In 2002, among the innovations awarded, 40% of them aimed at improving safety on the building site; 25% were technical innovations elaborated on the building site, 22.5% concerned the methods and 12.5% were related to environmental matters.

We selected four firms which won the Innovation Awards in 2000 or 2002. The enterprises will be called A, B, C and D to keep them anonymous. This was not a random selection. The four of them developed roofing equipment that improves safety and work conditions of the building site. The interest of such a selection is also to examine the impact of the internal organizational capabilities on the innovative and commercial strategy.

2.2. The cases of four roofing contractors developing new equipments

Company A is a roofer employing about 35 people. The innovation concerns a new scaffolding with different anchorage devices. The goal of the manager was twofold: Firstly, it was to follow the evolution of the regulation concerning anchorage point set-up and safety rules. Secondly, it was to develop a new system to increase the productivity of the working site. After designing the prototype, the enterprise collaborated with a supplier of roofing equipment. The manager considered that his enterprise did not have any human and financial resources to develop the product. Moreover the development of the new scaffolding system would have lead to a risky diversification. Both products and markets would have been new. So the owner and manager of

company A preferred to concentrate his resources on his core business and to cooperate with a manufacturer of equipment.

His partner, a supplier of roofing equipment employs 210 people. At that time, he did not have a collective scaffolding system in his range of products. So he was interested in developing this product designed to improve the efficiency on the building site and to ensure a maximum of safety for craftsmen. This company was able to rely on its R&D laboratory and extended the partnership to organisations promoting safety and health on the building sites. The aim was to develop a standardised system that could be used on any kind of roof.

Once the product developed, it was patented in Europe, Canada and the United-States. But the market is still reluctant to adopt the product because it modifies the behaviour of the craftsmen who use the scaffolding. This prevents its diffusion. To reduce the reluctance of potential users, the company created a subsidiary to rent, transport and erect/dismantle on site the scaffolding. By providing this new service, the manufacturer shows that the skills required to erect the product are not so specific. The installation also leads to an increase of the productivity of the building site. The new service helps the roofers to concentrate on their business and not on the erection/dismantling of the scaffolding. Moreover the subsidiary brings its professional approach to building site. Despite the success of the subsidiary, the innovation is a failure. About 1 million euros have been invested by the manufacturer to develop and sell the product. Almost no sales have been recorded. This failure recently led to the development of a new range of scaffoldings with no permanent anchorage. Its installation goes along with the habits of the roofers. Until now the product is quite successful and the sales are even higher than expected by the business plan.

Company B employs 15 people. The innovation concerns a new anchorage system. The regulation was at the origin of the innovation introduced by the manager. Company B used to work on the building site with contractors. One site being closed for not complying with the legal framework, a solution had to be found. The involvement of the manager in the project was very strong. It took him about six month to find an appropriate solution. This research phase required frequent interactions with the contractor. Once the first prototype was operational, cooperation with the Technical Centre for Mechanical Industry was established to reduce the weight of the product. Then the manager received some financial subsidies to patent his product. His brother, who is responsible of the design office of the company, was in charge of the development of the product.

To commercialise the anchorage system, the manager made several demonstration during local professional fairs. After taking out the patent and launching these first commercial initiatives, he decided to look for a trader. He was able to find a sole agent after receiving the Innovation Award. His agent is the world's largest manufacturer of concrete mixers as well as the largest French manufacturer of scaffolding and tubular structures for local councils. To market his products in France, he relies on a large network of sixty salesmen. His interest in the innovation was due to the award. It reinforced his trust in the product.

There is no written agreement between enterprise B and the sole agent. Trust is the cement of the commercial collaboration. The products developed by the innovator are displayed in the

catalogue of the manufacturer. Salesmen, who are in touch with the clients, represent the manager of company B and provide him with feedbacks. Then company B sends the products to the enterprises that order them. But the prices are established by the manufacturer (trader) who receives first the cash. At the end of each month, company B sends an invoice to his sole agent (the manufacturer). As mentioned by Richardson, in this case, there is no technological cooperation between the two partners because there is no requirement to match complementary activities. Their commercial relationship is based on market principles and trust.

This first success led the manager of company B to develop other roofing equipments. Anchorage devices and scaffoldings designed to prevent falls from height represent at the beginning of 2005 about one third of the turnover of the company (this business activity did not exist before 2000). This diversification which is very successful, became necessary in 1999 when the traditional business collapsed (the turnover of the three first months of 1999 were equal to the first month of 1998). The risks associated to the distribution have been mitigated. The product is new but the commercialisation of the products is assumed by the largest French manufacturer of scaffolding and tubular structures for local councils who had already built a large and sound commercial network.

Company C is a carpenter and a roofer employing 20 people. The manager developed a new product to comply with the legal framework and to improve the safety of its employees. The collective safety equipment on roof edges was tested within the company. The product was regularly improved thanks to the remarks of the roofers. After patenting it and registering the trade-mark, the manager subcontracted the manufacturing of the product to a small company with whom he already worked. He used the services of a sale agent in the Alps. He also invested some financial resources and dedicated lots of its personal time to commercialize the product on its own. To spur the sales of the product, he opened an exhibition stand at the main professional fairs concerning the building and construction industry. Before the Innovation Award, he was not aware of the quality of his product. But the award gave him some self-confidence. He even used it as a mean to convince the potential users. One organisation promoting safety and health on the building sites provides roofers who buy the products, with subsidies and contributes to the diffusion of the product.

However the sales have been quite limited and they represent today about 7% of the turnover of company C. After spending some of his time to launch the product, the manager decided to focus again on his core business: carpentry and roofing works. He was a little bit disappointed not to receive more assistance during the diffusion of the product.

Company D is the regional subsidiary of a corporation operating in the building and construction company with 2500 people worldwide. In France, 29 subsidiaries cover the territory and employ about 1500 people. The manager who developed the innovation, run a subsidiary employing 120 people specialized in roofing, insulating cladding and waterproofing works. An operative of the building site was at the origin of the innovation. The new system provided an anchorage point set-up on roof edges. It reduced the risks for people working on the roof who were previously anchored on the wall (because it was not possible to make a hole in the aluminium standing seam roofing). Once the product designed, it was produced by an ironsmith who regularly works with the company. The new safety system was used within the

company. No patent was taken out because there was no intention to adopt a diversification strategy and to market the new product. The core business of the group was not to sell safety roofing equipment but to work on the building site and to develop new waterproof materials. At the level of the group, 3% of the turnover is dedicated to R&D. But research works, are oriented towards the improvement of waterproof materials. Consequently, it was the supplier of the company who took the idea and integrated the safety system to its aluminium products (the supplier is an international metal company, providing steel and aluminium products to customers worldwide. One of its divisions produces steel and aluminium products for the building industry including roof & wall cladding).

2.3. Synthesis of the case studies

Despite the small sample of our analysis, our results confirm that builders are an important source of innovation. They may even be more innovative than the manufacturer when their business is concerned. A similar result was put forward Slaughter [15] who found that residential builders were the primary sources of innovation relating to stressed-skin panels.

In three cases, the innovations introduced were incremental. They keep the habits of the user by improving their safety. These innovations aimed at circumventing bottlenecks which, once corrected, enable improvements in productivity and safety of the building site. In the three cases (Companies B, C and D), the innovations were an ad hoc response to problems encountered in the course of a construction project. The innovations were solving problems which disrupt the daily activity. The research approach was more by trials and errors than by formal R&D.

The failure concerns the architectural innovation (innovation introduced by company A and developed by a manufacturer). The final output of the manufacturer was not a radical innovation. Basically, the scaffolding was providing the same service as other products (the protection of people working on roofs). But it required roofers to develop different skills to erect and dismantle the scaffolding on site. From their perspective, it could be considered as a radical innovation. The material supplier did not realise the impact of his product on the habits of the roofers.² To solve this problem, he created a subsidiary that installs the scaffoldings. The links between the existing components of the system that were disrupted by the innovation, have been reconfigured thanks to this new service. In the long run the diffusion of the product will depend on the strengthening of the statutory requirements concerning roofing equipments (the manufacturer renews every year the patent because he expects a “positive” evolution of the regulation).

These case studies also show that the owners of small firms are at the core of the innovation process³. Owners of B and C innovated and developed the innovations (the owner of company A decided to collaborate with a supplier who had technical, financial and commercial resources). Because of the limited number of executives within the enterprise, these two

² “Manufacturers and suppliers who are unaware of the changes required to implement their innovations, either in the links to other components, processes, or systems or in the product itself are likely to meet resistance in the spread of their products” [16, p.15].

³ The case of company D slightly differs because it is a subsidiary of a large group. One operative was at the origin of the innovation. But the manager contributed to its implementation within the subsidiary.

managers were in charge of marketing and developing their product. The limited size of these enterprises allows the owner to find quick answers to respond to evolving client demands.

Finally it is interesting to note that the development of a similar product lead to four different commercial strategies:

- Company A collaborated with a supplier and focused on its core business.
- Company B developed the product but left the commercialisation of the innovation to a large manufacturer who had already invested resources to build a large commercial network.
- Company C designed the product but subcontracted its manufacturing and took most of the commercialisation in charge.
- Company D (the subsidiary of an international company) used the innovation for its own sake but did not develop it because it was out of its core business.

3. Conclusions : Implications for national policy aimed at supporting innovative construction companies

These four case studies indicate that regulations are one of the main drivers for innovation on the building site. The four innovations presented in the aforementioned cases were launched to comply with the legal requirements established to prevent falls from height. Enterprises innovated to adapt their organisation to regulations. This result is confirmed by a recent report by SPRU (quoted by [17], p.734). According to this report, "*the most important sources for the construction firms are its suppliers, health and safety regulations, and clients.*" Studying energy efficiency in housing, Gann and al. [18, p.291] also considered that "*prescriptive regulations have forced firms to innovate, particularly at the component level, in order to comply with more stringent standards of energy efficiency.*"

The failure of the architectural innovation seems to indicate that building companies lack technical capabilities to understand innovation. According to Cohen and Levinthal [19], firms' ability to exploit external knowledge depends on their absorptive capacity. The reluctance of roofers to adapt the new scaffolding that leads to a change of the way they work, can be due to a lack of qualification. If roofers do not have the absorptive capacity to understand an innovation, then they will not implement it. One way to promote innovation within building enterprises would be to develop training programmes to increase the qualification of employees.

Most enterprises did not realise before launching their products that the commercialisation would be so expensive. It appears that the development costs are smaller than the commercialisation costs. This is particularly striking for company C. The manager would have expected more commercial assistance during the diffusion of his product. The commercialisation of a new product for a new market (to this given firm) appears more complex than technical matters. It also requires more financial resources.

These results indicate that national innovation policies dedicated to building companies should also focus on commercial issues. The creation of a product is just the beginning of the innovation process. Most small firms may think after receiving an Innovation Award that sales

will follow. Most of them are not aware of the difficulties associated to the commercialisation of a product. They need to identify the leading customers who could promote the innovative products. They have either to invest their financial and human resources to develop a commercial network or to cooperate with a firm which already knows how to market a new product.

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Section III

Organisational Studies and Innovations

Trust, Participation and Hospital Design – Two Approaches One Result

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Abstract

This paper is based on a study of the change and design process for the surgery and radiology building at Örebro University Hospital, Sweden. The basis for the process is the tradition in the County of Örebro to carry out projects in close co-operation with the users as well as aiming for high quality buildings. Traditionally building design projects were set up in a close co-operation between core business representatives and the real estate department. The building project utilized this cooperative approach.

In the study of the process, two approaches to the co-operation were identified. One (1) trust based process and one (2) participation based process. The trust-based process is characterized by having a respected leader, or a small group, with a strong support among staff that enables them to act for others. The participation-based process is characterized by a larger number of active participants representing all tasks, often in working groups dealing with sub tasks in the design process, and a need to get feed back before any decision is made.

It was found that both of the two processes worked well and that the result is considered as a usable building. This finding is compared with a finding from another study where the issue of discrepancies between client's goals and the outcome, is discussed. The paper discusses the two approaches, how they relate to client's goals and how these affected the process and what can be learnt for future change and design processes.

Keywords: Usability, design processes, participation, hospital design

1. Introduction

Within the Health Care, large investments continually are made in different construction projects. As public finances fund these, it is important that they meet both functional and financial requirements as well as the public eye. Whether a project is a success or not can depend on how well the programming and design process is managed. It is therefore important to study advantages and shortcomings in these processes and develop methods to improve these.

This paper is based on case study of the Örebro University Hospital (USÖ) [1] [2] and a study on experiences by clients on the outcome of construction projects [3].

2. Background

Although the construction trade is skilled in carrying out complex projects and mastering multidisciplinary design and construction projects there is a common opinion among representatives for core business and corporate real estate that the finished projects often do not meet the goals of the core business, or add the expected value to core business [4].

In a study of USÖ, it was found that participation and co-operation between core business and the construction project group supported the development of a usable building. The hospital has a long-term experience from participative building design processes and thus the staff, in both surgery and radiology, knew that involvement was a part of the process - it was never something they had to fight for. In the study of the process, two approaches to the co-operation were identified, one trust-based process and one participation-based process. In radiology, the head of the radiology department and technical manager they were allowed to develop a radiology department, both technically and organisationally, based on digital technique. If these persons had not owned the trust of the staff, the new solution would have faced fierce resistance by staff. The trust allowed for an efficient process where few actors pushed the process and the staff participated only in meetings and were not actively involved until the new radiology department was about to get staffed and completed. In surgery however, there was an active participation in testing and working with a mock-up room where work functions for surgery could be tested for real and not only agreed upon based on a functional specification. The gap between definition of function and real use was thus bridged [1].

Granath and Hinnerson [4] notes in a study on the outcome of design processes in corporate real estate, that a vast majority of the studied real estate professionals agree with the statement that there is a discrepancy, or at least perceived discrepancy, between clients' and core business goals on one hand and the outcome of the construction project on the other hand. The explanations to this are also elaborate and the condition is regarded as a problem. Very few participants experience however that this is a problem in their projects. Problems and threats of deviation from the goals occur but they are mostly solved during the course of the project is one of the arguments. The perceived discrepancy is thus possible due to the actions from the actors in the project itself. The participants just do not admit or realize this. Discrepancies between goals and outcome are thus a matter of communication and participation. Increased knowledge, outside interventions and ongoing development of goals is considered a natural part of the project that can be dealt with, not something that compromises the process.

As the building in the USÖ case is considered usable and appropriate for the core business Health Care, it is interesting to study the two approaches that managed to overcome ambiguous statements in the programming and the interpretations made in the transition to the design phase and how this relates to the findings from the Granath and Hinnerson study.

3. Method

This paper is based on two studies. One on USÖ [1], which focused on the process in the transition from programming to design, and one on the outcome of construction projects [4].

In the USÖ case study, a part of CIB/TG 51 study on Usability, the aim of the investigation was the understanding of a complicated concept rather than finding common quantitative evidence of a certain phenomenon. The study used a qualitative and practice grounded method based on several years of research. A previous and similar research project was the investigation of the multiple aspects of “the importance of spatial design to work place performance”, in which a method for this kind of research was developed [5]. The first component [i] of this investigation is to fuse practice and research together in the development of understanding. Theory developed from practice and theoretical reflection on and structuring of practical understanding are the cornerstones of the investigation. The creative process of investigating and reflecting on common situations between research and practice is essential. This method of developing innovative new concepts that challenges existing theories, as well as proven practice has been successful in earlier projects. The second component [ii] is the combination of self-evaluation by practice based on a selection of quick ethnographical research methods [6] [7] [5]. The third important component [iii] is choosing situations from different cultural contexts like countries, companies and industrial branches. Like the thematic network “Workspace”, this too is a co-operation between a numbers of countries represented by researchers and companies from different branches and to articulate these, primarily using workshops where researchers and practitioners meet.

The other study is based on the Delphi method, developed by Rand Corporation, and is often used for predicting future trends or to explain complex courses of events [8]. It is often directed to a large number of experts that is, e.g., asked how they predict the development of certain aspect in the future. A Delphi study is mostly carried out in at least three steps. The first step, included questions directed to a large number of experts throughout Sweden, including representatives from the construction industry, real estate industry, consultants, facilities management and core business representatives and users in large organisations. The second step in our study was based on the results of the first set of open questions. The answers from step one was summarized into a large number of statements and the experts were asked to react to these statements on a four-grade scale from “I agree totally” to “I disagree totally”. The aim was to identify common conceptions among a number of experts, as for an example the relation between the identified goals of a project and the outcome of projects, and the design processes itself. It was also aimed at exploring the behaviour of different actors, and show whether there is a difference in standpoint between different actors in the process.

4. Theoretical framework

Programming and design processes aim to deliver buildings usable for the client [9] [10]. When studying these processes it is important to scrutinize both content and process. Often traditional programming and design of buildings focuses on the properties of the building itself. It focuses on the functional properties of the building and assumes that usability will follow as a causal

effect of a functional design. Traditionally Swedish building research has been very successful in analysing building functionality, often with focus on housing design [11]. One of several evaluation methods related to usability is the “*The Serviceability Tool*” [12] [13] that uses the terms *performance* and *serviceability* where “Serviceability is about whether a building or facility is capable of performing as required” and “Performance means actual behaviour in service at a given moment”. Another important method is the Post Occupancy Evaluation – POE – technique developed by Wolfgang Preiser [14]. POE is traditionally a technique that is used for buildings in use and thus the process outcome rather than the process itself [15].

The current trend in programming has noted the poor performance of construction projects and started to view programming and briefing as a continuous process and not something, that is being done end defined at an early stage [10]. This view also affects the role of the programmer and how that relates to the interaction between users, clients and the design and construction team [10].

Participation is also related to planning of functions and performance of buildings. A growing awareness of the importance of employee participation in organizational change and workplace design is quite new in countries like US, UK and Germany. At the same time, this has been legislated and common practice in Scandinavian countries for almost thirty years, whereas in other countries it is not even considered as relevant [16] [2].

5. The hospital design case

5.1 Örebro University Hospital

The Örebro University Hospital, USÖ, is a development-oriented medical centre located in central Örebro, a medium sized Swedish town. It has extensive basic general medical facilities and provides health care for inhabitants in the region as well as to central parts of Sweden. The European Development Centre for Radiology is located at USÖ. The O-building that is the case in this study houses two main activities, surgery and radiology, and was opened in 1997. The usable area of the hospital buildings are over 200 000 m². The major development of the hospital was done in 1960: s but an ongoing renovation and investment in new buildings have made USÖ one of the best-maintained hospitals in Sweden today.

5.2 The process in general

Traditionally, health care is organised in a hierarchical way. Building projects however often fall outside the ordinary relations in an organisation. The real estate unit has since early sixties had an ambitious co-operation between core business and building projects in planning and designing and have developed a culture of participatory design. They also have a long experience as a client and organiser of building projects.

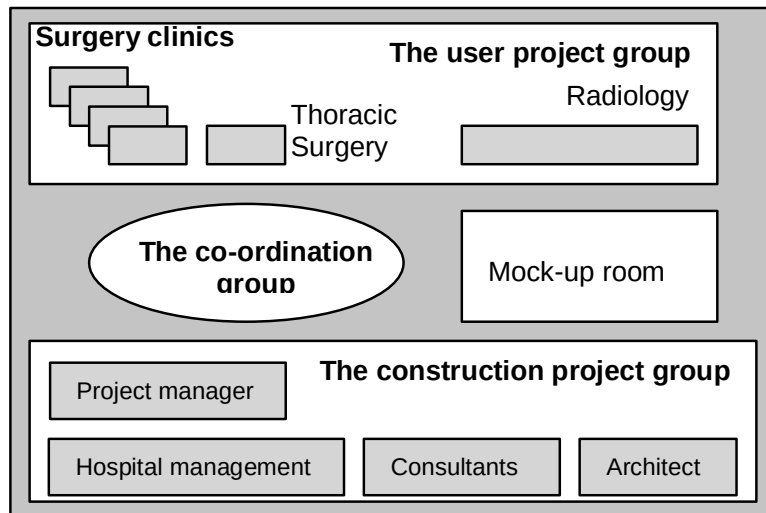


Figure1: Organisation of the design process

From the following case description of the project, we find that this participation from core business employees was very detailed and started early enough to affect strategic issues of the building project. The health care units that were affected formed design teams to develop useful solutions for their professional activities. The real estate department set up a project organisation to support the building project. Representatives for both groups met in a co-operation group to make decisions to deliver to the project steering group. The consulting architects worked closely together with the teams in both core business and the real estate department. The process to develop and design the O-building involved a large number of people. Three main groups carried out the process, thus we distinguish between the user project, the building project and the co-operation group.

Although the two parts involved in the project had the same organisation as described above, we could detect two different ways of working; a participation based model in surgery and a trust based model in radiology.

5.3 The participation based process model in surgery

In surgery, the main organisational issue was the change from an organisation where surgery was a general resource for the whole hospital and central located. In the new organisation, the

surgery was divided into units that organisationally belonged to different departments (clinics). This change was however decided beforehand and was a prerequisite for the new building.

In the process, one user project was set up for each unit. However, the thoracic unit that was added to the project in 1995 did not have a user group. Due to Swedish legislation and praxis, the different unions were represented. One person responsible for continuity and strategic issues participated, mostly the head nurse for each unit. The chairperson of the department (clinic) participated as well as a representative for the assistant nurses and department of medical engineering. No representatives for services like janitors or cleaners were represented. The project group was well rooted in and chosen out of trust by the rest of the unit. They reported back at unit meetings. A construction project manager from the real estate department led the building project. This group also consisted of the architect, technical consultants and representatives from the hospital management. A co-ordination group was set up as a bridge between the user project and the building project. The head of the unit, the chairperson of the department and representatives from medical engineering participated from the user project and the architect, construction project manager and sometimes the hospital management participated from the building project. The co-ordination group made decisions regarding the development of the project. The architect also worked directly with the different units. The work done in the user project groups was presented regularly at meetings on unit level. There were large papers on the walls where people could comment on drawings and other material that was displayed. The comments were given to the architect.

5.3.1 Co-operation in design

The different surgery units in the user project carried through design activities to investigate alternative solutions and articulate the needs of the units. An important arena that all units could use was a room with a complete mock-up of an operating theatre. This was the arena where nurses, doctors and medical technicians could meet with architects and other representatives of the building project and investigate different solutions. The mock-ups were used for simulation where the degree of truthfulness to reality was extremely high and detailed.

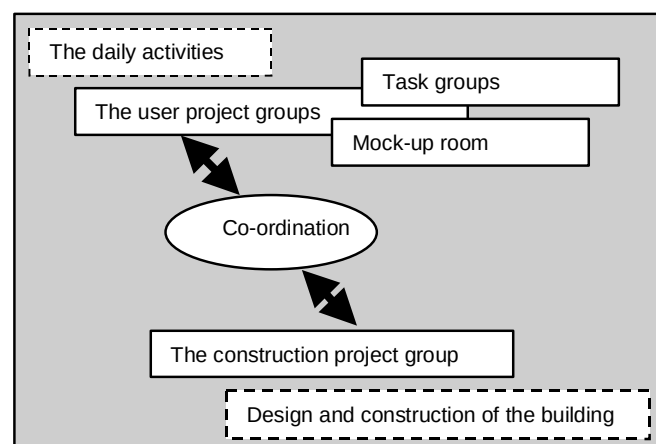


Figure2: Organisation of the design process in surgery

Most of the dialogue in the design process took place directly between individuals or groups from the user project and the building project and they often arrived at concrete conclusions and suggestions. Decisions, confirmation and policies were then forwarded to the co-ordinating group that had the formal power to take that role.

5.4 The trust based process model in radiology

In radiology, the main issue was the transition of technology. Many operators and nurses feared the new technology and the risk that their professional knowledge should be obsolete. As the more serious development in this direction took place after the briefing process for the building had started, it was also a problem for the building project. A step-by-step move of units and a thorough educational program was established to meet these problems.

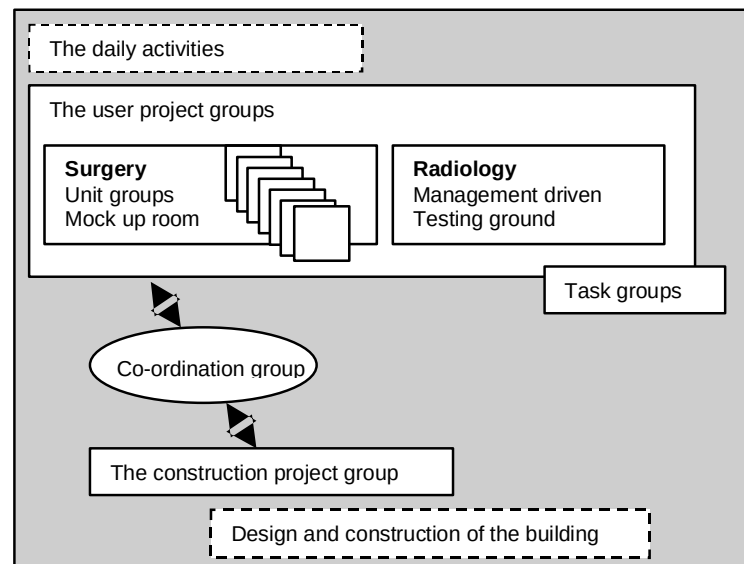


Figure 3: Co-operation in design

The process of the radiology units was somewhat different. The head of the department and the head of medical engineering were at an early stage dedicated to the idea of using new digital technology. The head of the department contacted the radiology department in the county and investigated if they were willing to convert to digital radiology and to connect to a network that could transfer digital x-ray pictures. All five radiology departments concluded that this would be a great advantage to them and agreed to participate. The idea was presented to the head of the hospital and the county politicians and got support as long as they kept the time and cost limits. The first brief for the units however suggested a mixture of traditional technology and digital technology and a step-by-step conversion to the new technology. The manufacturer of digital x-ray equipment – Philips - however took an interest in the developments and was willing to use USÖ as a testing ground for development work. This situation and the parallel development of equipment made it not feasible to use the same method of a common testing arena as was done for surgery. In this case, the development of technology was done through

innovative work in all steps of the chain from Phillips laboratories to the actual radiology unit in Örebro with iterations of information and knowledge between radiology nurses, doctors and technicians on one side and engineers and researchers at Philips in the other end. The result was that USÖ became the first hospital in Sweden that totally depended on and fully utilised digital radiology technology.

5.5 Important issues in the design process

A demand from the users was operating theatres with windows and daylight. This question was raised by the building project as they thought; this could be a problem for certain processes like keyhole surgery and that they would pull the curtains down most of the time anyway. The experience from the old operating theatres, located in the dark core of a double corridor building from the seventies, was however so definite that no discussion was necessary. The users were also inspired from research in environmental psychology that stressed the importance of pleasing environment for both staff and patients. A question related to this was access to outdoor terraces. This was a trickier question, as it was easy to advocate for the hygienic risks of going outdoors when working in a surgical unit. No real arguments came up that could justify outdoor terraces, but today there are terraces in the building to the pleasure of the staff. However, everyone realized that it was a calculated risk and it is now used with a strong awareness that the hygienic regulations must be followed rigorously. These issues are examples on what impact the participation process actually had on the building.

6. Discussion

Based on the USÖ case study and the two approaches it is shown that there are several ways of achieving a usable solution that satisfies the client. In the light of the Delphi study this is important as that study concludes that programming might not be sufficient. In the USÖ case, e.g., the mock-up room was used as a complement. However, as we found, the two approaches have different characteristics; participation requires a large amount of time, and the trust-based approach requires maturity from the organization in order to be possible. Studying the process that took part in the O-building case, we can clearly see the importance of participation for development of a usable building. By participation in the mock-up room work functions could be tested for real and not only agreed upon based on a functional specification. The gap between definition of function and real use was thus bridged. In radiology, the relationship between function and usability developed differently. Based on the trust for the head of the radiology department and technical manager they were allowed to develop a radiology department based on digital technique. If these persons had not had the trust of the staff, the new solution would have faced fierce resistance by staff. The trust allowed for an efficient process where few actors pushed the process and the staff participated only in meetings and were not actively involved until the new radiology department was about to get staffed and completed. The trust even allowed for drastic changes like the change of technology in the radiology department. An overall trust related aspect is also that the county has a long-term experience from participative building design processes and thus the staff, in both surgery and radiology, knew that involvement was a part of the process - it was never something they had to fight for.

Looking back at the USÖ study we find that the programming and the design phase were articulated. The organization was well prepared to manage participation and had a structured way via the co-ordination group to stay in contact with the construction project. This also allowed the users and the construction project to focus on their prime issue and direct discussions to the co-ordination group with its task of pushing the project forward. These processes were also given time as the county have incorporated an iterative and participative process suitable also to the, partly, political decision processes in public health care. This enabled those who were not directly involved to at one stage or another take a look into the project without it having to be organized as formal participation. Communication and information is essential as well in this process.

If we compare these findings with the findings from the Delphi study we find that the difficulties noted regarding un-articulated processes and lack of consistency in programming was managed through the USÖ approach that incorporated participation, openness and that the process was given time. The aspect of having time to develop and explore is, we conclude, due to the kind of decision process associated with the use of public funding. In this case we regard this as a positive effect that benefited the development in the USÖ case, depending on outset it might not. It must also be noted that the time in the USÖ case was utilized for establishing a design, the time given was used instead of passed.

7. Conclusion and further research

The experience from these two studies is that a well managed programming and design process results in a usable building. However with this somewhat obvious statement it is important to question what lesson can be learnt. From a Scandinavian perspective it is interesting that a trust-based process worked just as well, or better, than a participative one. As noted in the CIB TG51 group on usability the cultural and contextual aspects are discussed and it seems that the situation at USÖ enabled such a process to be performed. For future planning processes it is relevant to study what mechanisms that makes a trust-based approach feasible, and if it can be more efficient than a participative based one.

Another finding that raises questions is the fact that the USÖ was “given” time, it did not have to “take” time. This, we conclude, is due to the structure of decision processes regarding facilities within public health care, and in the USÖ case the stability of the organization, and led to a process where both the trust-based and participative-based process could develop. However, in times of outsourcing and change of view on clients and suppliers in public services, the question of time allocation might matter. A further study would be needed to study what resources are needed to outsource facility related services and how this relates to both client and user experience of quality.

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Changing Client Role in Emerging Construction Procurement

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Abstract

The client in the construction sector has a pivotal role in the successful delivery of projects. The role performed by clients in this regards has been undergoing transformation over the past two decades in response to demands for improvement and innovation to achieve better value for all the stakeholders involved in the delivery of projects. A review of some of the principal models for managing the procurement of projects provides an insight on the nature of transformation in the role performed by clients. The subsequent sections of this paper provide an outline of four procurement models that provide a context for exploring the change in role performed by the client. The subsequent analysis evaluates the role and requirements placed on the client by the criteria of managerial capability. The analysis shows a growing transition from a passive to an active role for clients in the management of the procurement process.

Keywords: construction, client, procurement, projects, management

1. Introduction

The role of the client in construction projects has been going through a transition over the last two decades (Cawthra, 1991; Technology Foresight, 1995; DTI, 2002). A significant outcome from this transition is a shift in the power-balance in favour of the client (Ling and Lau, 2002; Liauw et al., 2003). In attendance to the shift in power balance is a change in the nature and capability for managing the delivery of projects that clients are required to display in. The conventional approach for the delivery of construction products relies on methods that are rooted in the separation of responsibility and production activity for the different phases or tasks that make up the project (Anderson and Tucker, 1994). This naturally creates interface constraints as well as a limitation in optimising the functional, economy and production of the constructed product. Contributing to the interface constraints is the juxtaposing of different organisation systems and cultures, which often impact negatively on the productivity of the project. The solution to minimising the interface and optimisation constraints is considered to be in the adoption of a process orientation for all the activities connected with the delivery of construction products

(Cooper, 1994; Cooper et al., 1998). The process approach emphasises the integration of the contribution rather than the task output from each of the different stakeholders. McCaffer and Edum-Fotwe (2003) provide an illustration for considering construction from such a process perspective and identify interface between principal phases as key constraint to attaining optimum efficiency. The consideration of construction projects as production process induces a re-alignment of roles performed by the different stakeholders. The pivotal role played the client in conventional projects makes any such change in their role pertinent to successful delivery of future projects. To provide some boundaries to the nature of change in client role four procurement models are explored for the nature and role required of the client. Two of the procurement models are extensively employed in construction, and the other two are emerging alternatives that are finding increasing utilisation within the sector. The analysis shows a potential trend of a transition from a passive to an active role for clients in the management and technical requirements they have to address in the procurement process.

2. Construction Procurement Models

The subsequent sections of this paper provide an outline of the procurements models that are employed to provide a context on the way the management of procurement has been changing with regard to the role of the client. These comprise two established models of procurement and two emerging ones. The two established models which are designated in this paper as traditional are drawn from engineering construction, and building sub-sectors, while the emerging models reflect the stage-gate process approach, and the use of framework arrangements.

2.1 Traditional models

2.1.1 Engineering construction model (civil works)

The delivery of construction projects in this model is represented as a six phase linear process as shown in Figure 1.



Figure 1. High level process outline for engineering construction

The main benefit of this model is to provide clarity in the way the project delivery is structured, and as a consequence, lead to the identification of potential difficulties early enough to mitigate incidences of low productivity. Table 1 depicts the six phases with typical participants in each phase. This model is usually not applied to infrastructure and building projects procured in a traditional competitive tender or the increasingly popular design and build arrangements as the process assumes an internal client and supplier.

Table 1: Role of parties in engineering construction model for projects

Project Phase	Pre-Project Planning	Detail Design	Procurement	Demolition /Abatement	Construction /Production	Start-up/ Commission
typical participants	Client representative Planning Consultants Constructability Consultant Alliance / Partner	Client's representative Design Contractor Constructability Expert Alliance / Partner	Client representative Design Contractor Alliance / Partner Alliance / Partner	Client representative General Contractor Demolition Contractor Remediation / Abatement Contractor	Client representative Design Contractor (Inspection) Construction Contractor & subs	Client representative Design Contractor Construction Contractor Training Consultant Equipment Suppliers

However, the coverage of a start-up/ commission phase makes this model of delivering construction suitable for projects procured by turnkey arrangement and private finance initiative as well as alliance projects. While the engineering construction project model presents a clear involvement by the client or its representative, in reality that role is often passive, as the key activities undertaken reflect approvals and control.

2.1.2 RIBA Plan of Works (building works)

The RIBA Plan of Work is a robust procurement management approach which describes the activities from appraising the client's requirements through to post construction (Phillips, 2000). The stages are also used in the appointing documents to help identify the architect's services. This model of is predominantly applied for schemes that are classified as architectural in outlook. These schemes cover simple private dwelling houses through public sector offices to commercial accommodation such as hotel facilities. The key stages of the plan are outlined below in Table 2. The RIBA plan of works assumes a linear progression from one stage to the subsequent one. Thus, all design inputs are deemed to have been completed when construction commences. This, clearly, does not happen in practice, as several design changes are known to transpire during the construction stage, an indication of the incomplete input for the preceding design stages. The role of the client is equally assumed as passive in conformity with the notion that the client is hardly informed, and the consultant/designer knows what the client should want. The onus is therefore, on the specialist to effectively elicit the requirements of the client and formulate them into a design solution.

2.2 Transition in procurement

The need to increase efficiency within construction has occupied the attention of several of its stakeholders over the years (Latham, 1994; Egan, 1998). The inefficiencies identified with projects in the sector have been associated with a lack of a process approach by Egan (1998, 2002).

The emergence of knowledge as a prime value in the delivery of design has elevated the role technology could play to ensure the efficient management of knowledge within organisations.

Table 2: RIBA work stages for project development

	WORK STAGE	WORK STAGE DESCRIPTOR
A	Appraisal	Identification of Client's requirements and possible constraints on development. Preparation of studies to enable the Client to decide whether to proceed and to select probable procurement method.
B	Strategic Briefing	Preparation of Strategic Brief by, or on behalf of, the Client confirming key requirements and constraints. Identification of procedures, organisational structure and range of Consultants and others to be engaged for the Project. <i>[Identifies the Strategic Brief as CIB Guide which becomes the clear responsibility of the Client]</i>
C	Outline proposals	Commence development of Strategic Brief into full Project Brief. Preparation of Outline Proposals and estimate of cost. Review of procurement route.
D	Detailed proposals	Complete development of the Project Brief. Preparation of Detailed Proposals. Application for full Development Control approval.
E	Final proposals	Preparation of final proposals for the Project sufficient for co-ordination of all components and elements of the Project.
F	Production information	F1: Preparation of production information in sufficient detail to enable a tender or tenders to be obtained. Application for statutory approvals. F2: Preparation of further production information under the building contract. <i>[Now in two parts, F1 - the production information sufficient to obtain tenders and F2 - the balance required under the building contract to complete the information for construction]</i>
G	Tender documentation	Preparation and collation of tender documentation in sufficient detail to enable a tender or tenders to be obtained for the construction of the Project. <i>[Solely concerned with the documentation required for tenders. Particularly useful with D+B or management contracts]</i>
H	Tender action	Identification and evaluation of potential Contractors and/or Specialists for the construction of the Project. Obtaining and appraising tenders and submission of recommendations to the Client.
J	Mobilisation	Letting the building contract, appointing the contractor. Issuing of production information to the contractor. Arranging site handover to the contractor.
K	Construction to Practical Completion	Administration of the building contract up to and including practical completion. Provision to Contractor of further Information as and when reasonably required.
L	After Practical Completion	Administration of the building contract after practical completion. Making final inspections and settling the final account. <i>[Clearly separated from the construction phase]</i>

Knowledge management and sharing can be difficult without clear processes to capture and contain both what is already known, and the new knowledge and skills that are acquired on a daily basis (Lazarus, 2001; Edum-Fotwe, et al., 2004). The adoption of the process approach is equally seen as presenting construction with an opportunity for transforming its delivery of products by adopting innovations from manufacturing. This perspective has been championed in the UK by the *construction panel* of the Innovative Manufacturing Initiative (IMI). The development of a Generic Design and Construction Process Protocol as a direct response to the IMI construction theme has opened up the opportunity for a wider deployment of the process approach to procure construction (Cooper et al., 1998).

2.3 Emerging procurement options

A number of variants of existing models for managing the procurement of construction as well as alternative ones have been employed by different clients and projects. This section addresses the alternative models and comprises the process protocol and framework agreements.

2.3.1 Construction Process Protocol

The construction process protocol is based on the RIBA plan of works and provides a phase process to represent the delivery of construction projects. The protocol provides a departure from the linear approach to modelling the delivery of projects by viewing the interaction of activities within the process in a two-dimensional stage gate framework. Using manufacturing principles as a reference point, a framework of common definitions, documents and procedures were developed to help construction project participants work together seamlessly (Cooper, 1994). The design and construction process is mapped into eight sub-processes; Development, Project, Resource, Design, Production, Facilities, Health Safety and Environment, Statutory and Legal, and Process Management; four broad stages, as in Pre-Project, Pre-Construction, Construction and Post-Construction; and ten phases (Cooper et al., 1998).

The construction process protocol represents for the construction sector, the main generic design and construction process protocol (GDCPP) for the comprehensive management of projects. The introduction of the two-dimensional perspective by the process protocol for viewing the interaction of the activities in the delivery of construction presents an opportunity for a more effective project management. This can be very useful in achieving the same level of detail for the whole process. The main principles of the GDCPP are summarised below.

Whole Project View: This ensures that all the issues are considered from both a business and a technical point of view as well as ensuring informed decision making at the ‘front-end’ of the design and construction development process.

Progressive Design Fixity: The benefit of this approach is fundamentally the progressive fixing of design information throughout the Process, allowing for increased predictability of construction works.

A Consistent Process: The generic properties of the Process Protocol allow a consistent application of the Phase Review Process irrespective of the project in hand. This together with the adoption of a standard approach to performance measurement, evaluation and control, will facilitate the process of continual improvement in design and construction.

Stakeholder Involvement / Teamwork: The pro-active allocation of resources to Phases through a ‘stakeholder’ view should ensure that appropriate participants (from each of the key functions) are consulted earlier in the Process than is traditionally the case.

Co-ordination: The need for effective co-ordination between the project team members is paramount and ensures the correct application of the Process Protocol to the project.

Feedback: The Phase Review Process facilitates a means by which project experiences can be recorded, updated and used throughout the Process, thereby informing later Phases and future projects.

The process orientation presents clients as well as other participants with an overall picture of the project. This provides better opportunity for aligning the different operational regimes and task objectives for the various project participants. The implied assumption underlying the process approach is that client actively engages all the other stakeholders for all the phases of the project.

2.3.2 Framework Agreements

Framework agreements are procurement arrangements made with a single supplier or a number of suppliers with a view to achieving significant savings in cost and eliminate interface constraints to both the client and suppliers. The agreement operates as a continuous contract for the supply of goods and services to the project. There is no requirement for constant re-tendering at call-off stage as long as the contract conditions are unchanged for each project. This presents opportunities for substantial gains from continuous improvement by eliminating the transaction cost associated with repeat tendering. Where contract terms are changed, mini-competitions within the framework will need to take place. Clients may have more than one framework supplier in place for different requirements. However, the resource implications for the client should be borne in mind when deciding whether to appoint more than one framework supplier under a single framework agreement. The use of framework agreements lends themselves to the procurement of projects under the *prime contracting* and *design & builds* routes. They can also be appropriate for maintenance requirements of major infrastructure and facilities such as roads and hospitals. It should be noted that there is no commitment under a framework agreement for either party to undertake any business until the first contract is '*called off*'. Framework agreements are not usually contracts in their own right as defined in EU Procurement Directives, but agreements to do business under specific terms. Within the framework a contract (*call-off*) is let for each project. This initial call-off is no more complex than placing an order because the price structure and conditions of contract are fixed.

The client, within a framework agreement is required to engage actively with all suppliers on a continuous basis. This includes providing the framework suppliers with the *best* information available on annual forecast of anticipated demand, and standardising output specification to improve cost, predictability and maintainability.

3. Analysis of Client Role in Changing Procurement Regimes

The traditional and emerging models of procurement present various levels of involvement by the client in the delivery of construction. To understand the requirements placed on the client within the two categories of procurement models, a simple listing of criteria of three project principals were investigated in two areas, *managerial* and *technical* role. The other two project principals are the project sponsor and the project manager. This analysis within this paper is focused on the managerial role. The roles of the two other principals (the project sponsor and project manager) provide representations of the technical and risk requirements that are managed on projects. A comparative evaluation of the role of the client with reference to these roles therefore, provides a rational basis for judging nature of change in role by the client. The managerial roles and requirements were analysed over ten factors as follows: *Decision making, Effective critique, Communication, Motivation and drive, Team building, Facilitation, Interviewing, Negotiation skills, Assertiveness and Objective setting*. These were derived from earlier work on managerial roles in construction (Songer et al., 2004; Vossoughi, 1998; Pugh, 1991).

Figure 3 presents the analysed role of the client vis-à-vis the role played by the other two principals for the managerial attributes required of them in their functions they perform. These have been organised as essential and desirable criteria. Desirable criteria are capabilities that the client or the principal is not required to exercise to perform their role, but may assist with the performance of other related activities. The essential criteria however, are a must, as they form the basis of the involvement of the client or principal in the project process. The role of the client under the traditional procurement regime had focused on four key functions as essential requirements. These are *decision making, communication, negotiation skills, and objective setting*. This is naturally so as the client traditionally relies on the expert inputs from the other two principals to manage the project. Roles such as decision-making, communication, and objective setting are pertinent to the establishing the expectations of the client, and as such cannot be delegated to the other principals. It is easy to appreciate that need for the client to clearly and fully define their needs and expectations in the brief, since late changes of mind can prove expensive both in terms of timescale and cost. Equally, the need for effective negotiation skills is essential for the engagement of the principals in the first instance. The role of the client in the emerging procurement model elevates the requirements demanded of the client from the traditional models to include *providing effective critique, motivation and drive, team building, facilitation, interviewing, and assertiveness*. These requirements clearly call for a hands-on approach to managing the whole procurement process for delivering construction projects. It also implies a display of leadership and management skills to ensure a best practice performance by the client. Clearly it demonstrates that the drive for value in delivering construction projects places equal responsibility on the client as it does for the other principals in managing the procurement process. This equal responsibility for example translates in practice to a situation whereby clients are required to display astuteness in ensuring that the right team is appointed (either collectively or individually) to provide advice and to represent the client's interests as well as an active role in the establishment and working of task delivery teams.

MANAGEMENT CAPABILITY - Traditional						
	Project Owner		Project Sponsor		Project Manager	
Attribute	Desirable	Essential	Desirable	Essential	Desirable	Essential
Decision making						
Effective critique						
Communication						
Motivation						
Team building						
Facilitation						
Interviewing						
Negotiation						
Assertiveness						
Objective setting						

MANAGEMENT CAPABILITY - Emerging						
	Project Owner		Project Sponsor		Project Manager	
Attribute	Desirable	Essential	Desirable	Essential	Desirable	Essential
Decision-making						
Effective critique						
Communication						
Motivation						
Team building						
Facilitation						
Interviewing						
Negotiation skills						
Assertiveness						
Objective setting						

Figure 3: Changing client managerial requirements under different procurement regimes

It also means that the client is required to exercise more than just a desirable know-how of both technical and managerial roles which until the advent of the emerging procurement models had been the sole preserve of the professionals who act as principals. Furthermore, it calls for regular monitoring of the entire development process throughout all of its stages directly by the client, including responding to the reports of gateway reviews carried out at key approval points in the process and carrying out a post project evaluation of the process on completion.

Clearly, the deployment of manufacturing oriented methods of procurement is changing the role of the construction client from a passive participant in the project to an active one. Not only is the client owner of the completed product, but the nature of the procurement is demanding a situation where clients take ownership of the whole procurement process.

4. Conclusion

The last decade has seen an increasing emphasis on the client's role in ensuring that products and services within the construction sector meet defined needs fully and at the best possible value. This is particularly the case for the UK Government's role as a client for construction projects. The use of more business and manufacturing oriented processes for delivering construction is changing the role of the client in projects. An outcome of these changes is the sector's migration toward a re-defined procurement models and a re-allocation and alignment of the core functions and role for the different project stakeholders. The role performed by clients in this regards has been undergoing transformation over the past two decades in response to demands for improvement and innovation to achieve better value for all the stakeholders involved in the delivery of projects. In the paper, a review of some of the principal models for managing the procurement of projects has been presented. These provide an insight on the nature of transformation in the role performed by clients and gives an indication of an extended role for the client. The subsequent analysis evaluates the role and requirements placed on the client from a managerial perspective. The analysis shows a growing transition from a passive to an active role for clients in the management of the procurement process.

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Improving the Delivery of Social Housing in UK through Strategic Partnering– Using the Amphion Initiative as a case study

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Abstract

Amphion Consortium was formed as an initiative in implementing the Egan agenda (1998) which championed the use of long term partnering as a mechanism for achieving radical change in the construction industry. This project used this unique opportunity to develop, monitor and record the performance of 28 housing development projects which accounts for approximately 500 house units. Relevant KPIs, benchmarks and a robust data collection and site monitoring system were developed by the research team in conjunction with the RSLs, client agent and the main contractor following consultation with representatives from the Housing Corporation, DTI and the Construction Best Practice Programme. Detailed interviews with key project personnel, examination of site meeting notes and general feed back reviews were undertaken to identify good and bad practices associated with each project and with the Amphion experiment in general. The turbulent path followed by Amphion and their contractors illustrate how the strategic roles played by key players in the housing industry have a substantial effect on the construction process. Good communication, effective co-ordination and long term partnering which lead to continuous improvement of services and products emerge as some of the key drivers for the successful delivery of quality social housing which meet both the time and cost targets. The key players in the team including the RSLs, the contractor, the consultants and professionals have to be committed to the partnering process to make it successful.

Key Words: Social Housing, Amphion, Partnering, Key Performance Indicators (KPIs), Benchmarking

1. The background to the Amphion programme

The 'Rethinking Construction' report (1998) called for a radical review of the UK construction industry and recommended a number of measures, including long term partnering as a method of improving the performance of UK house building. 'Partnering is a management approach used by two or more organisations to achieve specific business objectives by maximising the effectiveness of each participant's resources. It requires that the parties work together in an

open and trusting relationship based on mutual objectives, an agreed method of problem resolution and an active search for continuous measurable improvement'[1]. Partnering can be either project specific, where the arrangement is for the duration of an individual project; strategic or long-term where the arrangement is for a specified period of time, normally covering a number of projects. Strategic or long-term partnering usually provides greater opportunity for improvement [2].

While Egan was reviewing the efficiency of the UK construction industry, a number of housing associations were reviewing the way they procured their housing stock and considered their new building stock was both expensive to build, and maintain. The defects that were still apparent, and the waste produced on site, did not seem consistent with a sustainable method of construction. As a consequence of this review, a small number of housing associations concluded that they needed to systematically change their procurement methods if they were to improve both the quality and cost efficiency of their new build programmes [3]. The required demand was beyond the scope of these housing associations alone and in order to generate more demand and change the procurement methods, the Amphion consortium was formed with 20 housing association members, who collectively agreed to procure 2000 pre-fabricated houses over a four-year period. Once the demand had been established, Amphion set about instigating change in their procurement processes. The key changes that were envisaged included the;

- development of a partnering arrangement with one preferred house builder
- development of a factory based house production facility
- establishment of key performance indicators (KPIs) by which any changes could be monitored
- setting up and managing of whole house building supply chain.

2. The Amphion Programme

Amphion promoted Egan principles by introducing lean production methods into house construction using modern timber technologies to produce housing in a factory setting [4]. One of the main objectives of the project was to promote volume (450 units in year 1, rising to 500 and 550 units in years 2 and 3) and continuity of production for the development of timber framed dwellings. The consortium set themselves the following targets to continue delivering improvements in quality, cost, time and customer satisfaction. In long term, they planned to:

- Achieve a demanding set of targets for incremental improvement in technology with the objective that by year 4 at least 75% of the superstructure will be factory produced.
- Further enhance training, not only for the site and factory operatives constructing and assembling the units, but also training for RSL staff so that they can be effective clients.
- Explore the possibility of external accreditation.
- Achieve significant reductions in construction periods and costs. Fewer defects, fewer site accidents and increasing customer satisfaction.

- Produce different templates to facilitate high density schemes, small site schemes and projects such as nursing homes and sheltered housing.
- Achieve growth through land acquisition.

3. The Research Project

The research project was to use the opportunity offered by the Amphion consortium programme of new build homes to develop, monitor and record the cause/effect relationships when introducing the change management tools used for Egan Compliance. The main aim of the project was to set, monitor and compare the KPIs and related benchmarks to be over and above the national and industry averages. Within this aim, the objectives of the projects were:

- To obtain agreement amongst all interested parties as to what benchmarks and KPIs need to be monitored to ensure Egan compliance;
- To develop a simple, robust method for on-site monitoring of KPI data;
- To calibrate the benchmarks and KPIs;
- To map the cause and effect relationships within the change programme.

The project was funded by the Engineering and Physical Sciences Research Council and the Department of Trade and Industry through the Link MCNS Programme. The main benefit of the project can be stated as, ‘the identification of best practice guidance and the development of simple, robust management information tools that will allow all Registered Social Landlords (RSLs) the facilities to drive improvements in the procurement of their new housing provision’.

The first stage of the research was the development of a series of performance indicators that could be used to monitor any changes that resulted from the new procurement approach. The project built on the ideas presented in the Egan report in which 7 key indicators were identified and extended to other KPIs which were relevant and specific to RSLs as well as the contractor. These were developed in consultation with the relevant team members with the help of workshops, brain storming sessions and many review meetings and included survey methodologies to obtain both quantitative and qualitative data on current new build performances. In all, about 50 KPIs, related benchmarks (where appropriate) and a robust data collection and site monitoring system were developed by the research team in conjunction with the RSLs, client and the main contractor following consultation with representatives from the Housing Corporation, DTI and the Construction Best Practice Programme. Specific metrics were developed under five thematic areas including Sustainability, End User Enjoyment, Project Performance, Cultural Performance and Respect for People. Following an initial pilot study these were reduced to 34 metrics under six themes and exceeded those required by national monitoring programmes. The effectiveness of the partnering process was monitored as one of the themes.

4. The Partnering Process

Partnering is a collaborative approach that benefits all parties involved, while focusing on the needs of the customer. In the right circumstances the rewards can be substantial. To gain

maximum benefit it is essential to extend the process through the supply chain in order to harness the specialist expertise of subcontractors, material suppliers and manufacturers.

4.1 Partnering Indicators

In order to evaluate the partnering criteria within the Amphion consortium, the following indicators were monitored.

Table1: Partnering Indicators that were monitored

Clients team and its response	Time to respond to instructions & urgent matters
Clients information	Information that was provided regarding the nature of site etc. which will make the contractors tasks easy.
Communication & Co-ordination	• Consultations with contractor • Contractor involvement stage • The number of qualifications (financial) presented by contractor
PPC 2000 conditions	Pre-contract matrix
Contractors cash flow	Time and payments • Time from possession to first payment • Total number of days late from issue of certificate to payment
Partnering ethos	Volume and continuity of work (% of Amphion work/ Total work load)
External professionals	• Planning approvals • Time taken beyond programme • Auditing of professional work (Number of errors / drawing revisions)

Amphion Consortium was set up to partner with one preferred contractor as well as selected suppliers in a supply chain. Due to the market forces that were beyond control of any team member, the contractor changed a number of times over a very short period of time and had adverse consequences over the whole process. The trust and confidence building process of the team was disrupted and many attempts made to get the supply chain partnering process were unsuccessful.

Eventhough demand was a key issue to be addressed, the consortium did not reach their target for the selected time period. This was mainly due to problems experienced by the contractor, land supply, the delays associated with section 106 projects and some unsuccessful capital bids to the Housing Corporation. Many shortcomings were identified:

- Factory production was initially working below capacity creating cost premiums at early stages with target cost reductions not achieved.

- Small infill sites were initially brought forward for inclusion in the programme when the product most suited larger sites with predominantly terraced and semi-detached houses.
- Development planning difficulties, including the nature and suitability of Section 106 agreements, could often delay the bringing forward of units in line with the plan.
- The technology was slow to advance and off-site manufacturing only reached a level of 35% opposed to the 75% targeted for the programme.
- Strategic changes in the partnership meant that quality of some projects was poor
- Value chains of the various partners were not sufficiently aligned leading to problems with delivering partnership benefits as intended [5].

It is fair to state that the Amphion partnering process did not get a good chance to be effective in the unforeseen short term contractor changes. Even though, many positive and negative criteria which could benefit future projects were identified in the process.

Table 2: Positive and negative criteria identified in the process

Positive Criteria	Negative Criteria
Contractor's early involvement and early discussions were beneficial.	The consortium structure, the member's involvement and commitment was not complete.
Attempts were made to increase the awareness of Amphion aims and objectives on site and make all staff aware of the Amphion process.	This process did not take off as envisaged and most staff members were unaware of the process that was unique to Amphion.
Domain of supply chain partners identified and an attempt made to get the supply chain effective.	This was not progressed as envisaged.
To improve Co-ordination and Communication policy groups were set up for each major issue.	The reporting process was not efficient and not in place for a while. The necessary reports and management charts not prepared on time.
Working group established to progress to Client Charter status	The number of policy groups reduced due to management difficulties
Analysis and maintaining an open book at Deptford	Cash flow problems.
PPC 2000- A simplified Partnering Agreement issued for use with the sub contracts.	New Partnering agreement has to be made after year 1 review. Increased use of amended contracts due to complex nature of schemes. Early execution of PPC 2000 contract documents - culture change required for by all parties – client resistance still being experienced in some cases.
Information for life cycle costing exercise coming through in the latter part of the project.	Lack of information for life cycle costing exercise at the beginning of the projects.
Identification of additional contractor partner based on operating location, land bank, social housing experience, and commitment to off site manufacturing and partnering.	Decision made to pursue possibilities with other suppliers at a local level.
Amphion becoming an off site manufacturing forum	Possibilities of terminating the consortium
The Amphion Design brief has been reviewed by a working group to include best practice and lessons learnt to date.	Debates about who Amphion is partnering with, firstly timber framed supplier and secondly main contractor.
Risk register was viewed as a shared tool for improving the accuracy for pricing. Risk was to be allocated to the party best able to deal with them and priced accordingly.	Problems with new partnering agreement and procurement agreements with changing contractors. Concerns continue to exist on quality of service from non-Amphion Architects
Post Contract- The establishment of a consistent team and employment of staff for on site activities. A post contract site diary to be kept and circulated with the view that the lessons learnt will feed into future contracts of this type.	Pre-contract process was unduly demanding in terms of time which resulted in uncertainties over programme and a greater number of tender qualifications than was desirable. More to be made of the pre-contract value engineering and the need for a common standard of information requirements for clients. The pre-contract requirements put pressure on timing - potentially at the expenses of accuracy to be amended or deleted.

5. Lessons learnt

Amphion has now reached the final year of the partnering process. The group had set up policy groups who met regularly to look at issues such as technology and innovation, benchmarking and partnering the supply chain. As the lessons learned by all those involved with Amphion begin to work their way through the system, significant improvements in performance can be observed and enable the consortium to continually value engineer the process and seek continuous improvement. Fig. [1] illustrates improvements in benchmarks scores for Projects 10, 11 & 12 which started on site two years after Project 1.

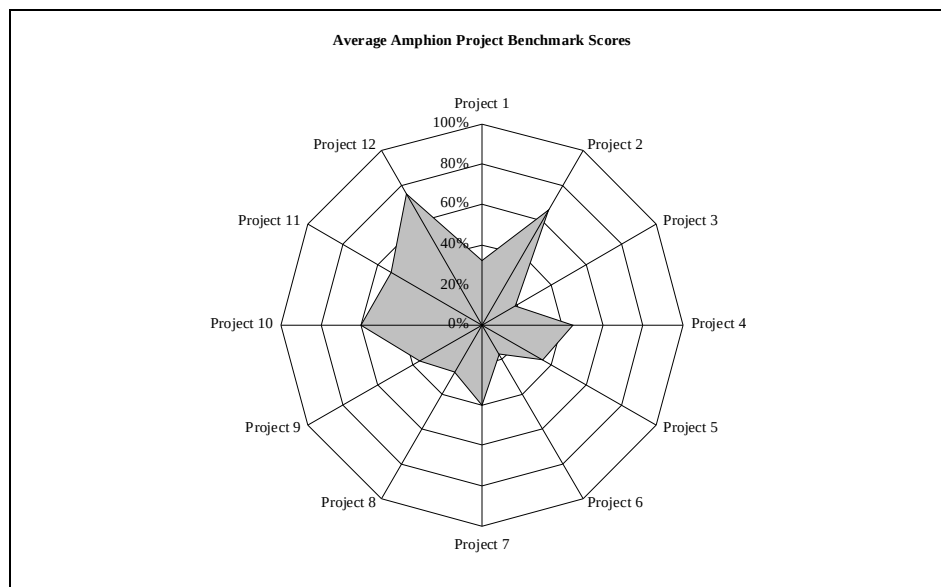


Figure 1: Average Amphion Project Benchmark Scores

The relationship with the contractor provides some key issues which can be beneficial to the industry as a whole. It was easy to see that in projects where the contractor got involved at an early stage many problems were solved before the project went on site for construction, thus saving on valuable construction cost and time. The more information that was provided to the contractor by the client at preliminary stages made it possible for the contractor to make more realistic feasibility sums regarding the project, allowing for problems in site to be dealt with speed and a minimum cost.

The importance of partnering the whole supply chain also emerged as a key issue in the process. If the contractor cannot co-ordinate his sub-contractors and suppliers, the whole partnering process ground to a halt affecting the cash flow of the contractor and the whole construction process. There were many good and bad practice issues that were identified by RSLs as important from the Amphion experience. The good practice issues were; increased health and safety measures, reducing the environmental impact, achieving the sustainability targets while the bad practice issues include defects not being attended on time, lack of communication and co-ordination and complicating the construction process by the introduction of many middle agents.

The main lessons that can be learnt from Amphion are not only from the data that was collected but by the interviews which gave an insight to the way that the key personnel felt about the whole partnering process. Many shortcomings in terms of communications between parties, distributing the knowledge gained by managers among the site and factory personnel, discrepancies in key management decisions among parties were commonly cited as drawbacks. In most cases decisions that were important to the process were not discussed or shared with the main personnel on site agents resulting in resentment among the lower ranked staff. From the workshops it was concluded that a new initiative like Amphion needs a good backup programme in terms of technical help, assistance and a quick method of problem solving rather than a long drawn process involving many hierarchical management systems. A central data base where information is stored and easily accessible to all concerned is also of crucial value.

In general, the study illustrates how the availability of land (which was a key issue in the changes in the contractor's profile) and the strategic roles played by key players in the housing industry have a substantial effect on the partnering process. Communication, co-ordination and long term partnering which lead to continuous improvement of services and products emerge as some of the key drivers for the successful delivery of quality social housing which meet both the time and cost targets. The key players in the team including the RSLs, the contractor and the consultants and professionals have to be committed to the partnering process. The lessons learnt from this project will benefit other RSLs, Government housing authorities, and industry professionals as they seek to address the challenge of achieving best practice and continuous improvements in new social housing development.

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Management System for A Virtual Construction Management Services Company (VCMSC)

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Abstract

A virtual construction management services company (VCMSC) is herein defined as a dynamic competitive network of collaborating special system contractors that reconfigure around a leading member whenever an opportunity arises. A single leading member guides this virtual network both on a short and long term basis, members can be geographically dispersed firms, organizational units, teams, or individuals. Each member concentrates on those parts of the value chain with which it achieves the maximum added value. A new management system of a VCMSC consists of six subsystems and related principles which together enable the virtual management of (i) project owner relations, (ii) project offerings and bidding, (iii) project design and engineering, (iv) project procurement, (v) construction, execution, and control, and (vi) network nurturing. In the near future, an empirical inquiry and a testing of the subsystems will take place to validate the suggested VCMSC model, overall, in the context of the building market in Finland.

Keywords: Construction management, management system, virtual management, virtual organization

1. Introduction

The paper is part of the ongoing study on **developing new concepts and systems** for managing a virtual construction-related company. The study is carried out in the unit of Construction Economics and Management (TKK/CEM) at the Helsinki University of Technology. Prior this paper, we have conceptualized the virtuality to a modest extent in the focal context [1], [2].

Our rationale for focusing on construction management (CM) services company is justified by referring to **the two representative accounts of CM forms** in the contexts of the USA and Finland as follows. In the USA, The organizational make-up of a CM firm is unique in the construction industry. Neither a contractor nor an architect/engineer (A/E) firm can match its functions or personnel. CM practice has substantiated a fact that CM firms must be multi-discipline organizations compared to traditional construction industry practitioners such as architects, engineers and general contractors [3]. There are two forms of **CM consulting** and **CM**

contracting also in Finland. A CM consultant acts as an agent (as in the case in CM Agency form in the USA). All the procurement packages will be bought from the market on a competitive basis. A client (an owner) enters directly into the contractual relationships with each of the subcontractors and suppliers. Design and procurement are performed concurrently (Figure 1). In turn, a **CM contractor** is responsible for PM, site management, site facilities and services, and construction works. A client has only one contract with this CM contractor. In turn, a CM contractor acts like a general contractor. Alongside, a client also relies on a separate agent who strengthens a client's organization and construction knowledge [4].

In addition, we align with the key contributions within virtual organization literature. A virtual organization (VO) as an evolving model is rooted in the paradigm of network organizations [5], [6], [7]. It resembles a dynamic network that facilitates the discovery and the configuration of core competencies in a value chain, which in theory leads to an optimal value creation process [8]. A **virtual company (VC)** is considered a purposeful system composed of a set of interrelated elements, i.e. actors, resources, and activities [8]. It has the ability to alter a value creation process [9] through a concept of switching [10]. The essence of VCs is meta-management of goal-oriented activity. In turn, dynamics within a **virtual construction management services company (VCMSC)** involves a 3-stage process of formation, operation, and termination, which explains how a structure comes about and how its management evolves over time. Initially, we defined a VCMSC in such a way as to be capable of adjusting to changes in its environment and renewing itself by designing and implementing new CM service processes based on the three constructs: IT-enabled network, virtual operations, and customer value [11]. A working mechanism was drafted in light of a theoretical concept consisting of three transitional layers that represent the organizational structure elements, while interactions between these layers represent the dynamic management elements [2].

The aim of this paper is to introduce the initial management system for a VCMSC. Our focus is on management, not on information technology (IT) as many virtuality-related scholars do. The sub-aims include (a) to define the principles for the virtualization of a traditional building contractor, (b) to design a management system of a VCMSC as a whole, and (c) to design its six sub-systems for managing (i) project owner relations, (ii) project offerings and bidding, (iii) project design and engineering, (iv) networked project procurement, (v) construction, execution, and control, and (vi) network nurturing. The paper is structured accordingly.

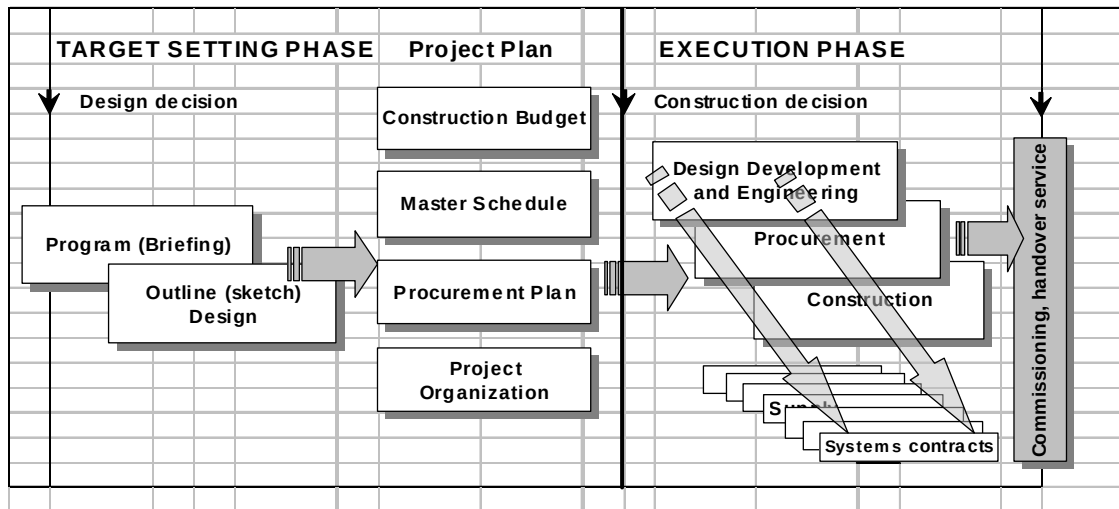


Figure 1: 2-phase building project process in the CM model in Finland.

2. Virtualization of A Traditional Building Contractor

2.1 Flat and Virtual Organization

Herein, a traditional building contractor competing in the context of the building market in Finland is transformed toward a **flat and virtual organization** through outsourcing. There are several flat features, i.e. all middle levels of management are removed and functional units such as cost estimation, procurement, and building design services are outsourced (Figure 2) [1]. Prior internal project staff is encouraged to act as entrepreneurs who form a staff pool from which a virtualized contractor assigns key staff to each project separately. Client accounts are introduced in order to enhance the true engagement of account managers in quality assurance and client care. The remaining flat and virtual organization consists of company management and experienced project managers only. For each project, one project manager is assigned to carry the PM responsibilities through all phases. For the design phase, a project manager heads a building design team together with client representatives, an architect, various engineers, and a consultant. During the bid or proposal preparation, a project manager heads the buying of estimation services and the allocation of procurement packages via competitive networking. When a particular bid is won, a project manager mobilizes a site organization from a staff pool and (s)he also manages the construction phase.

Company management is responsible for arranging and developing the competitive and collaborative networking with selected members as well as enhancing supplier relationships and assuring each member's additional competencies in the case of possible extensions of contract scope. Each project manager retains a responsibility to hand out the procurement contracts for

her/his ongoing project. The **five core-business processes** of a flat and virtual contractor include (1) client relationship management, (2) sales and bidding (competitive or negotiated), (3) product design management, (4) procurement and construction management, and (5) handing-over and after sales services.

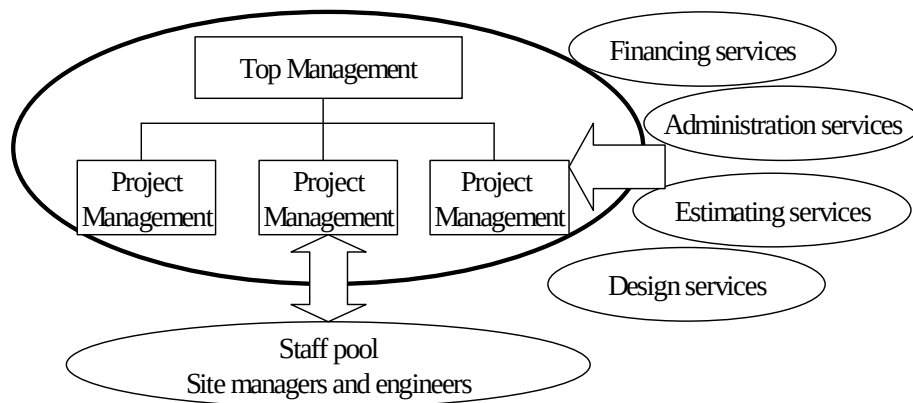


Figure 2: Flat and flexible organization model for a VCMSC [1].

2.2 Competitive Networking

In the context of building in Finland, all such forms of partnering that are based only on long-term one-on-one relationships have so far resulted in a loss of real competitiveness sooner or later. Thus, the delivery system of a VCMSC is based on **competitive networking** [1]. Procurement and PM processes are needed to ensure the product flexibility, design changes flexibility, short delivery times, and the concurrency of design, procurement, and the construction works on site. Networked members and external suppliers are motivated to add value-for-client money through their product expertise, whereas a VCMSC (i.e. a leading member) focuses on enhancing its CM and PM expertise. A procurement strategy is revised to allow the extension of delivery and contract scopes, a decrease in number of individual deliveries, and the creation of network membership with the most important suppliers. Competitive networking implies that a leading member networks with several special product contractors [12] that supply the same products, functional elements, or services (Figure 3) [1]. The profitable performance of a VCMSC's network would become endangered without internal competition.

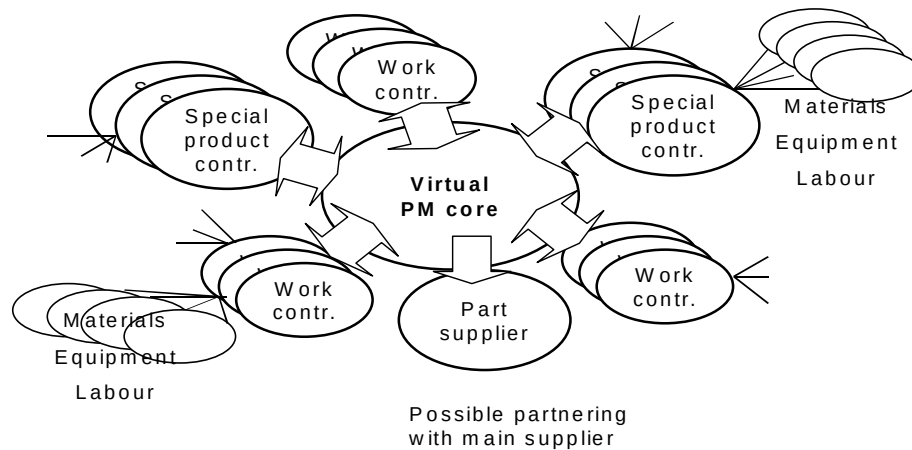


Figure 3: Delivery system of a VCMSC based on a leading member and competitive networking [1].

3. Management System Model of A VCMSC

3.1 VCMSC Management System

In the general CM context, individual practitioners are needed to perform various CM services for owners. The support for the assumption of this multitude is that a range of expertise required for performing all CM services and the demand for timely CM performance on projects precludes the performance of complete CM services by an individual firm, except on the simplest of projects [3].

Herein, a VCMSC is defined as a dynamic network of collaborating entities that reconfigure around a virtual core whenever an opportunity arises [2]. **The proposed management system** of a VCMSC consists of six subsystems, i.e. (1) Project owner relations management system (PORMS), (2) Project offerings and bidding management system (POBMS), (3) Project design and engineering management system (PDEMS), (4) Project procurement management system (PPMS), (5) Project construction, execution, and control management system (PCECMS), and (6) Project network nurturing management system (PNNMS). Next, each of these subsystems are defined briefly to facilitate an understanding of the scope of the VCMSC's management system and explain how each sub-system fit into the overall functioning and the execution of complete services by a VCMSC.

3.1.1 Project Owner Relation Management System (PORMS)

In general, when **construction companies** face increasing competition, cooperation between owners (clients) and contractors is emphasized. The role of a project manager is vital for mutual trusting relationships and customer satisfaction [13]. Client satisfaction can be defined as how well a contractor meets the expectations of its clients, which is in return one of the measures of a contractor's performance. The expectations of a client are affected by the building needs (investment) in question, past or direct experiences with the same contractor and the similar ones,

word-of-mouth information, and the contractor's marketing activities and image. A decision of a client to appoint the same contractor for the next project is strongly influenced by past experience, as decision makers either have strong normative beliefs or they rely on the advice of their representatives. Typically, the former guide the procurement behaviour of a client in the case of the regular procurement of buildings and a high level of repeat business [14].

However, traditional marketing seems to be ineffective in such competitive arenas where potential clients are identifiable and the focal CM firm target each of them. Herein, a VCMSC enhances the quality of its services through **the pre-emptive expert relationship building** with targeted existing and potential new clients (owners). In particular, the abundance of various contacts through a pool of the networked members will enable a VCMSC to generate repeat business, positive rumours, and so on. Through **its PORM system**, a VCMSC generates and updates a list of the most potential clients (Figure 4).

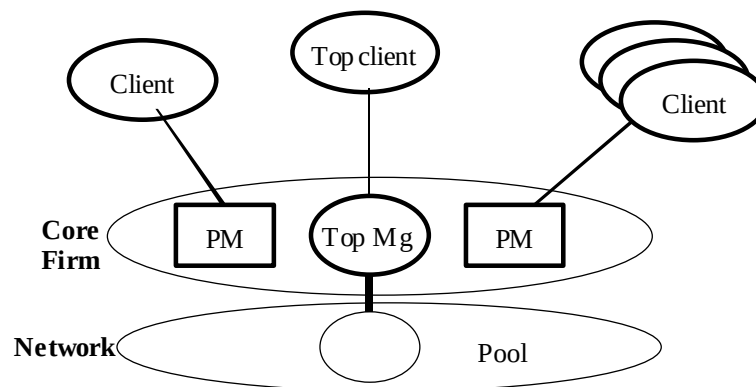


Figure 4: Project owner relation management system (PORMS).

Company management and project managers act as client accounts for ensuring future work. Continuous investments in client relationship management are fairly high (aligning with [14]). However, we expect that future returns will turn out be much higher when a VCMSC will capture a series of CM contracts behind a protective “wall” consisting of the normative beliefs of the collaborative clients.

3.1.2 Project Offerings and Bidding Management System (POBMS)

In building bidding processes, a productive breakdown makes it possible to define work scopes accurately enough to eliminate overlaps and gaps between the work scopes [15]. One of many innovations of the CM system is multi-bidding and multi-contracting which minimizes frequent and difficult construction trade interfaces, provides each contractor with as much construction continuity as possible and schedule effectiveness. This is so because more control is given to each contractor over its own program and finger pointing is reduced in the event of interfacing contractors with different priorities. Multiple contracting provides a simple way to involve target contracting groups. Regardless of why they are targeted, it is possible to reserve specific work scopes for exclusive bidding by contractors in the group. Deciding which work scopes to set aside

depends on the match-up of contractors in the target group and the requirements of the work scope [3].

However, traditional subcontracting prevents both an owner and a principal contractor from inviting subcontractors to innovate and deliver their best (new) solutions based on the accumulated professionalism. Thus, **the leading member of a VCMSC** collaborates herein with a competitive network of eligible members, i.e. special system contractors (SSC) with their own special resources; material, equipment, labor. With **its POBM system**, the leading member performs the work scope breakdown and prepares a list of bid packages, buys bills of quantities and a cost estimate from an expert consultant(s), and distributes the bid packages (aided by advanced IS) to a set of networked SSCs for the bid preparation. The goal of a bidding process is to generate the most attractive solution to a client. A project scope needs to be large and versatile enough so that the project becomes a viable target for a VCMSC with its specialty network. As a rule, each package will be bid by at least three members (incl. external SSCs) who have room in work load, available staff, resources, and an interest to submit a proposal (Figure 5).

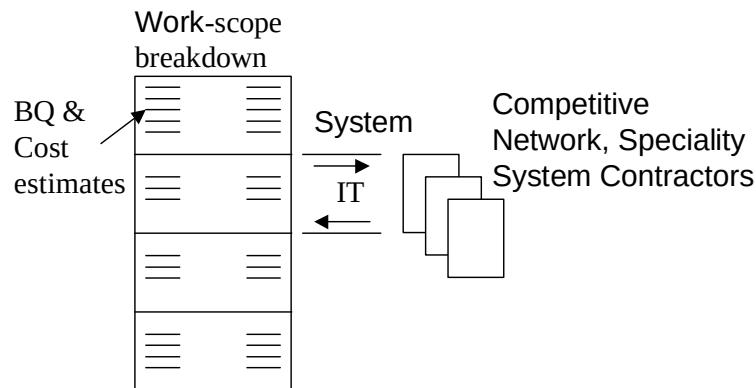


Figure 5: Project offering and bidding management system (POBMS).

The top management of the leading member makes all the decisions during the networked bidding process. A POBM system enables to understand client needs fast, compile the best offering, divide work scope among SSCs and obtain the most competitive prices for each package.

3.1.3 Project Design and Engineering Management System (PDEMS)

In general, design and construction practices and project delivery systems have moved toward **the integration** which has encouraged stakeholders to manage design and construction processes concurrently in causally overlapping phases. Narrowing gaps between design and construction through the integration improves constructability especially during pre-construction phases (conceptual planning, design development, procurement). A design development phase consists of (a) schematic design where a design team investigates alternative design solutions, and (b) detailed design where a design team evaluates, selects, and specifies the systems and components of the building project in question. A lack of construction knowledge/experience integration in planning and design processes can lead to constructability problems during construction phase because most design professionals have only little experience in construction practices, local

considerations, availability of different resources, and so on. During the procurement phase, when a project formally transitions from the design preparation into the construction preparation and when the project bidding and awarding is performed, a contractor's reliance on the contract documents to visualize the construction process limits its ability to become more familiar with the project in question [16].

However, the traditional stage model where all the design documents are completed before the related procurement (and construction work) is too slow and does not allow to utilize the networked expertise in real-time. Thus, **the PDEMS** is herein designed to improve constructability as this subsystem provides network members, special system contractors, with a platform to contribute early enough to the detailed design of the project packages that are

allocated to each of special system contractors. The leading member of a VCMSC establishes a **product model** as the core of a PDEMS which enables the effective exchange and change of project information. In each project, all project stakeholders are having the real-time access to the most recent design documents. Typically, a pre-construction constructability review is divided into the sub-reviews that take place by design packages. Designers get on time the real-time feedback regarding design changes and adaptations through the design layout reviews and the identification of design conflicts (Figure 6).

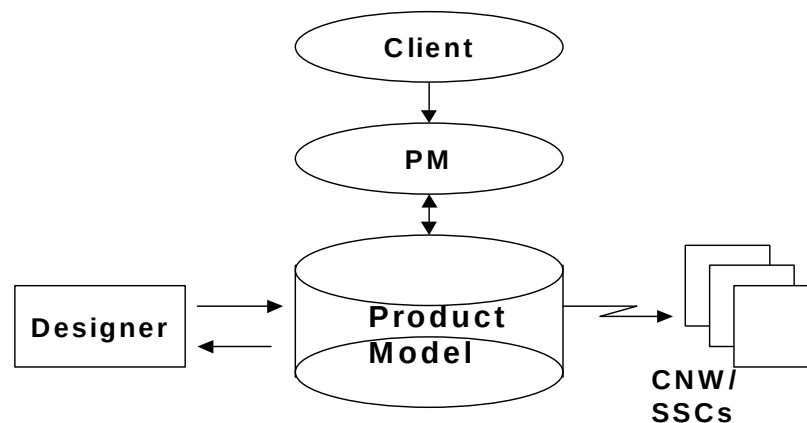


Figure 6: Project design and engineering management system (PDEMS). (Key: CNW refers to the network and SSCs to special system contractors.)

3.1.4 Networked Project Procurement Management System (NPPMS)

In general, partnering in its simplest form is a commitment between two or more organizations to work together for the common purpose of achieving specific business objectives by maximizing the effectiveness and benefits of cooperation. **Partnering agreements** can be created in various forms to suit particular objectives, “strategic alliances” organizations are one of the more common forms of partnering in which two or more strongly positioned or dominant suppliers partner with equally dominant customer(s) because they have a mutual dependence on each other [16]. Partnering provides an opportunity for cooperative contracting in which the open, competitive bid process keeps the parties at arms length prior to the award of the contract, and

once the contract is established there are major benefits to all partners from the development of an organizational culture characterized by trust and cooperation. Building partnering infrastructure requires leaders who determine the degree to which the organization is structured to support its strategic objectives, redesign the organization as a partnering network to ensure that the organization's culture is aligned both with its partnering philosophy and processes.

Herein, **the NPPMS of a VCMSC** provides the members of the network with the internal arena to compete effectively in order to come up with the integrated best offering. On the other hand the **leading member of the VCMSC** will be able to move towards outsourcing those processes which are not part of its own core skills. When a project opportunity arises, the leading partner notifies the members, i.e. special system contractors via Internet data transfer to post their offers/bids, selects the bids, and notifies the winning bidders, who will in return take part in the detailed design, or do it altogether, and provide tailored solutions as part of their bid packages. Systems are herein divided into the five principal categories [18]: (i) base building systems (ground work and excavations, demolition, foundations and building frame, roof, facades and outer levels), (ii) permanent space systems (stairs, entrance halls, auditoriums etc.) and components, (iii) technical building services systems (HEVAC systems, information systems etc.) or technical base systems (technical core), (iv) flexible space systems (separate space areas or departments, HEVAC techniques of the space infills), and (v) exterior area systems (area structures, including HEVAC technical work). The system allows the special system contractors to collaborate in order to win new business and develop new projects, even concentrate the weight of a large company yet retain the speed and flexibility of a virtual network.

3.1.5 Construction, Execution, and Control Management System (CECMS)

The advanced management of construction projects is a problem in information, or rather, a problem in the lack of information required for decision-making. In order to keep the projects rolling, decisions have to be made before all the information required for the decision is available. Decision-making is about robust decisions, rather than optimal decisions [19]. Key decisions concern project quality, schedule, budget, and information itself. In the same vein, **the CECMS** of a VCMSC provides the leading member or the CPM team with an advanced planning system in which the workplaces and the coarse general planning are combined, the detailed activity planning are done just before beginning of each activity, and short time rolling window is used through the whole project. The corrections must be performed immediately. If work stops in one workplace, it is jumped over and a new team will be allocated (Figure 7).

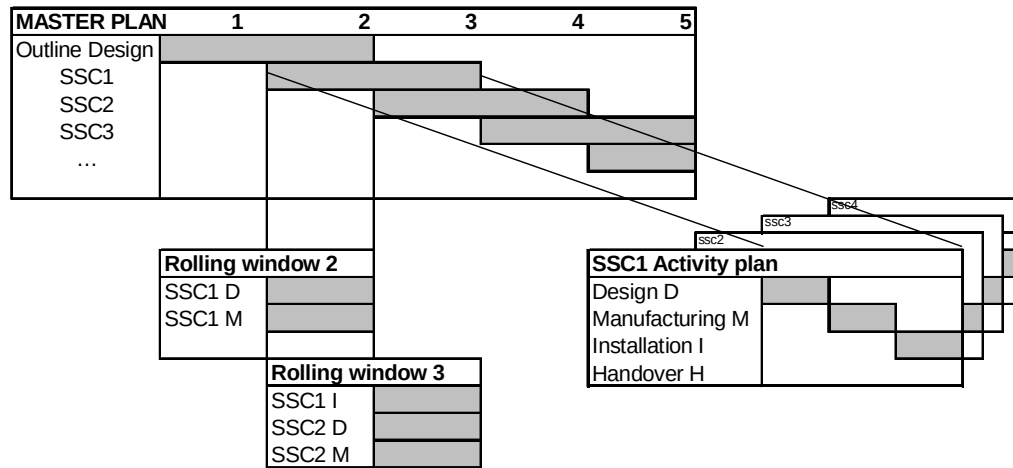


Figure 7. Construction, scheduling, execution, and control management system (CECMS).

The CPM team plans a **master plan**, which contains the main systems or packages to be performed and the special system contractors performing them without too many details. For control purposes, the critical path and milestones are made together with their dependencies. Each of the special system contractors plans its activity plans/schedules which are re-integrated into the real-time master schedule(s). An activity plan is prepared in the way that allows each activity to be presented in a rolling window in detail just before it starts to show what sub-system and work will be executed on site and how.

3.1.6 Network Nurturing Management System (NNMS)

In principle, A leading member acts as a strategic center and expects its network members to follow rules and meet contractual obligations. **Involvement with network members** beyond traditional subcontracting includes several key issues such as developing the competencies of the members, borrowing, developing, and lending new ideas, and sharing perceptions of the competitive process and customer needs. The quality of relationships and the shared values differentiate and define the boundaries of a network organization [17]. Among **longer-term, close relationships**, there are various approaches such as a close single source, preferred supplier relationships and arms-length competitive tendering relationships. Suppliers are assessed in terms of three categories: (a) strategic suppliers, who are awarded long-term arrangements but normally only as preferred rather than single source suppliers, (b) non-strategic suppliers, who are procured through more arms-length relationships, and (c) specialist suppliers, who are also awarded long-term supply agreements, often on a single source basis. The initial selection for long-term supplier status is done on a basis of the volume and/or the strategic importance of a project [16].

Herein, the **NNMS** enables the **leading member of a VCMSC** to develop the competences of its network in order to produce innovative building solutions that will ultimately lead to a success in new projects. The leading member needs to work more closely with the networked members to ensure that system specialist contractors of the right caliber are selected, who would develop the required expertise both in the short and longer term. Shorter lead times and construction periods as well as higher cost certainty and a larger scope for cost reduction can be achieved through a deeper degree of integration between system specialist contractors. A leading member may choose the core VCMSC team project by project. One of member selection strategies implies that each building scheme is approached on a “fit-for-purpose” basis, i.e. the required expertise and competences are determined and the necessary functional areas are specified for the project in hand. Overall, high effectiveness is gained through providing key members with continuous workload and improving synergic project performance along the joint principles of competence nurturing. On the one hand, a special concern is given to the avoidance of monopolistic dependency when nurturing network relationships. A viable VCMSC cannot become dependent on any single special system contractor. On the other hand, none of these special system contractors should become fully dependent on one particular VCMSC. In other words, the former are encouraged to compete both individually and through other collaborative arrangements in other competitive arenas to gain more experience and knowledge of better practices.

4. Conclusions

In short, a VCMSC is defined as a dynamic competitive network of collaborating special system contractors that reconfigure around a leading member whenever an opportunity arises. It is proposed herein that **the viable management of a VCMSC** involves the six areas or dimensions along which each of the corresponding subsystems are designed and leveraged. Initially, some key principles of VCMSC management are distilled as follows. First, advanced owners of buildings are the ones that gain the highest value-for-money through the reliance of virtual construction management contracting. Second, a competitive network is established and motivated in order to achieve sustainable-like advantages over a series of projects. Third, the special system contractors produce all the systems and solutions that make a viable whole or a building. They also deliver all the changes that are leveraged in real-time to all network members. Fourth, the real competitiveness is measured through the integrated offerings and procurement of a set of the systems project by project. Fifth, the advanced construction project management is based on a master plan and a set of activity plans/schedules with rolling windows. Sixth, the conditions of sustainability of a VCMSC include the continuous renewal of the network, the nurturing of the innovation competences, and the advanced ways of integrating the network through the other five areas or dimensions. In the near future, **the empirical inquiry and the testing of the subsystems** will take place to validate the suggested VCMSC model, overall, in the context of the building market in Finland. In turn, the advanced information systems and solutions need to be specified, procured, and applied to support the VCMSC management system. For this endeavor, all interested foreign experts in virtual CM and networking are welcome to join the TKK/CEM development team.

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Analysis of the Organisational Culture Profiles of Construction Firms in China

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Abstract

The vast economic growth in China in the past decade has brought about a unique opportunity for the development of China's construction industry. However, China also faces many challenges and uncertainties resulting from the fast changing economic environment. The construction industry has been criticized for poor performance and low effectiveness in terms of quality and profitability. Given that organizational culture plays a significant role in work performance and effectiveness, this paper presents a culture – effectiveness model for investigating the Chinese state-owned construction enterprises. The culture – effectiveness (C-E) relationship has received increased attention in organizational research although there remain significant questions over the existence and strength of such a relationship. This paper presents the results of cluster analysis of the culture profiles of Chinese construction enterprises and develops a model for investigating the C-E relationship.

Keywords: Organizational culture, effectiveness, Chinese contractors, state-owned enterprises.

1. Introduction

The past decade has witnessed China's rapid and extensive economic growth that has brought about a major opportunity for the development of China's construction industry. The value of the total investment in fixed assets in 1999 amounted to 2988 billion RMB Yuan while it was only 91 billion in 1980 [1, 2].

However, Chinese construction companies (state-owned enterprises) are often accused of poor performance and low effectiveness in terms of quality and profitability [3, 4]. Hence, ways to improve the effectiveness of the Chinese construction companies are considered important and

the postulation that there is a relationship between organisational culture and organisational effectiveness becomes a focus for investigation.

There are many environmental and project factors that affect the performance effectiveness of the state-owned enterprises in construction (SoEs) and that, one could argue, may fall outside the immediate control of the SoEs. However, organizational characteristics that fall under the control of management, and which represent how the enterprises organize themselves in response to the environmental challenges, are most crucial in determining consistency of their effectiveness appropriately. It is argued that the ability of the SoEs to both well organize themselves internally and respond to the environment externally comes from the organisations' cultures, an intangible force currently believed to play a tangible role in affecting the competitiveness, development and ultimate survival of the SoEs [5].

2. Organizational culture and effectiveness: a review

In the past twenty years, it has been increasingly recognized that organizations, ostensibly similar as they are in terms of structure, may differ substantially in their performance and effectiveness. There seems to exist factors which permeate organizational life and influence every aspect of organization operation. The study of organizational culture stems from such realization, by organizational scholars as well as practitioners, with a belief that once the ambiguity and unpredictability of organizations are better understood, their performance and effectiveness could be greatly improved by adopting better organizational designs [6]. As Schein [7] puts it, "The concept of organizational culture holds promise for illuminating this difficult area" and since the early 1980s, culture studies have acquired prominent status in the management field.

The purposes of studying culture are many; but the principal purpose is to find out how it affects organizational performance with a view to improving effectiveness – arguably one of the most important organizational-level variables. Such culture-effectiveness link studies (see [8], [9]) can be divided into the following three stages:-

2.1 The Budding Stage

In the field of organizational research, the culture-effectiveness link studies developed alongside the emergence of the human relations school in the middle of the last century, with the Hawthorne studies being the pioneer, indicating implicitly how group culture affects performance. Jaques [10, 11] related the customary and traditional ways of thinking and doing

things to the working behaviours of employees. Although the effects of the commonly shared “ways of thinking and doing things” are not directly investigated, his findings indicate that organisational culture could be a serious barrier to productivity if it were not congruent with the organizational structure and environment. Pfiffner and Sherwood [12] suggest that there may be a relationship between the culture and the effectiveness of a firm, but they do not conduct any further investigation of the nature of such a hypothesized link. Silverzweig and Allen [13] are the first to intentionally and explicitly look into the effect of culture on the performance of a company. Of their eight case studies, which involve various branch organizations that have suffered losses and intended to raise their effectiveness, six organizations improve their performances substantially after changing their culture. Such findings lead them to suggest that there is a close link between culture and performance of an organisation.

2.2 The Promulgation Stage

The end of the 1970s marked a clear change from implicit attention to the culture-performance/effectiveness link, with the attempt to explain the shining success of Japanese enterprises at that time. Ouchi is one of the outstanding scholars to arouse people’s attention to the importance of employees’ commitment and the unitary vision for the company’s success, by arguing [14, 15] that emphasis on certain humanistic values contributes to the company’s economic performance. These values include employee-concern and consensual decision-making which, generally, characterize Japanese enterprises. Based on their experiences with more than 30 Japanese and American companies, Pascale and Athos [16] put forward a similar idea that the higher productivity of Japanese firms is attributable to their emphasis on human relations, by arguing that focus on skills, style and employee goals lead to high performance. That strong culture has made the difference between successful firms and less successful ones is claimed by Peters and Waterman [17], who argue that superior performance is to be achieved only if the firms move to a more adaptive and humanistic approach from pure technical and rationalistic approach. Deal and Kennedy [18] also put out a similar view that a strong culture is not only able to respond well to the environment, but also to changing circumstances, thus enhancing the performance of firms. This period of the 70s to early 80s was characterized with a relatively popular belief that a link existed between culture and performance, but without much substantial evidence.

2.3 The Testing Stage

The doubts, scepticism and, even, contradictory findings [19, 20] concerning the culture-performance link led to a large volume of empirical studies from the end of 1980s to present, attempting to test such theoretically disputable link, as a further step in exploring and uncovering the cultural phenomenon of organizations. The major researchers include: Barley, Meyer and Gash [21], Cooke and Rousseau [22], Dennison [23], Rousseau [24], Calori and Sarnin [25], Gordon and DiTamaso [26], Kotter and Heskett [27], Marcoulides and Heck [28],

Petty, Beadles, Lowery, Chapman and Connell [29], Dennison and Mishra [30], Wilderom and Van den Berg [31], and Sawner [32]. The findings of research studies, though different to some degree, show a culture-effectiveness link. Relying on co-relational techniques, most of the studies are not able to establish a firm direction of such relationship, the significant correlations indicate possible causal relationship between organizational culture and effectiveness that should be investigated further [9].

While culture has been gaining in popularity in the general management field, culture studies in the construction industry also have intensified. Maloney and Federle [33, 34] introduce the Competing Values Framework as their paradigm for analyzing the cultural elements in American engineering and construction organizations. Gale [35] looks at culture as a means to reduce conflicts in construction. Seymour and Rooke [36] present their views of the culture of the UK construction industry. Rowlinson and Root [37] offer their views of the impact of culture on project performance. Hall and Jaggar [38] note the importance of culture differences in international construction. Liu and Fellows [39, 40] highlight the culture issues in project procurement and also explore the impact of culture on project goals. With Hong Kong real estate profession as the research context, Liu [41] explores the relationships between cultural dimensions, strength and the real estate professionals' perceived job satisfaction.

At present, culture research findings are not entirely consistent with one another, and sometimes even contradictory. Due to the complex nature of the constructs of "organizational culture" and "effectiveness", there is a lack of an integrative and comprehensive framework for C-E (culture - effectiveness) research.

3. Developing the C-E linkage model

3.1 Behavioural Approach

Much of the research on organizational culture has emphasized the central importance of the values and beliefs that lie at the core of an organization's social system. However, one of the key challenges in research of the organizational culture and effectiveness (C-E) link relates to the establishment of a theoretical basis for explaining the assumed relationships [9]. In such C-E link studies, most of the ideas about the relationship between culture and effectiveness have attributed the success of organizations to some combinations of values, beliefs and practices. Such attributions imply a general framework that organizational effectiveness is a function of organizational culture.

Although this framework shows the link between these two organizational variables of culture and effectiveness, it offers nothing more than a superficial one – without indicating the mechanism of how organizational culture operates on the final organizational outcome, leaving such an "organic process" ignored as a "black box". In order to substantiate the assumed link,

the organizational culture operating mechanism on behaviour has to be investigated in more detail.

In the study of organizational behaviour, one of the traditional theories is the S-O-R (Stimulus-Organism-response) sequence [42] which has been applied by Liu and Walker [43] in the modelling of the construction procurement process in terms of the B-P-O (behaviour-performance-outcome) cycle. Given the idea that organizational culture is the “software of the mind” [44] that is shared by organizational members, it influences the cognition and perception of its members, guides their behaviours, integrates its internal processes to ensure the ability to survive and adapt to the environment [45, 7, 22, 23, 30, 46]. Therefore, it is postulated that organizational culture can be taken as the “stimulus” for the adoption of various behaviours in the organization.

3.2 Schema Theory

Based on a detailed review of the social cognition literature, Markus and Zajonc [47] conclude that schema theory is the most useful and pervasive perspective on the mechanics of social cognition. Many definitions appear in the current literature. However, the definition offered by Marshall [48] might be the most comprehensive: “A schema is a vehicle of memory, allowing organization of an individual’s similar experiences in such a way that the individual can easily recognize additional experiences that are also similar, discriminating between these and ones that are dissimilar; can assess a generic framework that contains the essential elements of all these similar experiences, including verbal and nonverbal components; can draw inferences, make estimates, create goals, and develop plans using the framework; and can utilize skills, procedures, or rules as needed when faced with a problem for which this particular framework is relevant”. As implied from the above definition, schemas serve as mental maps which enable individuals to orient themselves within their experimental terrain and guide interpretation of the past and present, as well as expectation for the future [49]. The seven functions listed below is the most comprehensive summary from Taylor and Crocker [50]:

- § Providing a structure against which experience is mapped;
- § Directing information encoding and retrieval from memory;
- § Affecting information processing efficiency and speed;
- § Guiding filling gaps in the information available;
- § Providing templates for problem solving;
- § Facilitating the evaluation of experience;
- § Facilitate anticipating of the future, goal setting, planning, and goal execution.

Schemas are dynamic. As schemas incorporate more and more new information, they become expanded and more and more elaborate [51, 52, 53, 49]. Schema theory suggests very important implications for expanding our understanding of the role of organizational culture in guiding sense-making in organizations. According to Rumelhart [54], knowledge about any stimulus can

be schematized and, therefore, individuals can have at their disposal many schemas. Harris [49] argues that organization-context-specific schemas are most relevant to understanding organizational culture, since social knowledge is generally contextually bound. Culture scholars usually stress human motivation from the perspective of culture. However, to assume that individuals are endowed with a fixed set of needs and that a social institution is there to satisfy them commits a fallacy of abstract individualism and yet to assume that culture is unproblematically internalized is to “over socialize” the individual and oversimplify the process by which a person actively appropriates socially shared meaning [55]. Strauss [56] argues, in a broader sense, that human motivation is “the product of interaction between events and things in the social world and interpretations of those events and things in peoples’ psyches”.

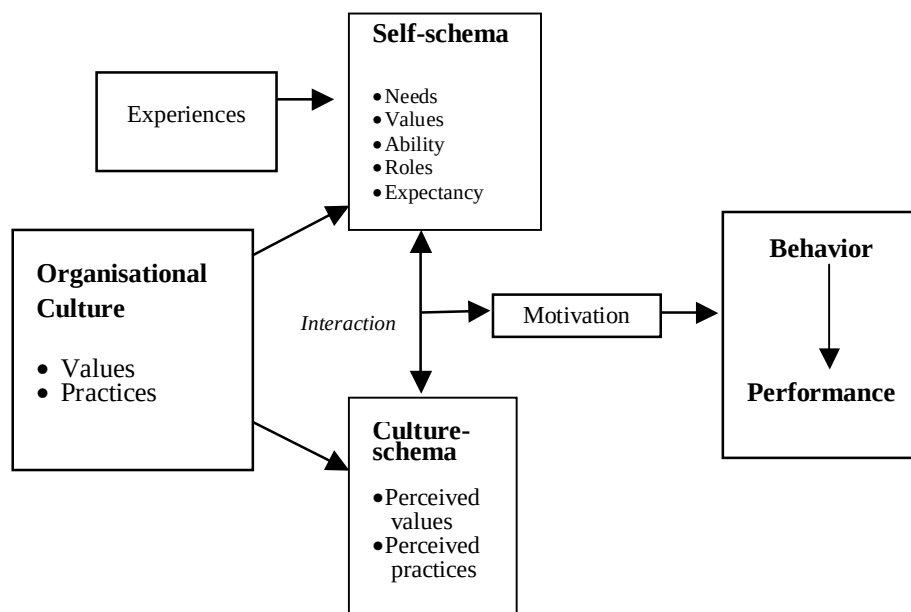


Figure 1: Organizational Culture, Schemas and Performance

Motivation theories suggest that people do what they do to satisfy their needs. Given all human conscious behaviours are motivated by their needs and goals [57], individuals tend to evaluate their performance against the attainment levels of such goals and the satisfaction levels of their needs as their behavioural outcomes. Such evaluation by organizational members is a process of comparing the organizational rewards of their behaviours and performance against what may be expected (goals) by them. In an organization, rewards are basically classified in two categories: extrinsic rewards and intrinsic rewards [58]. However, the satisfaction of the employees does not solely depend on having their own goals met and their own needs satisfied. Individuals are also concerned about the fairness of the rewards according to equity theory [59, 60]. Hence, the level of satisfaction is also influenced by the outcome of the individuals’ “horizontal” comparisons with other organizational members, particularly their peers.

The above analysis focuses on the individual or micro level of outcome effectiveness. However, the performance of organizational members also leads to the organizational or macro level of outcome effectiveness, as the performance of the organization is, to a large extent, attributable to the aggregation of individual performances moderated by the external environment. The organizational-level effectiveness in culture studies is multi-dimensional, usually centering on such dimensions as customer service quality, market share and economic return, external adaptation and ultimate survival. Fig. 2 indicates the relationship between performance and effectiveness outcome.

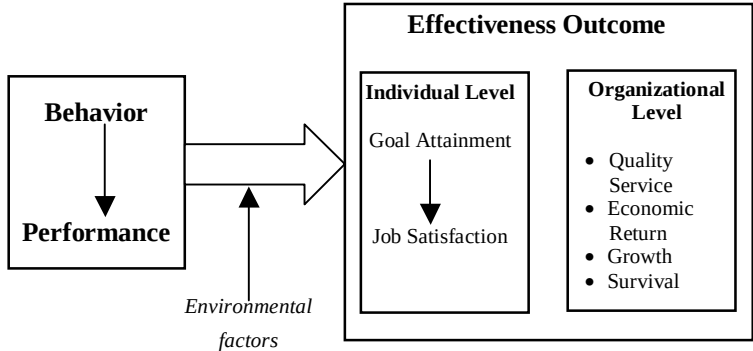


Figure 2: Performance and Effectiveness Outcome

3.3 Research Objective

From the above discussion of the relationship between organizational culture and effectiveness, this paper focuses on the following research objective relating to the Chinese state-owned construction enterprises:

To examine if the relationship between organizational culture and effectiveness is reciprocal and whether organizational culture is both an asset and a liability, depending on its positive or negative impact, on organizational effectiveness.

4. Research Design

The research design comprises three stages:

(1) The first stage comprises preliminary case studies of selected Chinese construction enterprises with the purpose to test and choose from two culture measuring instruments, i.e., OCI – Organisational Culture Inventory [61, 62] and OCAI – Organisational Culture Assessment Instrument [46]. Both OCI and OCAI have previously been widely used and tested as reliable in measuring organizational culture. Five construction companies from China north (Beijing and Tianjin) to China south (Shantou in Guangdong) are selected from the A Complete List of the Chinese Construction Enterprises (Ministry of Construction, 1989). The results of the selected case studies are presented in this paper (which, from respondents' feedback and Cronbach Alpha coefficients, show that OCAI is more suitable, in terms of validity and reliability, for measuring organizational culture of Chinese construction companies).

(2) (a) The second stage comprises a major survey of state-owned construction enterprises using OCAI to assess their organisational culture profiles and cluster analysis is applied to analyse that sample into groups.

(2) (b) An organizational effectiveness survey instrument is developed for measuring performance effectiveness of the same enterprises in stage 2(a). At the time of the stage 2 major survey, the organizational effectiveness instrument is administered together with the OCAI. The culture profiles from stage (2a) are mapped onto the effectiveness measures in order to analyse whether culture is a variable to explain the variance in organisational effectiveness.

(3) The third stage adopts a qualitative research approach by means of case studies selected from stage 2 to identify specific culture variables predominant in particular environmental contingencies contributory to performance effectiveness, thereby, to indicate future directions for research in organisational culture change.

5. Empirical Results

This paper reports the findings in stage 1, i.e. the preliminary case studies of five selected construction enterprises in order to identify the suitable culture measuring instrument.

Both OCAI and OCI are designed to measure the relatively shallow layers of organizational cultures, such as practices, norms or rules, and cultural phenomena, and these differences are likely to exist in the Chinese construction enterprises. OCI is empirically found to be lengthy (120 questions) and respondents remark that the questions are not very clear – as far as interpretation by respondents in the specific Chinese cultural environment is concerned. The response rate on OCI is disappointingly low at 8% compared to that of around 40% (see fig. 3) on OCAI. The Cronbach Alpha coefficients for the culture types in OCI are lower (8 out of 12 culture types with cronbach alpha less than 0.79, lowest being 0.22) than the OCAI (lowest cronbach alpha at 0.79), hence, OCAI is adopted for the stage 2 major survey.

5.1 Measuring instrument – OCAI

The OCAI, including its theoretical base in the Competing Values Model and the interpretation of the four culture types, i.e. clan, adhocracy, hierarchy and market, is explained in detail in Cameron and Quinn [46] and Quinn and Rohrbaugh [63]. Each culture type contains 6 questions, hence, there is a total of 24 questions in OCAI that describe six scenarios, including dominant characteristics, organizational leadership, management of employees, organizational glue, strategic emphasis, and criteria of success. Based on the “content” of these six scenarios, four types of cultures are formulated, namely, clan, adhocracy, market, and hierarchy. The six scenarios/questions are used to stimulate the respondents to interpret the relative resemblance of the cultures of their own enterprises. Clan culture describes an organisation that focuses on internal maintenance with flexibility, concern for people, and sensitivity to customers’ adhocracy culture describes an organisation that focuses on external positioning with a high degree of flexibility and individuality; hierarchy culture describes an organisation that focuses on internal maintenance with a need for stability and control; and market culture describes an organisation that focuses on external positioning with a need for stability and control [46].

5.2 Data Collection

The construction enterprises in stage 1 and 2 are chosen on three basic considerations: (a) categorized as first-class construction enterprises¹ by the Ministry of Construction (MoC), (b) engaged in building construction, and similar in organization size; (c) respondents hold relatively high positions. Five construction enterprises are selected for stage 1. The major survey in stage 2 consists of stratified sampling from a total of 552 first class SoEs. The number of respondents from each enterprise in stage 1 is given in fig. 3.

¹ According to “*Administrative Regulations of Construction Enterprises*” [64], construction enterprises are categorized into 4 classes: First Class, Second Class, Third Class, and Fourth Class. In the first-class enterprises, there are 29 sub-groups such as building (civil and industrial engineering), chemical and hydro engineering; highway and transportation engineering, of which building construction enterprises are the largest subgroup.

5.3 Data analysis

The culture mean scores of the five enterprises in stage 1 are given in fig. 3. ANOVA confirms that all five enterprises differ significantly on all the OCAI questions relating to the four culture types. The figures marked in **bold** in fig. 3 denote the dominant culture type in the particular enterprise.

Fig. 3 Mean Culture Scores of construction enterprises in stage 1

Enterprise Culture type	1 Beijing	2 Langfang	3 Tianjin	4 Gezhouba	5 Shantou	Average	N	Cronbach Alpha
Clan	2.8326	2.9717	3.0240	3.2614	2.3952	2.9391	182	0.79
Adhocracy	2.0088	1.8468	1.7070	1.7100	2.8590	1.9462	185	0.86
Market	3.2280	3.0319	2.1667	2.2105	3.4102	2.7084	171	0.88
Hierarchy	3.5746	3.4667	3.5323	3.0738	2.3513	3.3441	178	0.84
Respondents (N)	38	35	56	38	26			

On average, hierarchy culture is the predominant type (mean score of 3.3441), however, the Shantou enterprise is the exception with a predominantly market-oriented culture.

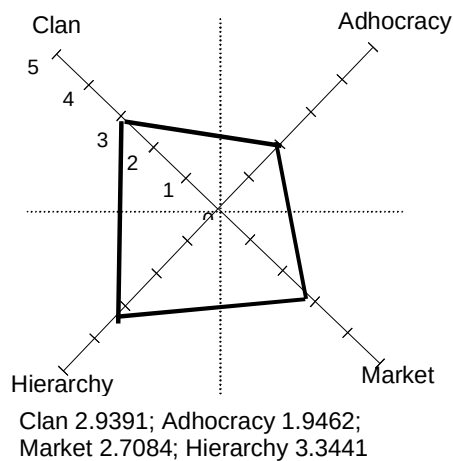


Figure 4: Mean organisational culture profile of construction enterprises

To attempt to represent organisational culture in four distinct types/profiles would be misleading. The four types adopted by Cameron and Quinn [46] provide a basis to systematically organize culture variances at the organizational level but does not pretend to be comprehensive of all cultural phenomena – especially at national level. The framework of the four culture profiles supports a platform to interpret key elements of organizational culture that

can foster change and improvement in organisations, i.e. a framework that provides an “intuitively appealing and easily interpretable way to foster the process of culture change” [46].

Findings from stage 1 of the five selected cases show that:

- cultural difference exists at the corporate level of the Chinese construction enterprises,
- of all the four culture types, hierarchy and clan are stronger than market and adhocracy.

This implies that, although there exist cultural differences at the corporate level, the Chinese traditional national culture, characterized by Confucianism and nurtured by decades of highly unified political ideology and centralized planned economy, has great influence at the corporate level. However, China’s recent open and reform policy has been exerting impact on its current culture, which can be reflected from some of the individual cultural traits in the enterprise 5. (Enterprise 5 is located in Shantou, in the south of China, which is more exposed to western market influence). The cultural results reflect the general status of China’s mixed and transitional characteristics, politically, socially and economically.

In the next stage of research, cluster analysis is to be carried out to classify the enterprises into groups that share similar organisation culture profiles across the four culture types, scores at the individual-level for each type of culture need to be aggregated into the organisational (enterprise)-level. In order to test if a particular culture profile, is more effective than the others, the clusters of SoEs (with different culture profiles) will be tested for comparison of their organizational effectiveness indicators by Kruskal-Wallis test.

6. Conclusion

This paper presents a theoretical framework developed for investigating the culture and effectiveness of Chinese construction enterprises. It also offers a proposed methodology for testing the C-E hypothesis by collecting empirical data from the Chinese construction industry. The pilot study in stage 1 shows that the OCAI questionnaire can be used in assessing the culture profiles of the Chinese companies and that differences seem to exist in different regions (especially that which have been exposed much to western market influence) although hierarchy and clan cultures still dominate.

Three important factors that shape the culture of an organization have acquired the consensus of culture scholars, summarized as [6]:

- The societal or national culture within which an organization is physically situated;
- The vision, management style and personality of an organization’s founder or other dominant leader; and
- the type of business an organization conducts and the nature of its business environment.

Considering the traditional Chinese culture and the current status of the Chinese construction industry, the above general culture profiles of Chinese construction enterprises seem to be consistent with the particular Chinese context. Hierarchy culture is still at the dominating status that reflect 40 year's centrally-planned economic system with all the enterprises being of an institutional nature that strongly focused on "order", which eventually led to the widely-criticized "red tape". The second dominating culture, clan culture, reflects the traditional Chinese culture that focused on "harmony and *guanxi*" and "people-orientation". With the recent 20 years' economic reform, there appears to be more and more competition in the Chinese construction industry which, in turn, leads to the internal market culture of the Chinese enterprises. The very low score of adhocracy culture in the general culture profile suggests that innovation and risk-taking spirits are still quite absent among Chinese construction enterprises.

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Section IV

Human resource
management

The importance of workplace support and work flexibility for civil engineers

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Abstract

This quantitative study examined the relationship between a supportive work culture and the work and life experiences of Australian civil engineers. Data were gathered from a sample of 1000 male and female civil engineers in a wide variety of work and family situations. The research investigated the level of work-family conflict perceived by civil engineers and the work-family balance values of their employing organisations. In addition the relationship between these work culture perceptions to other variables, such work and non-work satisfaction and burnout was investigated. The results indicate that civil engineers who perceive their organisation's values to support both their work and family life reported greater job satisfaction as well as lower intentions to quit. The results also demonstrate the "buffering" effect of flexible practices and a supportive work environment. It was found where organisations had flexibility and organisational values supportive of work and family integration, the positive relationship between work-family conflict and burnout was reduced. The implications of these findings for organisations employing civil engineers are discussed.

Keywords: organisational culture, civil engineers, work-family conflict, burnout.

1. Introduction

1.1 Background

Considerable changes, not only in the demographic composition of the workforce, but also in the roles and expectations of men and women have led to organisational and employee attempts to reconcile responsibilities in the work and non-work domains. Many job and organisational features found to impact negatively on family and non-work life are pertinent to civil engineers. These include long and irregular work hours, schedule inflexibility, high job demands, job insecurity and frequent relocation [1, 2].

This paper reports on findings of a recent research project investigating civil engineers and their perceptions of how supportive their workplaces are towards greater work and family balance.

1.2 Work Family Conflict and Organisations

Legal requirements and organisational performance issues appear to be at the core of the many arguments put forward for supporting employees' lives outside work. Legislation that stems from a social justice base, presents a strong motive for companies to address the concerns of their employees with family responsibilities. Along with most industrialised countries Australia has adopted equal opportunity legislation promoting equal work conditions for men and women. In 1990, Australia ratified International Labor Organisation (ILO) Convention 156, addressing workers and their family responsibilities. Consequently legislative and industrial reforms have flowed through, prohibiting dismissal on the basis of family responsibility as well as improving working conditions [3].

Organisations are also increasingly recognising the positive benefits of work-family initiatives. Decreased levels of work-life strain have been found to result in increased job satisfaction, decreased employee turnover and improved levels of organisational commitment [4]. Organisational variables such as schedule flexibility, supervisor support and time overload [5, 6, 2], and family-related variables such as parenting overload, spousal and familial support, and family distress [2, 7] have been found to directly influence family relationships, work-family conflict and intent to leave the workplace [8]. Support from supervisor, spouse and family, have been shown to reduce work-family conflict through their impact on role overload and work distress [7, 9]. Burnout is also associated with increased work family conflict, as well greater levels of absenteeism and turnover, and reduced organisational effectiveness and job satisfaction [10, 11, 12]. At an individual level, burnout has been associated with anxiety, depression, reduced self-esteem and substance abuse [13].

1.3 Supportive Work Culture

Grover & Crooker (1995) found that employees in companies with family-supportive benefits had higher levels of affective commitment to the organisation and expressed lower turnover intentions, regardless of whether the employee individually benefited from the policy [14]. Grover and Crooker postulated that work-family benefits had a positive influence on employees' attachment to the organisation because they signified corporate concerns for employee well-being. However while providing work-family policies and initiatives is important, it is imperative to recognise that these will have very little worth, and employees will not feel secure in utilising them, unless their value is entrenched within the culture of the organisation [15]. Many work practices assume that an employee's work domain is totally isolated from their family domain.

Denison defined organisational culture as "the deep structure of organisations, which is rooted in values, beliefs, and assumptions held by organisational members." [16, p624]. Bailyn [17] outlined three characteristics identifiable in a family-friendly work culture: flexible work scheduling, flexible work processes and an understanding by organisational leadership that family needs are important. Warren & Johnson [18, p163] consider a culture can be classified as family friendly when "its overarching philosophy or belief structure is sensitive to the family

needs of its employees”. Thompson, Beauvais & Lyness [19, p394] expanded the understanding of work-family culture to include the “shared assumptions, beliefs, and values regarding the extent to which an organisation supports the values and integration of employees’ work and family lives.” They consider a negative work-family culture to have at least three components; organisational time demands or expectations that employees prioritise work over family, negative career consequences associated with utilising work-family benefits, and lack of managerial support and sensitivity to employees’ family responsibilities. Research has shown that supervisors play a key role in the effectiveness of both the implementation and utilisation of work-family policies and that employees’ whose supervisor supported their efforts to balance work and family were less likely to experience work-family conflict [5]. Supervisor support is also an important buffering factor in the relationship between work family conflict and burnout [6].

Much research has proposed that workplace support can play an important part in assisting employees manage their work and family responsibilities. However little research has specifically focused on the supportiveness, or otherwise, of the organisations employing civil engineers. This research will determine the prevalence of supportive organisational values and the level of work-family conflict perceived by civil engineers as well as testing several hypotheses regarding influences of, and on, supportiveness, flexibility, work family conflict and emotional exhaustion. The hypotheses which will be considered are as follows:

H1: Respondents who consider their workplace to be supportive of a balance between work and non-work responsibilities will also report lower levels of work to family conflict, greater levels of job and life satisfaction and lower intentions to quit.

H2: Work load and organisational time demands will have a main effect on work family conflict (WFC).

H3: There will be a positive relationship between work family conflict (WFC) and emotional exhaustion (EE).

H4: Managerial support will moderate the relationship between work family conflict (WFC) and emotional exhaustion (EE).

H5: Work inflexibility will moderate the relationship between work family conflict (WFC) and emotional exhaustion (EE).

2. Method

2.1 Sample

The sample was recruited with the help of an Australian professional organisation for engineers. Data were collected using a self administered questionnaire sent to 500 male and 500 female civil engineers aged between 25 to 55 years. Questionnaires were completed anonymously and returned in a reply paid envelope. Of these, 208 participants returned completed questionnaires, with an additional 30 labeled “return to sender” resulting in a return rate of 21.4%. Three participants were excluded as they had either failed to complete the majority of the questionnaire, or wrote that they did not identify themselves as civil engineers. The final sample consisted of 205 civil engineers, 78% who were partnered and 52% who had children. The

sample consisted of 112 females and 92 males that had an average age of 36.7 years, and an average working week of 45.4 hours ($SD = 10.4$). Further information on the sample can be found in Table 1.

Table 1: Demographic characteristics of the sample

	N	%		N	%
Gender			Age		
Male	92	44.9	up to 30 years	57	27.8
Female	112	54.6	31 - 40 years	81	39.5
			41 - 50 years	55	26.8
Work hours/week			over 51 years	10	4.9
20 hours or less	5	2.4			
21 - 35 hours	16	7.8	Family Structure		
36 - 45 hours	99	48.3	Couple with dependent children	90	43.9
46 - 55 hours	66	32.2	Couple with non-dep children	15	7.3
56 hours or more	19	9.3	Single parent	9	4.4
			Couple without children	53	25.9
No of employees in organisation			Single person	38	18.5
1 – 19	32	15.6	No of Children		
20 – 49	25	12.2	0	95	46.3
50 -199	24	11.7	1	23	11.2
200 – 999	55	26.8	2	55	26.8
1000 or more	66	32.7	3 or more	28	13.7

Respondent's employment within the public sector was 34.6%, with 65.4% of respondents indicating they were employed within the private sector. Most respondents (78.5%) were full-time salaried employees, with only 5.9% part time salaried, 6.3% self employed and 7.3% hourly contract employees.

2.2 Measures

The survey consisted of questions concerning demographic, organisational, professional and familial factors. All measures have been used in previous studies and were adopted because of their known high levels of internal consistency. *Work load* was measured using a 3-item scale adopted in a study by House, McMichael, Wells, Kaplan & Landerman [20] which had been used in previous studies. Respondents were asked how frequently they felt, from never (0) to very often (4), certain conditions within their job relating to speed, difficulty and time restraints. A higher score is indicative of a higher work load with a maximum score of 12. The alpha reliability for the sample was .84. *Work hours* was measured using a single items asking respondents how many hours they worked per week. *Work-family culture* was measured via a 20-item scale [19] that investigated three main areas: managerial support, negative career consequences, and organisational time demands. The co-efficient alpha reliability for each sub-construct was .86, .82 and .80 respectively. Respondents were asked to decide to what extent the statements characterised their current organisation using a scale ranging from strongly disagree (1) to strongly agree (7). It included items such as "In the event of a conflict, managers are

understanding when employees have to put their family first”. *Inter-role conflict* was measured via a ten-item, 7-point scale ranging from 1 (for strongly disagree) to 7 (for strongly agree), developed by Netemeyer, Boles & McMurrian [21] with the sub-constructs of work to family conflict, and family to work conflict. The co-efficient alpha reliability was .91 and .85 respectively. Items for each subscale were summed and high scores indicated a higher level of conflict. A sample item was “The demands of my work interfere with my home and family life”. *Burnout* was measured using the 16-item Maslach Burnout Inventory (MBI) due to its brevity and proven reliability and validity of results. The MBI comprises three sub-scales evaluating emotional exhaustion (I feel emotionally drained from my work), cynicism (I have become less interested in my work since I started this job) and professional efficacy (At work, I feel confident that I am effective at getting things done). The items for the third dimension of burnout are framed in positive terms and thus a low score reflects a low sense of professional efficacy. Items were rated on a seven point Likert scale where 0 = never; 1 = A few times a year or less; 2 = Once a month or less; 3 = A few times a month; 4 = Once a week; 5 = a few times a week; and 6 = Every day. *Job satisfaction* was measured via a 14-item scale developed by Hackman & Oldham [22]. The scale tapped into specific facets of their employment such as their satisfaction with their pay, job security, social, supervisory and growth. Respondents were asked how satisfied or dissatisfied they were with different aspects of their job (1 for extremely dissatisfied to 7 for extremely satisfied). A sample item was “The amount of independent thought and action I can exercise in my job”. The alpha reliability for each sub-construct was above .8, except for social which was .6. Overall job satisfaction was calculated using the mean value of all sub-scales. *Turnover intent* was measured via the two items on a scale ranging from 1 (for strongly disagree) to 7 (for strongly agree). A higher score reflected a higher likelihood of a person leaving their job. The alpha reliability for the sample was .79. *Work inflexibility* was measuring using a three-item 5 point Likert scale adapted from Hill, Hawkins, Ferris, & Weitzman [23] which focused on how much flexibility respondents had in deciding where and when their work was done, as well as how and what work was to be undertaken. Complete flexibility was rated 1 with a higher number indicating less flexibility. Mean inter-item correlations were calculated and found to average .38. *Life satisfaction*, which assesses an individual's perception of their quality of life in general, was measured using a five-item scale ranging from 1 (for strongly disagree) to 7 (for strongly agree) developed by Diener, Emmons, Larsen, & Griffin [24]. A sample item from this scale is “I am satisfied with my life.” The scales’s alpha reliability for the sample was .89.

3. Results

3.1 Statistical Techniques

Data were analysed using SPSS for Windows (version 12.1) and the results are presented in Tables 2 to 6. Factor analyses were conducted on two of the scales as they were known to be multi-dimensional. The factorial model for burnout was consistent with the Maslach Burnout Inventory yielding three factors; “emotional exhaustion (EE)”, “professional efficacy (PE)” and “cynicism (CY)”. These were retained and have been considered separately in further analyses. A three-factor work-family culture was found to be sustainable under confirmatory factor

analyses, however five of the twenty items loaded more heavily on a different factor than that found by Thompson et al. (1999) when developing the scale. This original study's results did provide strong evidence that some sub-constructs were measuring part of the same underlying dimension which was confirmed in this study. It was therefore decided to use the same items for the factors as used by Thompson and her colleagues. These were "Managerial support (MS)", "Career consequences (CC)" and "Organisational time demand (OTD)". The alpha co-efficient for each was found to be greater than .8 indicating a good level of internal consistency of items used within the sub-constructs.

Bi-variate correlation analyses were conducted to assess the degree to which one variable is linearly related to another, thereby determining the direction and strength of linkages between variables. Multiple regression analyses were used to determine the main effects, in hypotheses H2 and H3, and whether factors suggested in hypothesis H4 and H5 were moderator variables. Moderator variables affect the "direction and /or strength of the relation between an independent or predictor variable and dependent or criterion variable" [25, pg1174]. This is illustrated in Figure 1 below. The moderator hypothesis is supported if the interaction (path c) is significant while the predictor and moderator variables are controlled. Procedures described by Baron and Kenny [25] were used to test for moderation effects. Prior to conducting any tests for moderation effects, all continuously measured variables were centred. This is achieved by subtracting the mean value for a variable from each score for that variable and eliminates problems associated with multi-collinearity.

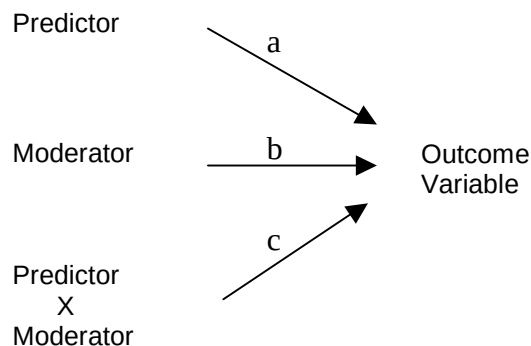


Figure 1: Moderator model [25, pg1174]

3.2 Descriptive Statistics and Bi-variate Correlations

The results (Table 2) indicate that civil engineers perceive their work load to be high and their organisations to be only very slightly supportive of employees with family needs with a mean item value of 4.69 for managerial support (MS), 4.41 for career consequences (CC) and 4.19 for organisational time demands (OTD). This represents a mean overall score of 4.5 (neutral was 4, slightly agree was 5). Work-family conflict (WFC) had a mean value of 22.04 which represents a mean item value of 4.41. This indicates that, in general, civil engineers feel they have a

moderate level of work-family conflict with the mean score for WFC being above the mid point mark.

Table 2 also provides the bi-variate correlations between the variables measured in the study. These results are presented below and significant linkages are only described once. As hypothesised (H1) civil engineers reporting organisational values which were supportive of their work and family also reported lower levels of work-family conflict ($r = -.410$, $r = -.331$ and $r = -.514$; $p \leq .01$), greater levels of job satisfaction ($r = .447$, $r = .396$ and $r = .292$; $p \leq .01$), greater levels of life satisfaction ($r = .366$, $r = .334$ and $r = .374$; $p \leq .01$) and lower intentions to leave their organisations ($r = -.375$, $r = -.325$ and $r = -.373$; $p \leq .01$). In addition those that reported a more supportive culture also reported less work flexibility and lower levels of burnout particularly in the emotional exhaustion. Average work hours and work load were significantly and positively related to work family conflict and emotional exhaustion, indicating that engineers who work longer hours, or perceive their work load to be heavy, have greater levels of burnout and greater interference of work within their family domain. Interestingly greater workload was also positively correlated with job satisfaction.

Respondents who had higher levels of emotional exhaustion were also less satisfied with their job, had less work flexibility and greater turnover intentions. Engineers reporting greater levels of life satisfaction also reported significantly less work to family conflict. As expected there are also statistically significant correlations between work flexibility and the supportive workplace indicators. It should be noted that many of the measures of organisational experiences, satisfactions and well-being are themselves correlated (i.e. life satisfaction and burnout, life satisfaction and job satisfaction, etc.).

3.3 Tests for Direct Effects and Moderating Variables

To test hypothesis H2 to H5 a series of regressions were used. To test for moderating effects in H4 and H5 the independent variables were first entered in the regression and then the interaction of interest was added. The dependent variable of emotional exhaustion was first tested to ensure it did not differ by industry sector, age or gender. As no significant differences existed none of these variables were included in the regression analysis as controls.

Table 3 shows a main effect of work load and organisational time demands (OTD) on work family conflict supporting hypothesis H2.

Table 3: Multiple regression for work load and organisational time demands as predictors of work family conflict

	R²	F	β
<i>Independent variables</i>			
Work load	.331	49.96	.272***
Organisational time demands (OTD)			-.420***

* $p < .05$, ** $p < .01$, *** $p < .001$

The model explained 33.1 per cent of the variance in work family conflict. Of the two variable organisational time demands made the largest contribution ($\beta = -.420$) although work load also made a highly significant contribution.

Table 2: Means, standard deviations and intercorrelations for study variables

	Mean	SD	1	2	3	4	5	6	7	8	9	10	11	12	13
1. Work hours per week	45.37	10.36	1												
2. Work Load	8.57	2.07	.440(**)	1											
3. WFCulture: MS	4.69	.93	-.235(**)	-.187(**)	1										
4. WFCulture: CC	4.41	1.12	-.193(**)	-.147(*)	.682(**)	1									
5.WFCulture: OTD	4.19	1.37	-.344(**)	-.347(**)	.658(**)	.640(**)	1								
6. Work to family conflict	22.04	7.01	.372(**)	.419(**)	-.410(**)	-.331(**)	-.515(**)	1							
7. Family to work conflict	15.08	5.96	-.080	.073	-.029	-.201(**)	-.115	.184(**)	1						
8. Burnout: EE	2.77	1.35	.229(**)	.377(**)	-.406(**)	-.371(**)	-.494(**)	.496(**)	.138(*)	1					
9. Burnout: CY	1.75	1.28	.016	.005	-.350(**)	-.327(**)	-.317(**)	.275(**)	.094	.536(**)	1				
10. Burnout: PE	4.48	1.07	.140(*)	.217(**)	.167(*)	.229(**)	.136	-.008	-.074	-.174(*)	-.380(**)	1			
11. Job satisfaction	5.23	.86	.031	.138(*)	.447(**)	.396(**)	.292(**)	-.206(**)	.091	-.293(**)	-.562(**)	.413(**)	1		
12. Turnover intentions	3.45	1.83	.076	.131	-.375(**)	-.325(**)	-.373(**)	.352(**)	-.030	.358(**)	.536(**)	-.247(**)	-.536(**)	1	
13. Work inflexibility	3.17	.96	.234(**)	.094	-.324(**)	-.266(**)	-.195(**)	.153(*)	-.138(*)	.297(**)	.309(**)	-.124	-.349(**)	.296(**)	1
14. Life satisfaction	22.41	6.69	-.119	-.127	.366(**)	.334(**)	.374(**)	-.306(**)	-.078	-.350(**)	-.430(**)	.300(**)	.553(**)	-.386(**)	-.246(**)

** Correlation is significant at the 0.01 level (2-tailed).

* Correlation is significant at the 0.05 level (2-tailed).

Table 4 shows a main effect of work family conflict on emotional exhaustion in the expected direction. Thus, hypothesis H3 was supported. The interaction between work family conflict and managerial support (MS), while approaching significance, did not have a significant effect on emotional exhaustion, indicating that managerial support does not moderate the relationship between work-to-family conflict and emotional exhaustion. However when the test was conducted for the male and female respondents separately (see table 5 below) managerial support did moderate the relationship between work family conflict and emotional exhaustion - but only the female sample. Thus hypothesis H4 was confirmed but for the female sample alone.

Table 4: Multiple regression for WFC and MS as predictors of EE for whole sample

Step	ΔR^2	F Change	β
1. Independent variables Work family conflict (WFC) Managerial support (MS)	.295	42.228	.398*** -.243***
2. Interaction WFC X MS	.012	3.456	-.113

* $p < .05$, ** $p < .01$, *** $p < .001$

Table 5: Multiple regression for WFC and MS as predictors of E for male and female engineers

Step	Male			Female		
	$r R^2$	F Change	β	$r R^2$	F Change	β
1. Independent variables Work family conflict (WFC) Managerial support (MS)	.165	8.800	.284** -.206*	.404	36.993	.493** .493*
2. Interaction WFC X MS	.002	.159	.040	.032	6.047	-.186*

* $p < .05$, ** $p < .01$, *** $p < .001$

Table 6 reveals that work inflexibility did significantly moderate the relationship between work family conflict and emotional exhaustion thus supporting hypothesis H5.

Table 6: Multiple regression for work family conflict and work inflexibility as predictors of emotional exhaustion (burnout)

Step	ΔR^2	F Change	β
3. Independent variables Work family conflict Work inflexibility	.296	42.407	.461*** .226***
4. Interaction Work family conflict X Work inflexibility	.020	5.809	.141*

* $p < .05$, ** $p < .01$, *** $p < .001$

4. Discussion and Conclusions

The purpose of this paper was to explore the prevalence of work-family conflict and supportive organisational values experienced by civil engineers. The research found that civil engineers do experience moderate levels of work-family conflict and in general work in organisations that they do not perceive to be very supportive of employees' need to balance work and family demands. The profession appears to suffer a "cultural lag" with traditional values being considered the norm and consequently the ones rewarded (e.g. long work hours, full-time working). In this study 90 per cent of the sample worked at least 36 hours per week (the remaining ten per cent being predominantly female) and over 41 per cent of the sample worked over 46 hrs/week. This is occurring despite the fact that men are reporting an increased preference for more part-time work and less working hours [26]. While 56.1% indicated they were happy with the hours they worked; 41% of respondents indicated a preference to work less and only 1.5% wanted to work more. The study did not, however, support a preference for part-time work options. This may be related to the sample's low level of satisfaction with their current pay and benefits, compared to other facets of job satisfaction measured.

The paper also examined the relationship between perceptions of a supportive work family culture and job satisfaction, work load, turnover intent as well as life satisfaction and mental health. The data indicates strong positive correlations between a supportive work culture and job satisfaction. Job satisfaction is closely linked to affective organisational commitment which has been associated with higher productivity [27] and a more positive work attitude. The data also shows that if an organisation is perceived by employees to be unsupportive of work-family balance then turnover intent increases. Staff turnover has specific expenses in terms of costs relating to retraining, recruitment and lost productivity and the civil engineering profession must be careful that its members do not leave it in order to pursue careers that provide greater benefits. At a personal level those reporting a supportive culture also reported higher levels of life satisfaction and better levels of mental health. So from an occupational health perspective as well as from an organisational performance viewpoint the data provides evidence of the benefits of a supportive work culture.

The results also demonstrate the importance of a flexible supportive work environment. Work load and organisational time demands predicted 33.1 per cent of the variance in work family conflict. This result suggests that perceived work load, and the expectations that organisations place on the time employees should commit to the workplace, have the potential to indirectly influence turnover intentions through their effect on work family conflict. Organisations must therefore be cognisant of the expectations they place on employees if they wish to retain staff. Work family conflict also demonstrated significant main effects on the emotional exhaustion dimension of employee burnout and flexibility was found to moderate this relationship. Burnout has been found to be associated with negative organisational and personal measures. Managerial support also moderated the relationship between work family conflict and emotional exhaustion for the female sample. These findings have important implications for management. Firstly they suggest that supportive managers and flexible work practices can be a preventative strategy for burnout caused by work family conflict. They also indicate that gender differences exist in the work family area and these need to be considered in the human resource management practices of organisations employing engineers.

In order to achieve a supportive culture, change must be driven from the top down and sensitivity training for middle managers and supervisors may also be required [5, 19, 15]. The provision of benefits delivered through human resources policies is not sufficient in itself and a workplace culture must exist within which employees feel comfortable taking advantage of alternative workplace policies [15, 19]. However, the change needed in engineering may not come easily. Indeed, however accepting of change they may be at the start of their career, male entrants inadvertently reinforce current attitudes and practices by emulating the behaviour of the managers who influenced their own career development [28]. Fielden and colleagues [29] also suggest that in the construction industry, a lack of compliance with cultural norms, such as refusing to undertake long hours, can adversely affect the promotion prospects of employees and even their job security.

It should be noted that while this study has revealed associations between work and family variables, being a cross-sectional study it is limited in its ability to determine causal relationships. Further analysis of the full dataset will be carried out to examine the effect of gender and family structure and investigate the presence and effect of work-life benefits currently available to civil engineers. It is hoped that this work will inform companies on these issues so they can develop policies that are suitable for their different employees.

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Labour Productivity in the building industry

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Abstract

The cost of labour in the building industry is in the region of 25 - 40 % of the cost of building. Hence the cost of labour is quite high and yet it is the main cause of variability in construction costs. The time used by workers on daily basis on productive activities averages about 30% of the total time available for construction work. The remainder of the time, i.e. about 70% is wasted on non-productive activities, delays and added activities. For a company in the building industry to remain competitive, it must try to improve the productivity of its labour. This paper reviews the literature on labour productivity in the building industry. It looks at the definitions, measurement, use, factors affecting and theories on improvement of labour productivity in the building industry. It is noted in the industry lacks generally agreed strategies for improvement of labour productivity. The paper further reviews the paradigms of innovation, benchmarking, and industrialization among the theories aimed at improving the productivity of labour in the building industry.

Key words: Labour Productivity, Building Industry.

1. Introduction

1.1 Background

The construction sector has a strategic role in all developing and developed countries. The construction industry is the single largest industrial employer in Europe employing more than 7% of the labor force (Proverbs, Holt and Olomolaiye[1]). According to Uganda's Ministry of Finance in Uganda [2], the construction industry contributes 12% of the Gross Domestic Product (GDP) and employs 5% of the registered workforce in Uganda.

In most developing countries, labor-intensive production is still in use in the construction sector and this situation will remain for a couple of years to come.

According to Buchan, Fleming and Kelly [3], Zakeri, et al [4] and Kaming et al [5], Gilleard J. [6] labor cost is somewhere between 20% and 50% of the total project cost. Hence the reduction of labor and therefore construction costs can be best carried out by labor productivity improvement. Productivity is the key to greater competitiveness, as it is critical to the profitability of most construction projects.

The time used by workers on daily basis on productive work averages about 30% of the total time available for construction work (Jenkins, [7]). At the same time, low productivity has led to high labour costs in comparison to the construction costs.

As pointed out by Yates and Guhathakurta [8], labor productivity is becoming an increasingly important topic to members of the construction industry. The problem of low and decreasing labour productivity appears in many other countries. For example, Teicholz [9] found out that labour productivity in the United States has continued to slowly decline (with a few exceptions) over the past 25 – 30 years. The important topic addressed in the Emerson report (1962), the Latham report [10] and the Egan report [11] is the issue of productivity in the construction industry.

1.2 Definitions

Different people have been using the word productivity to mean different things. Productivity is defined by Calvert et al [12] as the ratio of outputs to inputs. Labour productivity is one of the partial factors of productivity. It has been defined as the ratio of the total output to the labor input (Gilleard, [6]). Noor ([13]) defines it by the following equation

$$\text{Labour productivity} = \frac{\text{unit.output}}{\text{labour.manhours}}$$

The determination of output is a relatively simple task, as they can be physically measured. As pointed out by Noor [13], the determination of labour workhours associated with measured output is a more contentious issue because it can be a measure of different input times. Different measurements of input times will give rise to different productivity measurements.

Labour productivity measured in terms of the paid time provides useful information to contractors for scheduling and estimating purposes on future projects. On the other hand, labour productivity measurements based on time available for work help to provide the basis for analyzing the effects of adverse weather conditions on labour productivity. Labour productivity

measures that are based on productive time help in determining the effect of various factors on productivity such as constructability and delays due to lack of materials and equipment.

The measurement of output suffers from the non-standardization of the construction industry. For example, even concreting which can be measured in cubic meters has several factors influencing its productive time. The quantification of quality and increased use of prefabrication complicates the quantification of labor inputs also. There is need for the industry to agree on the way to measure the inputs.

2. Use of labour productivity

Productivity is one of the key measures of construction performance. Latham [10] and Egan [11] clearly addressed the importance of raising productivity in the construction industry in UK. The studies and the recommendations made for the UK construction industry are relevant worldwide. It was observed by Kaming and Olomolaiye [14] that poor productivity of construction craftsmen is one of the most daunting human resource problems in developing countries.

As pointed out by Kaming et al [5], the success of a construction company in today's competitive environment largely depends on accurate estimation of productivity.

Labour productivity rates are used as indicators of the construction time performance. They are used in planning and scheduling of construction, controlling of the cost and worker performance, estimating and accounting.

If a company wishes to reduce risk, increase profits, or gain market share, there is direct need within the firm to have accuracy data on and use of labor productivity (Gilleard [6]).

Although studies have been made in a number of countries, most of the data available is not directly relevant to all countries because of the differences in materials used, techniques employed and working environment. Construction workers too have differences in the work culture.

3. Methods of obtaining labour productivity

Before productivity can be increased, there is need to measure and quantify the existing situation. Lord Kelvin's dictum 'to know properly you must measure it' is sound advice to anybody interested in measuring productivity. The measure of construction productivity is thus a very important issue.

There are two different methods of generating data on productivity – accountancy based and engineering based methods.

Accountancy based standards rely on the analysis of historical accounting data to establish work-hour requirements for specific types of work. Engineering based standards involve breaking down complex work processes into small manageable parts and analyzing these parts for the length of time required to complete these processes. The accountancy-based data are relatively easy to follow but they do not capture the varying working conditions.

The engineering methods of measuring labor productivity include work measurement, work sampling, time and motion analysis, and modeling.

Work measurement is the determination of the time required for an average operative to carry out a particular task in accordance with a specified method and standard of performance (Calvert, [12]). Work sampling involves observing individual pieces of the work process and classifying the results as either productive or non-productive. It is useful for recording productivity levels for comparative purposes. Harris and McCaffer [15]) describe its use. Thomas [16] roundly condemned activity sampling as being unsuitable for measuring productivity in construction activities.

Time and motion studies are said to be the most accurate methods for generating productivity standards. Factor based modeling is arguably the most applicable engineering-based technique to the construction industry and has the potential to produce useful data. The factor model technique has been recommended by a number of authors (Gilleard, [6]) although it is yet to be accepted internationally.

4. Factors affecting labour productivity

Factors influencing productivity of construction workers in many countries have been explored (Borchering, [17]). Gilleard [6] acknowledges that labor productivity figures are highly variable, affected by such factors as the mode of employment, overall task duration, and length of the workday.

Identifying and evaluating the factors that influence productivity are critical issues faced by construction managers (Motwani et al [18]).

Most of these factors have been arrived at by asking the workmen directly and the project managers. Borchering [19] recognized that the best means of acquiring information about production problems is by asking the workmen themselves.

The common factors influencing construction productivity have been listed by Yates and Guhathakurta [8], Keone [20].

According to Keohn [20], productivity is related in part to the following variables: management (proper planning, realistic scheduling, adequate coordination, and suitable control); labour (union agreements, restrictive work practices, absenteeism, turnover, delays, availability, level of skilled artisans, and the use of equipment); government (regulations, social characteristics, environmental rules, climate and political ramifications); contracts (fixed price, unit cost, and cost plus fixed fee); owner characteristics; and financing.

The factors affecting labour productivity can be summarized under the categories of design, manpower, management, environment, and others.

Design issues including: design complexity, design changes, and quality.

Manpower issues including: worker motivation, skills of the workers, recruitment of workers, recruitment of supervisors, absenteeism, labour turnover, communication problems, labour disruptions, alcoholism, stoppages because of work being rejected by consultants, stoppages because of disputes with owners/consultants, stoppages because of insolvency, labor composition, overcrowding.

Management issues including: material shortages, delays in materials delivered to site, disruption of power/water services, stop-work orders because of accidents, site congestion, site layout/access, construction method.

Environment including harsh working conditions and others including construction volume, regulatory requirements, economic conditions, social factors

According to Burton [21], companies should only track the important activities. Rosefielde and Mills [22] argued that any measure of construction productivity that does not account for the changes in design and quality would lead to low, if not negative, measures of construction productivity.

5. Current theories for improvement of labour productivity

The current thinking that will improve construction productivity hinges on the theories of innovation and knowledge transfer, benchmarking and industrialization. Motwani, Kumar and

Novakoski [18] however pointed out that theories of improving productivity vary from business to business and because of the variety of uncontrollable productivity influence factors it is hard to have one plan.

5.1 Innovation

The performance of the construction industry in terms of productivity, quality and product functionality has been low in comparison to other industries, and a low rate of innovation has been provided as the major explanation to this situation (Winch [23], Gann [24]). As stated by Winch [25], construction is commonly characterized as a backward industry, one that fails to innovate in comparison to other sectors. While the other sectors modernized through the introduction of interchangeable parts, then assembly lines, and then automation, construction retained its craft method of operation and fell further and further behind the rest of the manufacturing industry in terms of productivity, quality and hence value for money.

Innovation is a process of gaining and using new and existing knowledge to enhance either a product or process (Dodgson and Bessant [26]). Freeman [27] defines innovation as the actual use of a nontrivial change and improvement in a process, product or system that is novel to the institution developing the change. Innovation as defined by Barret and Sexton [28] is the effective generation and implementation of a new idea which enhances overall organizational performance. The main factors for innovation include: reward for innovation; opportunity for innovators to communicate their knowledge directly by presentation of events; funding and support the industry Research and Development (R&D). The adaptation of new procurement methods and the new organizational structures are seen to improve the ability to provide more integrated and innovative solutions.

The industry requires radical changes if improvements in quality, productivity and performance are to be achieved. The construction industry is increasingly being challenged to successfully innovate in order to satisfy better aspirations and needs of society and clients, and improve competitiveness (Latham[10] and Egan [11]).

As pointed out by Motwani, Kumar and Novakoski [18], improving communication skills, preplanning and stricter management could help to raise the individual productivity rate from an average of 32 per cent productive time per hour to almost 60 per cent per hour.

It is important that the Construction Industry adopts TQM if it is to improve productivity since TQM is about changing attitude and skills so that the culture of the organization becomes one of preventing failure and doing things right first time all the time (ISO [29]).

A framework for improvement of productivity would address innovation of remedial measures such as recruiting and training a younger generation to have necessary skills, process improvement, standardization, and transfer of knowledge within the industry. The focus should be on continuous upgrading the management and technical skills of supervisory staff.

Barret and Sexton [28] acknowledge that although construction firms have always demonstrated an ability to innovate, construction practitioners are now very much getting to grips with the need for and management of innovation as an explicit endeavor.

5.2 Benchmarking

Before productivity can be increased, there is need to measure and quantify the existing situation. The point made is that a construction company should have a measurement procedure in place such that it can determine how it is doing relative to the benchmark. As pointed out by Adrian [30], by measuring the company's performance relative to the benchmark and by implementing improved processes and procedures, the construction industry can work towards improvement.

Benchmarking is the search for the best practices that will lead to superior performance of an organization (Camp [31]). Houston in a document titled Planning, Organizing and Managing Benchmarking: Users Guide, defines benchmarking as a systematic and continuous measurement process of 1992; a process of continuously measuring and comparing an organization's business process against business leaders anywhere in the world to gain information which will help the organization to take action to improve its performance.

As early as in the 1800's, Fredrick Taylor's work on the application of the scientific method of business had encouraged the comparison of work processes. This was within the concept of benchmarking.

As Lema and Price [32] point out, there is need to explore the potentials of benchmarking for performance improvement in the construction industry. The construction industry can learn from the wealth of experiences available throughout the manufacturing industry. A common understanding of benchmarking has to be reached, and a conceptual framework that would cater for the industry's primary objectives at various levels has to be developed.

Lema and Price [32] point out that benchmarking is seen as a perfect vehicle to ensure that the customer gets the best quality under competitive conditions that ensure lowest prices. The three key roles of benchmarking are: to widen the competition base by exposing internal organizational processes to external market forces; accelerate the TQM process and therefore increase efficiency by providing the opportunity to learn from others, adopt and improve; and act as a tool

for cooperation to improve overall industry performance. The preconditions for successful applications include: the need for performance improvement; the recognition and acceptance that there are lessons to be drawn from others that can lead to improved performance; the willingness and capability to change for better performance; and the accessibility to the best practices. The problem with the construction industry is the lack of initiative to make full use of benchmarking to create change.

5.3 Industrialization of construction

Increasing heavy demands for the products of the building industry were made in the years following the end of the Second World War during the reconstruction programmes. Since the Second World War, the world population has more than doubled. Currently, the demand on housing is very high and the number of homeless people has been growing. There is also a big number of huge construction projects, which are being undertaken notably in Eastern Asia and China. While the increase in demand of construction products is happening, there is growing shortage of skilled manpower. Shortage of manpower is unlikely to improve to any significant extent (Foster [33]).

Industrialization of construction is needed to increase the productivity of the industry generally while at the same time reducing the amount of site labour involved. Industrialization involves the rationalization of the whole process of building (which includes the process of design, the forms of construction used and the methods of building adopted).

Foster [33] defines industrialization as essentially an organizational process – continuity of production implying a steady flow of demand; standardization; integration of the different stages of the whole production process; a high degree of organization of work; mechanization to replace human labour wherever possible; research and organized experimentation integrated with production.

There is need to industrial all sectors of the construction industry if we are to satisfy the current demands. Ideally housing would be easier to provide for using industrialization in construction because most of the spaces and products can be standardized as exemplified by the precast concrete box units (Hansson [34]). Variations would only cater for special cases. The industry requires radical changes if improvements in quality, productivity and performance are to be achieved (Latham[10] and Egan[11]). Currently the industry is fragmented and has many stakeholders who are not well coordinated. Product and process industrialization would help to improve the situation.

Since the second world war, the idea of industrialization has received much attention both in Europe, North America and elsewhere. However, in spite of a great number of attempts, there has been a relative lack of success of industrialized building methods (Warzawski [35]). The

share of prefabricated components has risen, and there are examples of advanced industrialization, notably the Japanese house producers (Gann [24]) and the American metal building providers (Ellifritt and LaBoude[36]) but a wider breakthrough for industrialized construction has still not occurred. According to Warzawski, the main problem of prefabrication of today is the lack of a system approach to its deployment on the part of the various parties involved.

The building construction industry still lacks in being rational. This is manifested by poor labour productivity due to lack of integration of design, poor supply chain management, on site fabrication and assembly with many inefficient processes.

6. Conclusions

It has been noted that the industry lacks generally agreed ways of measuring and strategies for improvement of labour productivity.

It can be concluded that there are many factors that affect labour productivity and their effects vary from one industry to another. There is need to quantify the effects that those factors have on labour productivity so that remedial measures are sought. Although a few have been explored in specific industries, there are still many gaps to be filled in this area.

Although the literature indicates that the theories on innovation and knowledge transfer, benchmarking, industrialization in construction can be used to improve on labour productivity, there is still need to develop strategies on how they can be used. There are gaps on the relevance and application of the theories to improve labour productivity.

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Good Practice People Management through Human Resource Information Systems (HRISs)

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Abstract

Project organisations require extensive knowledge about their human resources in order to make informed and timely deployment decisions in the fast moving and highly competitive market place. One of the contemporary trends within strategic human resource management (SHRM) has been the application of human resource information systems (HRISs) as support tools for managerial decision-making. This technology has the potential to greatly enhance an organisation's ability to collect, store and utilise personnel data. Traditionally, construction organisations have been characterised by the older 'personnel' style people management practices and low take-up in technology. However, a recent EPSRC funded study of large UK-based construction contractors' SHRM practices found that many industry leaders in the country are beginning to utilise the potential of HRIS technology. An early survey (Raidén *et al*, 2001) indicated approximately 65% of these organisations to use computer applications for HR related functions. This paper reports the results of further research which explored the utilisation of such technology within seven case study organisations representative of the largest UK construction firms. Although the research revealed many innovative practices, none of the companies were found to adopt an integrated approach to SHRM-operations collaboration. Accordingly, an agenda for further development in the area is suggested. This promotes the strategic integration of the organisational and human resource planning, team deployment, performance management, human resource development and employee involvement activities which are central to effective human resource and project management.

Keywords: strategic human resource management (SHRM), human resource information systems (HRISs), team deployment

1. Introduction

The project-based nature of construction work requires firms to set up temporary organisational structures at dispersed geographical locations [1]. Work in this context is rarely ongoing and repetitive activity. Resources are transient and change is constant [2]. The project team forms the

central working unit in this setting. Hence, the characteristics of staff allocated to project teams has a crucial effect on the success of an organisation. Accordingly, project-based organisations, such as construction contractors, require extensive knowledge about their human resources in order to make informed and timely team deployment decisions, particularly in the modern fast moving and highly competitive market place.

Strategic Human Resource Management (SHRM) provides an influential approach to the management of people in many business sectors [3]. It comprises a set of practices designed to maximise organisational integration, employee commitment, flexibility and quality of work [4]. This is achieved through integrated employment relations, Human Resource Development (HRD) and employee resourcing functions. Employment relations provide the overall philosophical framework for organisational culture, policy and practices. HRD focuses on individual and organisational learning and development. Employee resourcing comprises of the staffing, performance management, HR administration and change elements of SHRM [5]. The staffing activities include Human Resource Planning (HRP), recruitment and selection, and team deployment. Performance management includes employee appraisals and career development. The HR administration function consists of the collection, storage and use of employee and organisational data in support of HR monitoring and analysis. One of the contemporary trends in employee resourcing has been the application of Human Resource Information Systems (HRISs) as support tools for managerial decision-making and HR administration. This technology has the potential to greatly enhance an organisation's ability to collect, store and utilise personnel data.

Traditionally, construction organisations have been accused of adopting 'personnel management', rather than the modern SHRM style people management practices. However, more recently many industry leaders in the UK have begun to use HRISs [6]. A recent survey [6] indicated relatively widespread investment in such technology but also found that the system capabilities were rarely exploited to their full potential. This paper reports on the in-depth follow up on the survey findings. Initially, HRISs and current literature on construction people management are reviewed. This is followed by an explanation of the research methodology and discussion on the findings and results of the study. The paper concludes by suggesting an agenda for further development in the area.

2. Human Resource Information Systems (HRISs)

'Human Resource Information Systems' (HRISs) is the term used to refer to a particular type of hardware and software that is aimed at supporting the SHRM function within organisations. Broderick and Boudreau [7] define HRISs as a:

“composite of databases, computer applications and hardware and software that are used to collect/record, store, manage, deliver, present and manipulate data for human resources”.

In short, HRISs provide an electronic database for the storage and retrieval of employee data that offers the potential for flexible and imaginative use of this data [8]. Two main types of IT applications suitable to HR needs are:

- 1) *Transaction processing/ reporting/ tracking applications* best suited to support routine high volume HR decisions;
- 2) *Expert systems* which seek to improve decisions through rules derived from careful analysis of expert decisions over time, and decision-support systems that seek to improve decisions for which the rules are changing or are not well defined, and the right outcomes are unknown [7].

While some of the HRISs available are simply sophisticated database applications, an expert system incorporates artificial intelligence into the system, thereby increasing its learning capabilities. It solves problems by heuristic or approximate methods, which do not require perfect data. Thus, expert systems have the benefit of being able to propose solutions with varying degrees of certainty [9]. Other significant benefit of an expert system is that its workings are transparent: the system is capable of explaining and justifying solutions or recommendations in order to convince the user that its reasoning is correct [9].

The uses of HRISs range from automating basic data management tasks, through to enabling managers to integrate their business objectives with the SHRM priorities and providing employees with self-service functionality [8]. Table 1 differentiates between the two, automating and informing.

Table 1: Uses and benefits of HRISs (after Tansley et al [8])

Automate	Inform
<i>Use of the system</i>	
Electronic filing cabinet	Sophisticated database/ expert system
Enables storing and analysis of employee data	Enables managers to act on HR information
Support more effectively direct control – employee activities and productivity transparent to managers	Assumes a philosophy that the system itself and appropriate managers can make decisions – provides access to comprehensive range of information
Facilitate close supervision and monitoring	Facilitates empowerment and indirect control
HR access	Employee self-service
<i>Benefits</i>	
Task mechanisation – can save mental and/ or physical labour in data management	Can transform HR practices
Process automation – can enable greater efficiency of HR practices	Can enable managers to integrate their business objectives with HRM priorities
Cost reduction (in reduced overheads)	Cost reduction (in reduced overheads)
Improved HR service: faster service, improved quality and consistency of information	Availability and accessibility of wide range of information

Table 1 highlights a fraction of the key functionalities of HRISs and their associated benefits. Many writers and professional practitioners have recognised the substantial benefits that HRISs can bring to the efficient management of the HR function [7, 10-17]. The systems have particular capabilities for managing staffing, HRD, performance, reward and HR administration [18-22]. They can help HR professionals to improve productivity, control employee benefits, streamline compliance with HR legislation, manage the payroll function, and lower the costs of employee resourcing [23]. As outlined in Table 1, in essence they automate daily administrative HR tasks, integrate cross-departmental activities and ensure the accuracy and consistency of employee records.

Recent developments have led to HRISs having the potential to hold comprehensive databases of employee skills and qualities, including their future aspirations, and produce complex reports mapping the employee abilities and preferences against forthcoming vacancies/projects [24]. The latest generation of web-enabled HRISs now also allow employees to update their own personnel records, submit timesheet data, review benefits, request holidays and enrol on training courses [25]. This integration of so many key SHRM activities can facilitate both the recruitment and retention of staff by delivering automated features and quantifying the value of total compensation packages [19-21]. However, the key espoused benefit of automating SHRM processes is that it leaves HR professionals and line managers more time to focus on strategic activities, and provides information for them to be able to turn their employee assets to a source of competitive advantage [23, 26]. Thus, HRISs have the potential to revolutionise SHRM by providing up-to-date information, services to employees, return on investment, and strategic analysis and partnership [10, 23, 27].

Information Technology (IT) is often seen as an effective stimulus for achieving transformational change. For example Davenport [28] argues its role as both an enabler and an implementer of process change. Similarly, Tansley *et al* [8: 364] concluded:

“...introduction of the HR system could potentially provide the stimulus to actually effect the required change in employee management practices...”

Thus, the use of HRIS technology could help in developing the construction industry’s people management practices from the older ‘personnel’ toward SHRM. However, despite the numerous benefits HRISs can offer, extensive debate exists in relation to the profitable implementation and application of HRISs in practice. According to Tansley *et al* [8], much of the success depends on nine key factors including: Senior management support and commitment; Involvement of representatives from all potential user groups in the project team (e.g. senior managers, HR, IT, line management, employees); Provision of comprehensive range of information on both on the potential system(s) and their potential benefits; Suitability of the potential system to the industry/sector of work and the specific challenges its environment places; Suitability of the system to the organisational culture(s) and management style; Differences of operating systems/ approaches within different organisational divisions – need for integration/ business process review and redesign; Benefits vs. costs; Potential uses of the system (automate/ inform); and the relationship between HR and HRIS strategy and policies. Accordingly, the consideration and implementation

of HRISs must take into account a wide range of factors if maximum benefits of the technology are to be achieved.

3. The challenging context of the construction industry

As suggested above, HRISs offer the potential to support construction industry project management and culture transformation. In relation to project management, this needs to focus on the integration of the individual needs, preferences and requirements of employees' with the achievement of project/ business objectives by suggesting optimal solutions to particular resourcing requirements. In terms of culture transformation, HRISs could help in moving industry practices toward integrated and sophisticated employment relations, HRD and employee resourcing activities forward from the traditional 'personnel' view of legislative compliance. This could have long-term benefits in relation to the retention and development of staff in the industry overall, and hence in meeting the future succession management plans of the organisations in the industry. However, although HRISs are widely used to support SHRM within other sectors [5, 29, 30], the ways and levels of practice within construction organisations vary greatly [6].

Raidén *et al*'s [6] earlier survey explored the use of HRISs in the 100 leading construction companies in the UK. The postal questionnaire asked their use of information technology applications for SHRM related functions; which HRIS application, if any, they used; the lengths of time the system had been in place; the functions for which the HRIS was used; and how satisfied they were with the system. The results suggested that the use of computers for HR information in construction is broadly similar to the national average. However, the utilisation of such systems was identified as being extremely limited, restricted to routine administrative tasks. Employee records (82.2%) and reports and enquiries (68.9%) were most commonly cited functions followed by training and other HR administration, such as annual leave, pensions and attendance monitoring, at 40-50%. Only one third (33.3%) of the respondents said to use HRISs for managing appraisals and one fifth (22.2%) for staff deployment. This was despite the extensive capabilities the systems offer for supporting complex collection and retrieval of data and decision-making. However, as a result of the analysis of user satisfaction with the HRIS applications, it appeared that the more 'advanced' or strategically focused the activity the higher the user satisfaction rating [6]. This was concluded to infer that the companies that do use HRISs for complex SHRM tasks derive considerable benefit from their application. Furthermore, this could suggest that the complex and dynamic resourcing environment that the construction industry presents is well suited to the application of IT-based systems.

Loosemore *et al* [31: 109] identified the key advantages of using a HRIS to support SHRM decision-making in construction to include:

- Easier provision of information to line managers, thereby enabling rapid resourcing decisions during projects;

- Easier processing and control of employee records and performance data linked to reward systems (i.e. removing the need for managers to maintain unwieldy paper-based systems); and
- A reduction in the workload of the personnel function, thereby lowering the head office overhead associated with the SHRM function.

Ng et al [32] modelled an HRIS for Australian construction companies. They drew on the work of Patchett [33] who identified the major construction activities that require HR information as manpower planning and development, payroll, labour control, safety management, industrial relations and compensation and benefits. This approach seems limited in serving the full range of SHRM information requirements within construction companies. Numerous studies have also focused on developing generic scheduling support, cost control and information and project management models/ systems for the construction industry [34-39]. By combining these approaches to work scheduling and project management with an HRIS and optimal solution may be identified, although barriers to the process may present the industry's limited trust and confidence in IT systems [40-42].

4. Research methodology

Following detailed analysis and publication [6] of the HRIS survey results, an in-depth follow up on the findings was conducted via semi-structured interviews in seven case study organisations representative of the UK market leader. Table 2 lists the type of participating organisations, their main operating sectors and annual turnover at the time of the research interviews: 2001-2002. 'National contractor' refers to an organisation with its headquarters in the UK. This distinguishes case studies A-E and G from F, the 'European contractor', whose headquarters are located in Holland.

Table 2: Case study organisations

	Case study	Sector	Turnover (£'000s)
A	National contractor	Building	1,074.000
B	National contractor	Civil engineering	487.238
C	National contractor	Civil engineering	1,680.000
D	National contractor	Building	1,382.200
E	National contractor	Civil engineering	1,335.900
F	European contractor, UK branch	Building	706.000
G	National contractor	Building	649.000

The interview sample included divisional directors ($n=4$), operational senior managers ($n=9$) and HR staff ($n=11$). The data was tape-recorded, transcribed verbatim and analysed using NVivo qualitative data analysis software and summary statement matrices. This provided a robust but

flexible methodology for reporting and analysing the case study organisations' approaches and techniques on good practice people management with dual benefits. Firstly, the results of the study can help other organisations in the industry to evaluate and improve their take on personnel/SHRM and thus, can contribute to the improvement of the culture in the industry overall. Secondly, the research adds to the limited body of knowledge that currently exists on the industry's people management practices, particularly in relation to employee resourcing and HR administration [43]. The following section outlines and discusses the main results and findings before the conclusions, which suggest an agenda for further development in the area.

5. Results and discussion

The interviews highlighted several areas of SHRM in which HRISs were utilised to support managerial decision-making and HR administration. These included Human Resource Planning (HRP), recruitment and selection, team deployment, performance management and HR administration.

5.1 Human Resource Planning

A particularly successful HRP technique was found in company C, which operated a quarterly human resource planning schedule. Key managers met regularly to discuss the HR requirements for the following quarter in relation to the forthcoming workloads. Staff availability charts drawn from a resource management database were used as an information source for the meetings. This type of planning process was said to be particularly useful in identifying and balancing peaks and troughs in staffing requirements. Although the quarterly schedule represents a relatively short-term outlook on staffing issues, the system helped the organisation to introduce structure to the process and reduce the uncertainty inherent within the industry's staffing practices. The HRISs application (resource management database) clearly provided a crucial information source, and thus acted as a decision-support tool.

5.2 Recruitment and selection

Company C also focused on internal recruitment and promotion via the company Intranet. All vacancies were advertised in the HR facility and staff were regularly encouraged to access the available information. This provided transparent progression and development opportunities, which encouraged long-term commitment to the company. Information technology provided the main communications channel, via the company Intranet, and helped to link resourcing activities with the HRD element of SHRM.

5.3 Team deployment

Company B had recently restructured its operations to form two separate divisions comprising a regionalised and national business. Within the national businesses, HR personnel managed deployment via a central resource bank which members of staff could voluntarily agree to join. The central resource bank consisted of an employee skills database, which recorded the members' experience and qualifications. Use of such a database helped the company to ensure that only personnel willing or keen to travel were deployed to projects beyond the regional boundaries. This was particularly useful in managing work-life balance issues.

Company C also utilised their resource management database to inform team deployment. The system catalogued employees' job titles, previous experience and projects, line manager, etc. Availability charts provided a basis for decision-making which was supported by secondary criteria, such as appraisal records, career development needs, location, salary package and clients. All this information was held within the single database, and thus easily accessible.

Company D operated a particularly effective approach to the team deployment process. In creating a team, four main sources of information were drawn together to form a comprehensive picture of a potential team members' suitability for a project:

- technical competence (from job descriptions, experience summary sheets and chartered status records)
- personal development assessment (to support technical competence evaluation and provide information on personal aspirations, needs and preferences)
- personal relationships (line managers' subjective knowledge on how the employee works with other people/ as part of a team)
- time (employee availability re: current project/ commitments, potential disturbance of a move mid-project).

Clearly, computer hardware and software applications played a central role in the process. Technical competence data, employee development records and time information were all sourced through a HRISs. Only the managers' subjective accounts of employees' team working skills were not included in the system, although many modern HRISs can act as repository for such data.

5.4 Performance management

Company C's performance management system was geared towards providing information for their resource management database discussed above. This was seen as an effective tool for encouraging employee involvement as it integrated the employee needs and preferences

highlighted within the appraisal system with the HRP, team deployment and other related employee resourcing activities. For the organisation the system provided information managers and HR personnel could use to identify high flyers and potential succession planning candidates, individual and organisational competencies and capabilities, and how well their employees shared the company values.

Within their very strong hierarchical structure, company D operated a particularly innovative approach to career management. The company Intranet had a career “route map”, which clearly showed the options available from each post. Links to job descriptions outlined the minimum and outstanding requirements for each role. These were used to aid discussions on aspired and realistic future moves. They formed a practical tool for benchmarking performance against desired criteria and identifying training and development needs. The success of the Intranet ‘route map’ was clear; the careers section was the most popular site within the whole of the company intranet.

5.5 HR administration

At the time of the research interviews, companies A and E were in the process of developing in-house HRISs. In company A this was to form a complete HR database for the group and hold all basic personnel data, such as employees’ addresses, dates of birth, job titles, absence records and holidays. Inclusion of training and development aspects was planned for the future. Ideally, the system was to include everything the organisation need to know about their staff. Despite this, reporting labour/ staff turnover and absence, and ethnic monitoring were seen as the main applications for the system. HR specialists currently manage all HR administration, therefore, it was presumed that they would carry this on but in the future using HRIS. Potentially, such a comprehensive HR database is capable of informing human resource planning, recruitment and selection, team deployment, HRD and other SHRM related planning and decision-making.

In company E the internal HRP information system under development was envisaged to include facilities for comprehensive data management and decision-support. The system was to replace the current divisional databases and provide a centralised information source for the group as a whole. It was to run separately from the group’s personnel database, but with capabilities for data sharing between the two. The HR department assumed overall responsibility for maintaining the HRP information system as well as the personnel database.

In company G some of the HR information was currently recorded and stored within computerised systems, but these were operated in isolation from each other. For example, a bespoke database had been developed to hold employee records at a company-wide level, but training and development data was held on a separate system administered at a divisional level. Payroll details were held on yet another system held by the personnel department. This resulted in several members of HR and operational staff having to be involved in any SHRM related decision and the information being transferred across multiple systems. This did aid inter-departmental collaboration, however, when discussing the possibilities of introducing a HRIS, several

managers felt this would prove useful in reducing their administrative workload. Others suggested that it would be useful in promoting movement across divisions when demands on the business required it. This confirms Tansley *et al*'s [8] contention that a HRIS potentially provides a stimulus for changing in employee management practices.

6. Conclusions

This paper has explored the use of computer applications for SHRM functions in construction organisations. On the basis of the survey findings and an extensive literature review, the advantages of HRISs to the effective and efficient management of the people management element of construction operations has been supported. In particular, it offers the potential to greatly enhance the organisations' ability to collect, store and utilise personnel data to support managerial decision-making. The benefits were also highlighted to include increased employee involvement and integration of the resourcing and HRD aspects of SHRM. The research recorded many innovative practices on HRP, recruitment and selection, team deployment, performance management and HR administration. For example, Company C had particular strengths in HRP, recruitment and selection, and performance management, whilst Company D had devised a sophisticated team deployment function. However, despite the wide range of good practice found within the case study companies, none of the participating firms were had adopted a fully integrated approach to SHRM-operations collaboration. Accordingly, an agenda for further development in the area is proposed to include wider reaching development of the research project. This would help determine the applicability of the findings to a larger population and also potentially lead into the refinement of a tool developed to support the holistic management of the resourcing function. A Strategic Employee Resourcing Framework (SERF) [1] would promote the integration of the organisational and HR planning, team deployment, performance management, HRD and employee involvement activities that are central to effective SHRM and project management. The potential of this framework to revolutionise employee resourcing, and in particular the HR administration function, in the industry through the careful application of sophisticated modern HRIS software is significant [8].

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The Demand for Labour in Construction

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Abstract

The construction industry narrowly defined involves only those firms directly involved in the erection of structures and other constructed facilities, but this is part of a wider construction sector that involves all of those aspects of the business from obtaining the raw materials through to demolition and disposal of the facility at the end of its useful life. Statistics on construction normally only focus on the narrowly defined industry, but still suggest that it is a major contributor to the national economy and to employment in particular. However, the statistics also fail to take account of two other important aspects of the industry and these are the informal sector and the work done by 'direct labour organisations' (including do-it-yourself and mutual aid). Estimates of the scale of the broadly defined sector as well contributions of these aspects of overall construction are examined to give an overview of the full impact of the sector on employment in the economy.

Keywords: formal, informal, direct labour, employment, construction sector.

1. Introduction

There is some dispute over the causal relationship between economic expansion and the construction industry i.e. whether construction tends to be pulled by or is pushing the national economy¹. In most developing countries, however, the problem is a weak local construction capacity and inefficiency at all levels. Whether it pushes or is pulled, however, the construction sector is important because it is responsible for infrastructural development, construction of utilities and service facilities, houses and new buildings, repairs and maintenance, for example, all of which are ongoing activities regardless of whether the economy is in a boom or bust state.

One of the major objectives of development policy is not only the creation and expansion of production capacity, but the generation of employment opportunities to accommodate a changing labour force. Thus, in developing countries, construction is not only key to the modernization process, but its labour intensive nature makes it particularly attractive as a means of creating employment. It is also a valuable training ground for technicians, managers, craftsmen and entrepreneurs who are essential for the growth of any economy. Trinidad and

¹ Drewer [1] argues that the central problem is to remove those constraints on development which are a consequence of the 'lack of fit' between an economy's demand for construction and its capacity to absorb construction output. An efficient indigenous construction capacity is an integral part of social and economic development.

Tobago (T&T) is a small, open, oil and gas based economy that, perhaps more than most, has experienced the effects of boom and bust and the associated fluctuations in income and employment. This paper focuses briefly on the behaviour of the construction industry in times of economic expansion and contraction, before going on to look at the more broadly defined construction sector.

2. The Trinidad and Tobago Economy

The economy of T&T since the early 1970s has cycled from boom to bust largely in time with the price of oil. Increased oil production together with sharp increases in oil prices after the Organization of Petroleum Exporting Countries (OPEC) intervention between 1973 and 1981 ushered in a boom period for T&T with government's current revenue increasing from US\$233 million in 1973 to US\$2,762 million in 1981. Real GDP grew at an annual average rate of over 5% per year, and real per capita GDP increased by 45% over the period. The unemployment rate fell from 15.4% in 1973 to 10% in the early 1980s. Construction's contribution to GDP rose from 7% to 16.1% over roughly the same period.

During this boom period, in the late 1970s, the construction sector began to show signs of overheating with skilled labour and material prices, as well as the overall cost of construction rising sharply. It became clear that a major cause of this was an across-the-board push for development by the public sector. Every Ministry had major projects on the go and/or on the drawing board, and it was clear that there was need for a more rational scheduling of major public sector projects. This, however, was overtaken by events and the recession of the mid 1980s

The decline in petroleum prices in the 1980's led to a sharp contraction of the economy in terms of both output and unemployment. Between 1982 and 1989 total real GDP fell by almost 30%, and construction's share of GDP also fell dramatically from 17% in the 1981/82 period to 7.7% in 1990. While the GDP was declining, the unemployment rate was increasing sharply from 9.9% in 1982 to 22% in the late 1980's.

In the 1990s the economy recovered strongly, particularly in the closing years of the century. During this period, as shown in Table 1, the unemployment rate also declined from 22.0% in 1989 to 10.4% in 2002, however, at the same time the construction industry has consistently had unemployment figures significantly above those of the economy in general.

It can also be seen in Table 1 that construction has been responsible for more than 12% of total employment even though it has only contributed less than 10% of real GDP. This suggests that construction labour was less productive than the average across the economy. In an economically efficient market this should mean that labour would migrate from construction to where its marginal product is higher, or that construction productivity (as

measured by output per capita) should increase to the industry average. Neither seems to have happened in the statistics up until 2002.

Table 1 Economic parameters for Trinidad & Tobago 1973-2002

	Real GDP Growth Rate (%)	Real Construction as % of GDP	Construction as % of Total Employment	Unemployment Rate (%)	Inflation Rate (%)
1973	1.70	6.78		15.40	14.90
1982	3.80	16.95	18.45	9.90	11.4
1983	-10.31	15.66	18.03	11.1	16.8
1984	-5.80	13.24	17.02	13.3	13.3
1985	-4.12	11.18	15.45	15.7	7.7
1986	-3.28	8.77	13.76	17.2	7.7
1987	-4.57	8.36	13.03	22.3	10.8
1988	-3.92	8.58	10.90	22	7.8
1989	-0.83	7.85	10.56	22	11.4
1990	1.50	7.74	10.73	20	11.0
1991	2.69	8.37	11.47	18.5	3.8
1992	-1.65	8.59	10.89	19.6	6.5
1993	-1.46	8.15	11.03	19.8	10.8
1994	3.57	8.83	10.16	18.4	8.8
1995	3.96	9.16	10.06	17.2	5.3
1996	3.83	9.31	10.09	16.2	3.3
1997	2.82	9.14	11.27	15	3.6
1998	7.77	9.60	12.53	14.2	5.6
1999	4.39	9.79	12.55	14.6	3.4
2000	5.80	9.50	12.70	11.6	3.5
2001	2.80	9.70	14.12	10.8	5.6
2002	4.60	9.62	13.98	10.4	3.9

Source: Own derivation from Statistics published by the Government of Trinidad & Tobago

One reason for the apparent low productivity could be that the skill level in the marginal construction worker is well below the average, so expanding construction inevitably leads to lower short-term productivity. It is also possible that the low productivity also results from its relatively high labour intensity compared with other sectors. This characteristic is exacerbated by the tendency for smaller scale construction work to increasingly be handled by the informal rather than the formal system, and for the informal sector to use more labour-intensive techniques of building [2]. Although this may be a less efficient approach, its characteristics are not all bad. As Wells and Wall [2] point out, a shift towards what they call ‘artisanal’ production “creates income and employment for a large number of semi-skilled and unskilled workers, with substantial multiplier effects to the wider community. Other benefits include widespread acquisition and development of technical and managerial skills and familiarisation with market processes, which may provide a basis for further industrial development with more complex technologies in the future.”

As has been mentioned above, one distinctive feature of construction activity is the way demand and output fluctuate, typically considerably more than for manufacturing or the economy as a whole. This is a reflection of Keynes' multiplier and "is inherent in the demand structure of capital goods industries where relatively small changes in demand by consumers will cause the production capacity to be expanded or contracted at a considerably higher rate." [3]. The figures for Trinidad & Tobago (see Table 2) show that when the economy is growing, the construction sector tends to grow faster than the other sectors. In fact it tends to grow almost twice as fast as the growth rate for the economy as a whole. When the economy is contracting construction appears to decline at a faster rate than the other sectors and total GDP. Thus, the multiplier operates in both directions.

Table 2: Sector performances in Boom and Bust, (Average Growth Rate, %)

Periods	Total Real GDP	Construction
1951-61	8.0	15.2
1966-73	3.1	8.3
1974-82	6.1	13.4
1983-93	-2.2	-9.1
1994-2003	4.7	7.0

Source: Own derivation from Statistics published by the Government of Trinidad & Tobago

3. Perspectives on the Construction Sector

Wells [4] uses the term 'construction' to describe "the creation of physical infrastructure (roads, railways, harbors), other civil engineering works (dams, irrigation projects, power plants), all building work (including housing) as well as the maintenance and repair of existing structures." By its very nature, construction has strong backward and forward linkages with other sectors of the economy - buying its inputs from many different sectors and selling its output to all sectors. As a result, the value added or 'net' output of construction *per se* is only a small part of the total 'construction' process, especially given that a large percentage of total construction output consists of intermediate inputs from other sectors of the economy. The 'multiplier' effect of on-site construction activity has been estimated at two or two and a half times the net value of construction output [4].

The industry converts financial assets into physical assets, while directly and indirectly generating income and employment. The extent of the 'multiplier' effect in the home economy depends on how much of the required goods and services are sourced locally. Trinidad & Tobago is developed enough to be able to offer a fairly full set of inputs to construction and to benefit from most of the multiplier effects. [2]

4. Narrow and Broad Definitions of Construction

Construction can be defined narrowly as an industry focused on on-site construction activity. The broader definition includes for example, the quarrying of raw materials, the manufacture

and supply of building materials and the various associated professional services (including demolition). In the UK it is estimated that the broadly defined construction sector has more than twice the number of firms as narrowly defined industry. Furthermore, this “doubling rule tends to carry over to many of the indicators of the size of the industry” [5]. The official statistics only record the narrowly defined industry. However, the whole of the sector responds as one entity during times of expansion and contraction, so the total impact of construction is at least double that shown statistically.

Furthermore, there is an element of the formal construction sector that is not measured by the statistics as well as there being a large and active informal sector. The unmeasured formal sector involves what are called direct labour organizations (DLOs). These are organisations that provide construction services to themselves. These organisations are non-construction oriented and may be either public or private - with ministries and other agencies providing DLO construction services to the public sector, and the private sector DLOs undertaking a range of in-house construction work. DLOs are estimated to account for 6.3% of total industry output and a slightly higher proportion of industry employment in Trinidad & Tobago [6]. It is estimated that there is also self-build housing (including some housing built by contractors for private individuals) that is rarely recorded in the statistics and it has been estimated to represent about 4 to 5% of total industry output.

The informal sector is also of major importance in construction. This involves both legal and illegal elements. The former includes do-it-yourself building which is a common activity of significant importance. The latter includes what Feige [7] defines it as “those economic activities that circumvent the costs and are excluded from the benefits and rights incorporated in the laws and administrative rules covering property relationships, commercial licensing, labor contracts, torts, financial credit and social security systems”. The Central Bank of Trinidad & Tobago estimated that the informal sector provided gainful employment to some 2% of the workforce [8]. This appears to be a fairly conservative estimate given the experience in other parts of the world. Elsewhere, for example, “The size of the informal economy in India is large and about 92% of the total work force is engaged in the informal economy.” [9] Giles and Tedds’s [10] study of the Canadian underground economy² concludes that it represents about 15 to 16 percent of recorded gross domestic product (GDP). Schneider’s [11] measures of the average size of the shadow economy indicated that it represented around 16.7% of ‘official’ GDP for a group of advanced industrialised countries and 38.0% for ‘transition’ countries. The shadow labour force, as a proportion of the population of working age, involved in this production was around 15.3% in the industrialised countries and 30.2% in the ‘transition’ countries.

² Including both legal and illegal underground activities and both cash and barter transactions.

Frey and Schneider [12] present figures derived by Schneider and Enste [13] as shown in Table 3 below, of estimates of the size of the informal (underground) economy in various countries.

Table 3: Size of the underground economy relative to 1990s GNP.

Advanced Industrialised Countries		
	Greece, Italy	27-30%
	Spain, Portugal, Belgium	20-24 %
	Sweden, Norway, Denmark	18-23%
	Ireland, France, Netherlands, Germany, Great Britain	13-16%
	Japan, United States, Austria, Switzerland	8-10%
Developing Countries		
<i>Africa</i>	Nigeria, Egypt	68-76%
	Tunisia, Morocco	39-45%
<i>Central & South America</i>	Guatemala, Mexico, Peru, Panama	40-60%
	Chile, Costa Rica, Venezuela, Brazil, Paraguay, Columbia	25-35%
<i>Asia</i>	Thailand	70%
	Philippines, Sri Lanka, Malaysia, South Korea	38-50%
	Hong Kong, Singapore	13%
Transition Economies		
<i>Central Europe</i>	Hungary, Bulgaria	24-28 %
	Poland, Rumania	16-20 %
	Slovakia, Czech Republic	7-11 %
<i>Former Soviet Union</i>	Georgia, Azerbaijan, Ukraine, Belarus	28-43 %
	Russia, Lithuania, Latvia, Estonia	20-27 %

Source: Compiled from Schneider and Enste [13].

Trinidad & Tobago can be considered a transition economy and so, based on Schneider's figures, it may be assumed that the informal sector employs some 30% of the workforce. If informal employment is distributed in roughly the same proportions as formal employment, then around 15%³ of the informal sector will be employed in construction activities. This suggests that some 4.5% of the total workforce are employed informally in construction (i.e. 15% of 30%). This figure does not seem unrealistic given that there are many people who 'moonlight' by doing more than one job, and that there are a large number of small, unregistered firms that ply their trade in construction but go unrecognised officially.

Finally as an element of the informal sector is the self-help or do-it-yourself type of work, and this is a major contributor to construction output in the Caribbean. For example, it is quite common for relatives, friends and neighbours to get together to work on one another's houses. This 'do-it-yourself' and 'self-build' activity is a legitimate and large contributor to the economy and is estimated to contribute between 11 and 19% of the output of all construction activity in developed economies [14]. Because of the extent of the mutual aid and self-help approaches to constructing, renovating and extending housing in Trinidad & Tobago it is suggested that this 'do-it-yourself and self-build' activity would represent the top end of the

³ This is roughly mid-way in the range 10%-20% typical for T&T over the past 30 years.

range and hence contribute around 19% of the output of formal construction activity, and the same proportion of employment.

This would suggest that the reported employment figures for construction, are significant underestimates of the true extent of employment in the sector. It is not clear whether the informal sector will react to changes in the economy in the same way as the formal sector⁴. It is possible that as the formal sector expands the informal sector would contract, as there would be less need for informal employment. However, anecdotal evidence and personal experience suggest that this is not the case, and that as the economy expands workers are no less likely to have second jobs, and that the covert construction economy expands at least as much as the overt construction economy during boom periods. The implication, of course, is that policy measures taken to expand construction would have an even more significant impact on employment (and the economic multiplier) than indicated by the official statistics.

<i>Table 4: Summary of the employment effects of broadening the definition of construction</i>					
Employment in narrowly defined industry	Add 100% ² for jobs in the broadly defined sector	Add 4.5% ¹ for informal sector	Add 6.3% ¹ for DLOs	Add 19% ² for self-help and d-i-y	Total Employment
¹ Percentage of total employment		² Percentage of industry employment			

Given the tendency for larger and larger trading blocs to be established internationally, it is necessary to briefly look at how the requirement for such economies to be open will affect the construction sector. Of most importance may be the fear that many countries have that the ‘freedom of movement of people’ guaranteed within these blocs will lead to floods of people moving from the poorer areas to those that are better off. History shows that major development or redevelopment efforts have largely been accomplished by construction labour that has migrated from the poorer countries to the richer countries. As Drewer [1] notes “historically every major infrastructural development programme has required a dramatic migration of workers to satisfy the insatiable demand for construction labour” and that “during the early 1980s there were more than 150 thousand Korean construction workers in the Middle Eastern oil exporting countries working for Korean contractors”.

5. Conclusions

The non-measured elements of the construction sector are of major importance. The figures suggest that the reported employment statistics for the construction industry, are significant

⁴ Various factors have been shown to affect the scale of employment in the informal sector the most important probably being the burden of taxation (size and complexity) that the individual faces in a society [15][16], and the burden of regulation as indicated by the strength and efficiency of government [17]. Schneider and Enste [18] provide a good overview

underestimates of the true extent of employment in the sector. Table 4 summarises the effects of the various elements discussed here.

The figures suggest that if the *industry* employment represents 100%, the additional services that make up the *sector* add another 100%, mutual aid and D-I-Y add a further 19% of industry employment, while direct labour accounts for an extra 6.3% of the total employment, and the informal sector adds another 4.5% of total employment. Thus it may be reasonable to assume that the construction sector actually provides employment for around 300% of the figures quoted in the official statistics for the construction industry.

By way of future research it would also be important to empirically assess the performance of both the formal and informal aspects of the construction sector, and this is the subject of a future study by the authors in the near future.

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Capturing and Utilising Knowledge for Effective Employee Resourcing within Large Construction Organizations

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Abstract

The employee resourcing component of strategic human resource management (SHRM) comprises staffing, performance management and human resource administration functions. In order for it to be managed effectively, it requires the systematic and concurrent combination of dynamic organizational, project and employee data in order that appropriate resource allocation decisions can be made. Whilst much of the knowledge necessary for effective resourcing is categorical (or explicit), some employee-centred data (such as that relating to an individual's background, personality, skills and personal preference) is tacit in nature and thus is difficult to elicit and use in decision making. This research investigates ways in which large construction organizations can overcome these challenges in a way which takes account of employees' needs. It explores how such knowledge is currently captured within leading construction companies operating within the UK and, based on a synthesis of this practice, develops a framework for enabling other firms to elicit the tacit knowledge required for robust resourcing in the future. Effectively implemented, the framework has the potential to enable construction companies to take account of individual employee needs in the future. However, its successful operation will demand a culture of trust and openness if employees are to be explicit in stating their aspirations, abilities and limitations, all of which are vital for effective resourcing decision making.

Keywords: Resourcing, employee centred knowledge, decision making employment relationship.

1. Introduction

Employee resourcing is one of the key strategic human resource management (SHRM) functions within construction organizations [1, 2, 3, 4: p83]. It embodies core SHRM activities such as the recruitment, selection and deployment of employees within the organization, which should be managed in such a way as to support the strategic objectives of the firm. However, despite the vital importance of effective team selection and formation to the success of organizational performance, employee resourcing remains a reactive and largely operations-focused function in most construction firms. This reflects the fact that most construction companies remain grounded

in the traditional “personnel management” style people management practices, rather than those associated with the strategic human resource management (SHRM) approach [5, 6]. Under personnel management, a focus is placed on staffing administration and compliance with legislative and regulatory conditions (ibid.). In contrast, the concept of SHRM is that the effectiveness of an organization largely depends on the efficient use of its human resources which is achieved through employee commitment, flexibility and quality of work [7: p503]. Thus, as with many other aspects of management practice, HRM is currently underdeveloped within the sector [4].

A possible reason for the underdevelopment of the HRM function within construction is that allocating staff to projects demands the concurrent balancing of the often competing requirements of the organization, the project and individual employees. Whereas project and organizational resourcing requirements are relatively easy to discern, capturing employee needs and integrating them into the decision process is more problematic. This is because the knowledge requirements necessary are mainly tacit in nature, as they relates to an individual’s aspirations and personal preferences, as well as their professional experience, skills and competency. Being highly personal, such tacit knowledge is very difficult to communicate or share with others [see 8, 9]. If it is managed poorly or excluded from the decision making process with regards to human resource allocation and development, the result is likely to be dissatisfied employees and higher levels of staff turnover. This, in turn, is likely to disrupt projects and the achievement of strategic objectives. Thus, incorporating individual employee needs into the resourcing decision making process represents a major knowledge management challenge for construction firms.

Despite the recognised importance of the resourcing function and its wide reaching impact on construction people management, relatively little research has been undertaken in the area. This paper reports on a project which set out to develop a more robust methodology for capturing employee requirements of the resourcing process and integrating them into the resourcing decision making process. It examines the resourcing practices of leading UK based contracting organizations, focusing on how the tacit knowledge held by employees is fed into the resourcing decision making process. By combining effective elements of this practice and supplementing this with leading edge SHRM thinking around the resourcing function, it provides a framework for incorporating such decisions into the resourcing process in the future. This offers a new paradigm for incorporating employee needs within decisions which have hitherto been oriented towards the achievement of project goals at the expense of individual requirements of the resourcing process.

2. The Challenge of Effective Employee Resourcing in Construction

The employee resourcing function aims to match human resources to the strategic and operational needs of the organization, thereby ensuring the full and appropriate utilisation of those resources [10]. Whereas in most industries this represents the coordination of a set of fairly controllable tasks, the nomadic, transitory and project-based nature of construction often results in employee needs being ignored. This is primarily because construction projects tend to have a short lead-in

time which demands the rapid mobilisation of teams [4: 84]. This is despite of the fact that construction organizations usually manage these activities centrally within specialist departments or within divisional/ regional senior management teams [ibid: 83]. As is stated above, this reactive practice clearly overlooks the strategic importance of the development of highly committed employees who participate in the development of the organization.

The major components of employee resourcing comprise: staffing, performance, HR administration and change management [11]. These functions comprise several discreet but interrelated management activities, as summarised in Table 1. The *staffing* and *performance* objectives aim to ensure that the right numbers of employees with the right skills and competencies are in the right place at the right time. This is a balancing act in which managers are tasked with taking into account the longer-term strategic considerations of human resource planning (HRP) while providing immediate solutions for the shorter-term operational issues, such as recruitment and selection, team deployment, dismissal and redundancy [12, 13]. Ideally, management of staffing and performance are simultaneously concerned with ensuring the best possible performance is achieved whilst facilitating employees' career progression and offering them appropriate reward for their efforts. *HR administration* focuses on the collection, storage and use of employee data supporting the monitoring and analysis of HR information (14: p22). The *change* aspect of the function aims to achieve appropriate recognition for the significance of change and facilitate the continuous evolution of the organizational strategies and practices through the interrelated aspects of staffing, performance and HR administration.

Table 1: Employee resourcing tasks with related SHRM activities and objectives

SHRM objective	SHRM activity	Tasks involved
Staffing	Human resource planning (HRP)	Strategic human resource forecast (SHRF) – an input; development of a human resource plan – an output
	Recruitment and selection	Identification and analysis of recruitment needs; drawing of job descriptions and person specifications; advertisement of the vacancy; shortlisting candidates; selection process utilising appropriate selection techniques (i.e. interviewing, assessment centres, etc.); selection of the ‘right’ candidate; induction
	Team deployment	Formation and building of effective teams; deconstruction and redeployment of teams
	Exit	Redundancy, retirement, dismissal, voluntary exit
Performance	Performance management	Continuous evaluation and performance appraisal; feedback and reward
	Career management	Promotion; personal and professional development planning (PDP)
HR admin.	Collection, storage and use of employee data	Utilisation of appropriate HR administration system, e.g. manual filing system or a computerised human resource information system (HRIS)
Change management	“Change agent”	Ensuring proper recognition is given to significance of change; management of business and SHRM processes via which organizational culture and structure continually evolve

It can be appreciated that managing all of these functions concurrently represents a complex and challenging task for any large organization. However, within construction companies, additional external factors have an impact which renders it even more problematic. In particular, the challenging physical environment of the construction industry is a particularly problematic context for effective employee resourcing.

Unsurprisingly, current employee resourcing practices usually rely on the personal assessments of line managers [15]. These have the potential for inconsistencies, personalised allocation decisions and hence, disillusioned employees through the violation of a ‘psychological contract’ [1]. The domination of project and organizational needs predominating the resourcing process, has the potential to contribute to increase employee turnover and hence to contribute to the overall inefficiency of the industry. This places extreme demands on both HR departments and line managers, and requires a flexible approach to the employee resourcing function in construction organizations [1]. This requires the different components of the employee resourcing function (i.e. staffing, performance management, human resource administration and change management) to be integrated to form an interconnected network of decision-making and support processes [11]. Modern human resource information systems (HRISs) offer facilities to assist in this task [see 16,

17, 18]. However, these only provide data management tools and therefore must be supported with carefully conceived and well-managed strategies to support the organization's business objectives.

3. Tacit Knowledge and the Resourcing Process

As is explained above, recognition of employees' individual requirements of the resourcing process is fundamental to their effective management. This is a considerable challenge in terms of capturing knowledge about employees' individual preferences and using it for resourcing decisions. This is because the majority of necessary knowledge will be tacit in nature and therefore not easily visible or expressible. However, although such knowledge is highly personal and therefore difficult to communicate or share with others [8, 9], it is essential that it is captured if employee needs and aspirations are to be taken into account.

In recent years, there has been a great deal of interest in developing ways to manage knowledge more effectively in construction organizations, primarily through the development of new information and communications technologies (ICT). However, this emphasis has largely been at the expense of efforts to explore the human dimensions of effective knowledge management [19, 20]. Arguably, an overemphasis on technological solutions for managing knowledge within large organizations has contributed to the relatively high failure rate of knowledge management (KM) within many industries and organizations [21, 22]. Thus, there is a practical need to integrate KM programmes with human resource management (HRM) policy, to ensure its effective contribution to the performance of the modern business [20, 22].

Much of the current work in the area of knowledge has emerged from the initial work of philosopher Michael Polanyi. Polanyi first made the distinction between tacit and explicit knowledge [23, 24]. He describes these as two different types of knowledge rather than two forms of the same thing. Tacit knowledge is known, but difficult to say (i.e. locked in the mind). Conversely, explicit knowledge can be expressed in words or numbers and shared in the form of data, scientific formulae, specifications and manuals [25]. This kind of knowledge is readily transferable within the business community, and can be codified and stored in databases where it can be accessed and used easily. However, explicit knowledge may represent only the metaphorical 'tip of the knowledge iceberg' of the resourcing function.

Nonaka expands the concept of tacit knowledge and states that tacit knowledge includes cognitive and technical elements [see 26, 27]. The cognitive element centres on mental models in which humans form working models of the world by creating and manipulating analogies in their minds. These include schemas, beliefs, and viewpoints, which help individuals to perceive and define their world. The technical element of tacit knowledge includes specific know-how, crafts, and skills. For example, a manager may develop a wealth of expertise after years of experience but s/he is often unable to articulate the technical and philosophical principles behind it. In contrast to Polanyi, Nonaka also sees a connection between tacit and explicit knowledge in that they interchange into each other in the creative activities of human beings. This perspective is highly relevant to the resourcing process, where decisions about an individual's suitability for a project will be determined by both their skills and knowledge of relevance to the endeavour, but also their

personal aspiration and desire to involved within it. These types of knowledge come together in the process of deciding upon whom to allocate to project teams.

A key factor in ensuring that this is managed effectively is developing a climate of trust in the employment relationship between employers and their managers. Trust is important because employees will not be willing to share their work-related knowledge unless that feel secure that it will be used for them rather than against them [28].I If employees feel that their employment relationship is not fair, if they feel that work-related promises or commitments have not been kept, and if they do not trust their employer to keep promises or commitments in the future, then they are less likely to feel disposed to share knowledge at work. Ellis [29] argues that it is difficult to manage knowledge without trust, as most people will not risk sharing what they know without it. However, this can be seen as problematic within the context of the knowledge required for managing the resourcing process, the success of which effectively depends upon identifying: (i) the skills and experience that an employee brings to their role; (ii) their limitations in relation to the tasks inherent in the project for which they are being considered; (iii) learning opportunities in terms of further developing the individual's skills, competencies and abilities; and (iv) employees' personal needs and career aspirations reconciled against the project opportunities on offer. Clearly, identifying and understanding the limitations of employees is problematic given that most employees will not wish their weaknesses to be known by their employer. Even their positive knowledge and competencies may be seen as a commodity which they may be reluctant to convey to their employer in fear of them strengths being exploited in areas of the organization where they do not wish to work. However, the most difficult tacit knowledge to identify is the personal needs and aspirations of individual employees. Thus, finding ways for employees to feed this data into the decision making process is fundamental to the successful management of the resourcing process. If managed successfully, appropriate opportunities for employees to develop within the organization can then be identified.

4. Research Methodology

As is discussed above, this paper reports on a study which investigated the ways in which large construction firms attempt to elicit employees' tacit knowledge of relevance to the resourcing process. Much of the previous research on construction employee resourcing has focused on examining particular aspects of the function, such as recruitment and selection [30], project allocation [31, 32] or team building [33], adopting largely quantitative methodologies and developing solutions that primarily seek to satisfy the organizational/ project requirements and objectives. These approaches have ignored the benefits that a tailored strategic approach and qualitative methodologies can offer and so an interpretative qualitative framework was used. However, two challenges had to be overcome. Firstly, gaining an understanding of the complexities of the resourcing process and the approaches used to manage the function is problematic given the environment within which construction contractors operate [29]. Secondly, the researchers had no *a priori* knowledge of the likely approaches adopted by construction companies from which a hypothesis could be derived. Therefore, an inductive methodology was chosen which allowed for the examination of the resourcing process from a variety of stakeholder perspectives with the aim of gaining a holistic view as to how the function is managed. The

methodology also made the collection of in-depth case study material possible, which allowed employee resourcing activities to be investigated from several perspectives for single project examples.

Table 2 profiles the organizations that agreed to participate in the research. They were chosen as they operated throughout the UK and their activities spanned every major sector of construction activity. All of the companies were in the leading twenty UK contractors measured by annual turnover. Each provided a range of staff who were interviewed in a semi-structured manner. The informants comprised senior HRM staff, directors, senior operational managers with responsibility for resourcing decision-making and a selection of project-based employees at various levels of the organization. A research instrument was developed to guide the discussions to cover all the major topics within employee resourcing and HRM these also incorporating issues specific to project-based sectors. The interviews were recorded, transcribed verbatim and then coded and analysed using NVivo™ qualitative analysis software. NVivo proved invaluable in aiding the codification and organization of the research material and also in allowing for exploratory searches to be carried out on keywords, nodes and/ or attributes [see 34].

Table 2: Participating organizations

	Case study	Sector	Turnover (UK£'000s)
A	National contractor	Building	1,074.000
B	National contractor	Civil engineering	487.238
C	National contractor	Civil engineering	1,680.000
D	National contractor	Building	1,382.200
E	National contractor	Civil engineering	1,335.900
F	European contractor, division	UK Building	706.000

5. Findings

It soon emerged that no single organization managed the resourcing process effectively as a whole. However, several areas of good practice emerged in terms of ascertaining employee needs from the resourcing process and including these within decision making practices. The aspects of the case study material useful for the development of a Strategic Employee Resourcing Framework (SERF) are outlined below.

5.1 Human Resource Planning (HRP)

The HRP aspects of the resourcing function revealed some innovative practices amongst the participating firms. One such approach (Company D) focused on *succession planning*. This involved the identification of people who showed director-level potential, who were subsequently placed on executive development programmes. In company B, HRM specialists and departmental directors collaborated in identifying suitable candidates for their intensive management development programme. Their selection criteria were drawn from business plans and current

organizational capability charts. A named member of the HR team had the overall responsibility for overseeing and facilitating the process providing a single contact point for all involved. This ensured effective integration of the organizational strategic and operational requirements of the business with a management team capable of providing the services and products that clients demand. Many organizations also placed great importance on *graduate development*. Showing long-term commitment to developing graduates and offering them transparent progression opportunities were seen as key factors to successfully retaining the brightest candidates. Companies A and D in particular specialised in student and graduate development as a long-term staffing strategy. This type of long-term approach to graduate recruitment illustrates an effective integration of the strategic HRP and recruitment and selection activities integrated with HRD. The key to both the successful succession planning activities and the graduate was the transparent identification of those with potential in the organization. Rather than base promotions and accelerated career development on informal assessments of staff ability, the most successful firms had an open system whereby the criteria underpinning the selection of people for such schemes were explicit. This enabled those outside such schemes to target improvements to relevant skills and competencies.

5.2 Recruitment and selection

The compatibility of a company's value system to that of the potential candidate's was said to be one of the main determinants of resourcing success. Thus, company A actively promoted the company culture within their recruitment process and adverts in a bid to ensure that applicants' attitudes and abilities aligned with their desired values. In articulating the company values and culture in this way, this company had tried to ensure that potential employees were clear as to the behaviours that would be expected of them if they were appointed. They had put considerable effort into converting the implicit assumptions and working practices into a tangible description of their operating culture.

5.3 Team deployment

Company D operated a particularly effective approach to the team deployment process which exemplified the need for tacit knowledge capture from within the resourcing process. Four main sources of information were drawn together to form a comprehensive picture of a potential team member's suitability for a project:

- Technical competence assessments (from job descriptions, experience summary sheets and chartered status records)
- Personal development assessments (to support technical competence evaluation and provide information on personal aspirations, needs and preferences)
- Personal relationship records (line managers' knowledge on how the employee works with other people and works as part of a team)
- Availability and personal requirements (employee availability, current project/ commitments, potential disturbance of a move mid-project and employee personal requirements).

By systematically considering these four sets of criteria, robust assessments could be made of the most compatible project for each individual employee. Similarly, teams could be selectively and gradually dismantled in such a way as to avoid disrupting project management by aligning particular skills with particular project stages. This also facilitated the effective redistribution of knowledge from the project and its team members' experience of other sites. Regional engineering managers had been introduced to form a formal communication link between the site and office based staff. Their role had also been proven effective as an alternative for direct line management contact regarding appraisal interviews, career management discussions and grievance procedures. In effect, their role had been to manage the capture of knowledge relating to employees' abilities and needs from the resourcing process.

5.4 Performance management

Performance management was found to be the principal tool used for capturing the data necessary to underpin resourcing decisions. Company C and Company F used a similar performance management system which had a post-project appraisal feature, which meant that employees had an appraisal meeting after each project in addition to their annual performance review. This comprised an open discussion on the employees' performance on the project, what he/she had learned and what they would like to do next. This provided information that could be used in personal development planning. The developmental aspects of the project appraisal discussion had helped employees and their managers to monitor their progress and the achievement of the targets set in the performance appraisal. Moving towards a project-related appraisal process was seen as crucial for the effective management of the resourcing function, particularly because it was easier to articulate learning experiences immediately following project completion than on an annual basis as is typical in most organizations.

5.5 HR administration

Developing a repository and retrieval mechanism for managing the employee data necessary for effective resourcing was seen as crucial. Although none of the participating firms had developed such technology, Companies A and E were in the process of building internal HRP information systems. These were envisaged to include facilities for comprehensive data management and decision-support. In company E the system was to replace the current divisional databases and provide a centralised information source for the group as a whole. It was to run separately from the group's personnel database, but with capabilities for data sharing between the two. This ICT capability was seen as crucial for facilitating the rapid entry and retrieval of employee records for facilitating resourcing decisions.

6. Discussion: A Framework for Capturing and Integrating Employee-Derived Data within the Resourcing Process

The analysis of the good practice elements from the six case study organizations revealed that none of the firms provided a wholly robust methodology for capturing knowledge on employees'

individual abilities, needs and aspirations as part of the resourcing process. However, by taking elements of each of the practices used by the firms, this provides a framework which could address the challenges posed by project resourcing within the construction industry. This framework (Table 3) forms the underlying process elements of a Strategic Employee Resourcing Framework (SERF) [see 35 for a full description of the SERF model]. In addition to the process element, the framework consists of a web-enabled user interface and a Human Resource Information System (HRIS) application. The SERF connects the resourcing functions (HRP, recruitment and selection, team deployment, performance management and HR administration), thereby enabling them to be integrated with the wider HRD and employee involvement elements of SHRM. Such an integrated tool presents a radically different resourcing paradigm in comparison to the industry's traditionally production-oriented approaches as it integrates the organizational, project *and* individual employee needs into the process.

Table 3: Framework for Capturing and Integrating Employee-Derived Data within the Resourcing Process

Core resourcing element	Challenges of managing process within a construction context	Good practice identified from case study firms related to tacit knowledge capture	Benefits for the successful management of the resourcing process
<i>HRP</i>	Nomadic, transitory, project-based sector	Transparent identification of succession criteria	Effective integration of strategic and operational business requirements Long-term staffing strategy integrated with HRD
<i>Recruitment and selection</i>	Fluid and dynamic environment	Organizational culture explicitly described throughout the recruitment process	Efforts targeted at suitable population Candidates' value system matches that of the organization
<i>Team deployment</i>	Need to balance external, organizational, project and employee variables	Multiple sources of decision-support information Facilitation of communication from projects to office-based managers	Flexibility Quality of work High staff morale Effective knowledge transfer
<i>Performance management</i>	Reliance on personal assessments of line managers	Post-project reviews Structured performance management systems	Employee commitment Team deployment decision-making support Tool for employee voice and two way discussion
<i>HR administration</i>	'Personnel' (Rather than SHRM): low take-up on technology	HRP information system/ HRIS	Comprehensive data capture and sharing Decision-support for resourcing decisions

6.1 Case study

In order to examine the practical application of the framework described above, it was tested in a programme comprising the construction of ten schools divided into four projects. Each project

had a Project Manager, responsible to the Contracts Manager, who assumed responsibility for the production teams for one, two, three or four sub-projects. Each sub-project had a site manager who was responsible for the supervisory staff (foremen, engineers, trainees) and directly employed labour. On one section of the overall programme the staff were all new to the organization, apart from a site manager based on sub-project two. He was one of the longest serving members of the organization with 35 years experience in the region. The others had been specifically recruited for the projects. Other projects within the programme had high proportions of existing personnel supplemented with a few freelance and/ or newly recruited staff. One section four had a balanced mix.

This initial staffing strategy adopted by the case study organization resulted in multiple challenges throughout the overall programme duration. The new Contracts Manager required extensive resourcing guidance from his longer serving colleagues. The organization had no written policy or procedures for team deployment. Similarly, in recruiting new personnel he had to actively seek advice so as to be able to follow established unwritten company practice. At the site level, there was extreme pressure to meet expected performance levels. New recruits were trusted to undertake the work with the guidance of an older, very long serving site agent. Although this allowed for fresh ideas and working methods to be brought into the project, this was at the price of unproven working relationships and hence, reduced team synergy. The problems faced by the staff had been compounded by an abject lack of written policy or procedures on recruitment and selection or team deployment.

The resourcing framework was used in subsequent projects within the programme to address many of the issues emerging from its early operation. Firstly, in terms of policy and procedures, the system provided full details of all organizational and good practice guides on employee resourcing, HRD and other elements of SHRM. This included recruitment and selection procedures and team deployment processes, which ensured the effective utilisation of staff across the organization, its sub-divisions and departments as well as individual programmes as in this case. Thus, the inequalities between sections one, two, three and four were highlighted in subsequent project planning stages and new and experienced personnel were allocated to the projects more evenly. Secondly, the HRD element of the framework ensured that individual employees' or organizational tacit knowledge was transferred to the project through the appropriate use of company personnel. This alleviated the team building difficulties experienced and also develop useful future relations within new members of staff within the organization. This tacit knowledge was used to enhance internal relationships and thus, to foster organizational commitment.

The HR administration element of the framework, the HRIS, supported timely and accurate employee data storage and retrieval. This included explicit information about their background and skills, but also tacit information which refers to their experience and expertise. This data bank was used as a directory of organizational expertise through which resources could be deployed according to organizational and project requirements. At the same time, the employee involvement aspect of helped to ensure that the individual employee needs and preferences in terms of work-life balance, career ambitions, etc. were incorporated into the managerial decision-making. This way transparent and balanced decision-making took place, which was used to

rapidly satisfy employee/ client enquiries. In the long-term such a system can help in planning employee progression and also encourage repeat-business.

7. Conclusions

This paper has explored how knowledge is currently elicited within leading UK construction companies. Based on a synthesis of this practice, a framework for enabling other firms to capture the tacit knowledge required for robust resourcing in the future has been developed. Capturing individual employee perspectives on their skills, competencies and personal needs is the cornerstone of any successful project resourcing strategy. Such knowledge is difficult to take into account as it is tacit and specific to every individual employed by the organization. Nevertheless, if an organization fails to take employee needs in the resourcing process, the implications are likely to be detrimental both to project performance and to staff development and retention. Thus, capturing employee's perspectives on the resourcing process is key to the efficacy of the HRM function within large construction businesses. Although none of the firms participating in this research had developed a solution which demonstrably resolved the resourcing challenge, a synthesis of the best practices of those identified has resulted in a more robust methodology for addressing the challenge of taking into account employee perspectives in the resourcing process. However, its successful operation will demand a culture of trust and openness if employees are to be explicit in stating their aspirations, abilities and limitations. Although this may present a significant challenge to construction organizations, if both parties work to develop such a culture then the benefits should be employees who are appropriately deployed in a way which is sympathetic to both their needs *and* those of the organization.

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Modelling Construction Skills Supply for the Zambian Economy

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Abstract

The development of requisite skills in the right numbers to match the sector demands in construction within Zambia forms an essential aspect of the ability of construction companies to deliver projects efficiently. The availability of these skills is influenced by a number of factors including the training provision which governs the supply of the skills, sector and sub-sector volume capacity which drives the demand for the skills, and other socio-cultural as well as public sector policy on skills development. The nature of the interaction between the two principal factors of demand and supply for a developing country such as Zambia is particularly relevant as these two factors are self-reinforcing and also impact on the other socio-political cultural factors. The paper explores the interaction the two factors by examining the supply pattern of selected construction skills and how they reflect current skills needs (demand) of construction companies in Zambia. The scope of the analysis is craft-based and technician grade skills. The benefits of the analysis derives not only from the potential to identify possible skills shortfalls to inform public policy, but also highlight any change in the composition of the skills base that the supply organisations (construction sector training providers) may have to address.

Keywords: construction, skills, training, policy, demand, supply, Zambia.

1. Introduction

The construction industry in Zambia, as in many developing economies, is dominated by labour-intensive methods of production (Muya et al., 2003; Edum-Fotwe, 2003). This orientation for the production activity within construction means that the availability of requisite skills to the industry impact heavily on its capacity to deliver demanded outputs. The development of requisite skills in the right numbers to match the sector demands in construction within Zambia forms an essential aspect of the ability of construction companies to deliver projects efficiently (GRZ, 1996). The availability of these skills is influenced by a number of factors including the

training provision which governs the supply of the skills, sector and sub-sector volume capacity which drives the demand for the skills, and other socio-cultural as well as public sector policy on skills development (World Bank, 2003). The nature of the interaction between the two principal factors of demand and supply for a developing country such as Zambia is particularly relevant as these two factors are self-reinforcing and also impact on the other socio-political cultural factors. The research forms part of a much larger study funded by the DFID and administered by the British Council in Zambia. The objectives of the main study are to undertake the following activities in Zambia:

- examine current government policy and expenditure with reference to training and retraining of the workforce in the construction industry;
- investigate trends in outputs of institutions involved in training and retraining of the construction industry workforce;
- audit construction industry skills deficit through a survey of construction industry employers;
- explore levels of private sector participation in training and retraining programmes;
- identify constraints to implementation of appropriate training programmes; and
- assess current levels of skills possessed by construction craft workers

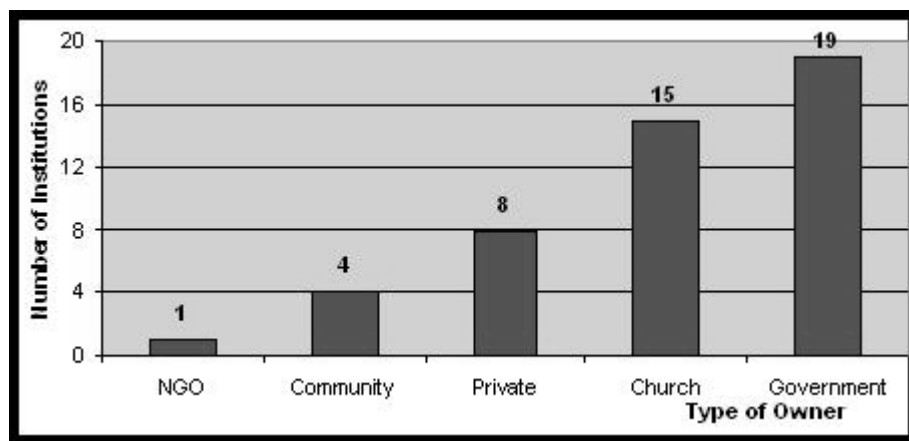
This paper explores the interaction the two factors by examining the supply pattern of selected construction skills and how they reflect current skills needs (demand) of construction companies in Zambia. The analysis is focused at the craft-based and technician grade skill levels as this presents a critical area for strengthening construction in most developing economies. The benefits of the analysis derives not only from the potential to identify possible skills shortfalls to inform public policy, but also highlight any change in the composition of the skills base that the supply organisations (construction sector training providers) may have to address.

2. Construction skills in Zambia

The development of construction skills in Zambia occurs both through formal and informal routes. The former is achieved through training and education with appropriate accreditation structures established. The latter involves hands-on apprenticeship often without any formal evaluation of proficiency. At present, the country's construction training institutions are in dire need of investment after accumulated years of under-funding and brain-drain. The continued reliance on central government to finance education and training in the country has led to the fall in standards, and the mass exodus of teaching staff due to poor conditions of service. Although the government has introduced user fees through the Technical Educational, Vocational and Entrepreneurship Training Authority (TEVETA), in almost all its institutions, the portion paid by government through budget grants remains unsatisfactory. Mashamba (2002) discuss the efforts of the Zambian government to address the current funding situation through a levy scheme.

With the liberalisation of the economy, a number of private training institutes have emerged to fill the vacuum created by the need to acquire skills in the construction industry. The Thorn-Park Construction School and the Nzelu Institute are two such private sector led construction institutions in the country. There are a number of other private schools run by individuals, NGOs, Community Based Organisations (CBOs) and churches in the country. While it may be said that Zambia is now a private sector-led economy, the government, by and large, still funds construction training at government funded institutions (Mashamba, 2002).

Since 1991, there has been a proliferation of a number of training institutions in various construction related trades. Table 1 shows that of the 47 institutes offering construction courses, only 19 representing 40 per cent are government owned. Therefore, about 60 per cent of the trade schools are either in the hands of churches, the private sector or CBOs. Outside government, churches are the main provider of construction skills training, especially in rural and peri-urban areas. Although the private sector may provide an avenue for earning a qualification and living in the construction industry, there is need to monitor the sector to avoid poor quality training.



(Source: Technical Education, Vocational and Entrepreneurship Training Authority - TEVETA 2003)

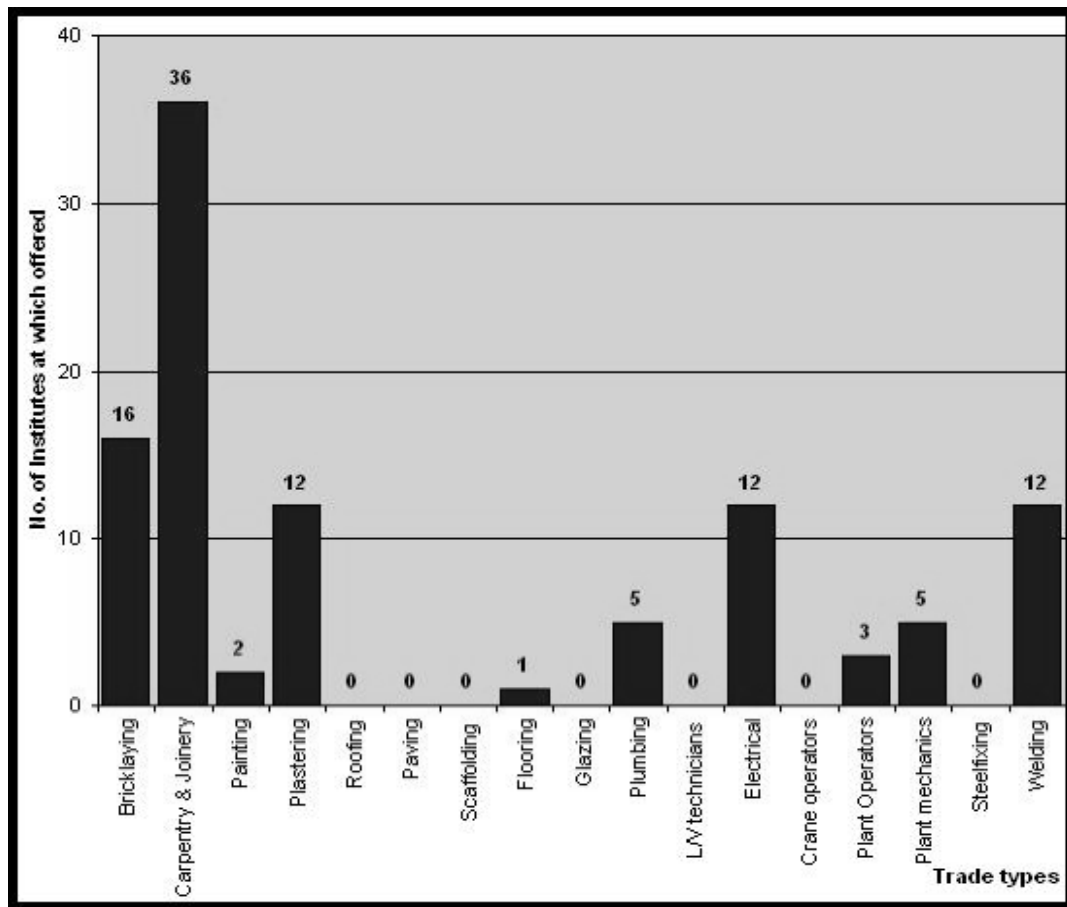
Figure 1: Ownership of construction trade schools

3. Skills modelling

Agapiou et al (1995) identified the craft skills required by the construction industry to include: bricklayers, carpenters, painters, plasterers, roofers, pavers, scaffolders, floorers, glaziers, plumbers, light/ventilation technicians, electricians, crane operators, plant operators, plant mechanics and steel-fixers. Figure 2 shows the construction related trades being offered at craft schools in Zambia. While the majority of the trade schools offer courses in bricklaying, carpentry and joinery, plastering, electrical and welding, there are no programmes for roofing,

paving, scaffolding, glazing, light/ventilation technicians, crane operators and steel-fixers in any of the trade schools.

There is evidence in every city and town in Zambia of high-rise buildings and other types of concrete structures that would have used scaffolding and steel-fixing expertise in their construction. It is also evident that there is wide usage of construction plant such as tower and mobile cranes in many construction operations countrywide. There is anecdotal evidence to support a view that steel-fixers and other such specialist skills acquire their training on the job in a rather informal and unconscious apprenticeship. Without training programmes in roofing, paving, scaffolding, glazing and crane operations, it may also be argued that craft-persons with skills in these areas may also have acquired their trades on the job in a similar informal and unconscious manner. This foretells an industry in limbo. No construction industry that stands to be competitive in the era of globalisation can depend on a workforce that has no formal training in key skills such as crane operations, scaffolding and steel-fixing. Other than being inefficient and uncompetitive, the health and safety practices in such an industry raise many questions. To be able to plan and make such a provision, it is essential to have a clear appreciation of the current capacity both from a demand and supply perspective. Such evidence can then help to qualify the nature and extent of skills constraints within the industry, and form the basis for any future industry strategy on improvement and development.



(Source: Technical Education, Vocational and Entrepreneurship Training Authority - TEVETA 2003)

Figure 2: Construction craft skills training offered at trade schools

4. Method of Investigation

The principal method adopted for explicating the nature of the demand and supply relationship of construction skills in Zambia is a time series approach. There are two main goals of such a time series analysis. First, it is aimed at identifying the nature of the phenomenon represented by the sequence of observations on skills provisions and availability. Second, the method of time series provides a means for forecasting for predicting future values of the demand and supply of skills variables. Both of these goals require that the pattern of observed time series data is identified and more or less formally described. Once the pattern is established, they can be interpreted and integrated with other strategic data for planning the construction industry as a whole. In this paper, the authors address the first aspect of the investigation to by providing a profile of the demand and supply of the construction skills. The predictive aspect of the investigation forms the subject of a different academic output. The provision of trained places represented by the numbers offered for final examinations is adopted as proxy for the demand of skills, and the graduation of skills as proxy for the supply of skills.

4.1 Nature and source of data

The nature of time series values are the realisations of random variables observed from real life phenomena or observations and reflect the following series detailed in equation [1]. y_t is the observed or returned value at any time t .

$$y_1, y_2, y_3, \dots \dots \dots y_t \quad [1]$$

These random values can be represented as a part of the larger stochastic process depicted by equation [2].

$$\{y_t : t \in Z\} \quad [2]$$

Equation [2] defines the set of all possible returns or observations of the series under investigation, in this case the demand and supply of construction skills in Zambia. It is this underlying process that will be the focus for subsequent theoretical modelling and development.

The data set was generated by reference to aggregate statistics compiled by the Examinations board responsible for technical training and education in Zambia. Current data on skills capture six principal categories. These comprise: Plumbing and Sheet-metal; Carpentry and Joinery; Bricklaying and Plastering; Painting, Decorating and Sign-writing; and Electrical. Figure 3 presents the aggregate demand and supply of the six skills in Zambia over the period 1987-2001. This illustrates the disparity between the demand and supply of skills for the construction industry in Zambia.

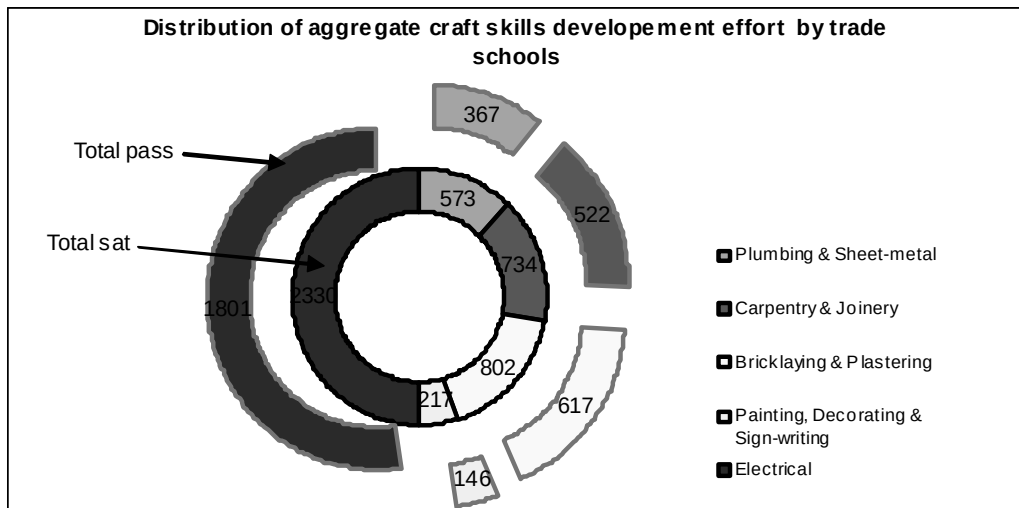


Figure 3. Number of craft skilled graduates in the construction industry: 1987-2001 (ECZ, 5-11-02)

5. Analysis and Results

Figures 3, 4 and 5 present the plots of the time series for the demand for trained skills, supply of trained skills, and the ratio of supply to demand in respective order. The demand supply ratio provides an indication of the skills capacity deficit that exists within the construction industry.

The analysis presented in this paper addresses the capacity for skills supply to the construction industry. This is represented as a skills capacity index. Skills capacity index is defined by the ratio of skill of the skills supply to the skills demand as outlined in equation [3].

$$SCI_t = \left(\frac{SS_t}{SD_t} \right) \quad [3]$$

where for any period defined by t :

SCI_t is the skills capacity index in the period

SS_t is the skills supply in the period

SD_t is the skills demand in the period

The various values of SCI returnable from the analysis are interpreted as follows;

$SCI \Rightarrow 0$	under capacity and constrained industry
$SCI \Rightarrow 1$	balanced capacity industry
$SCI > 1$	overcapacity with a supply glut

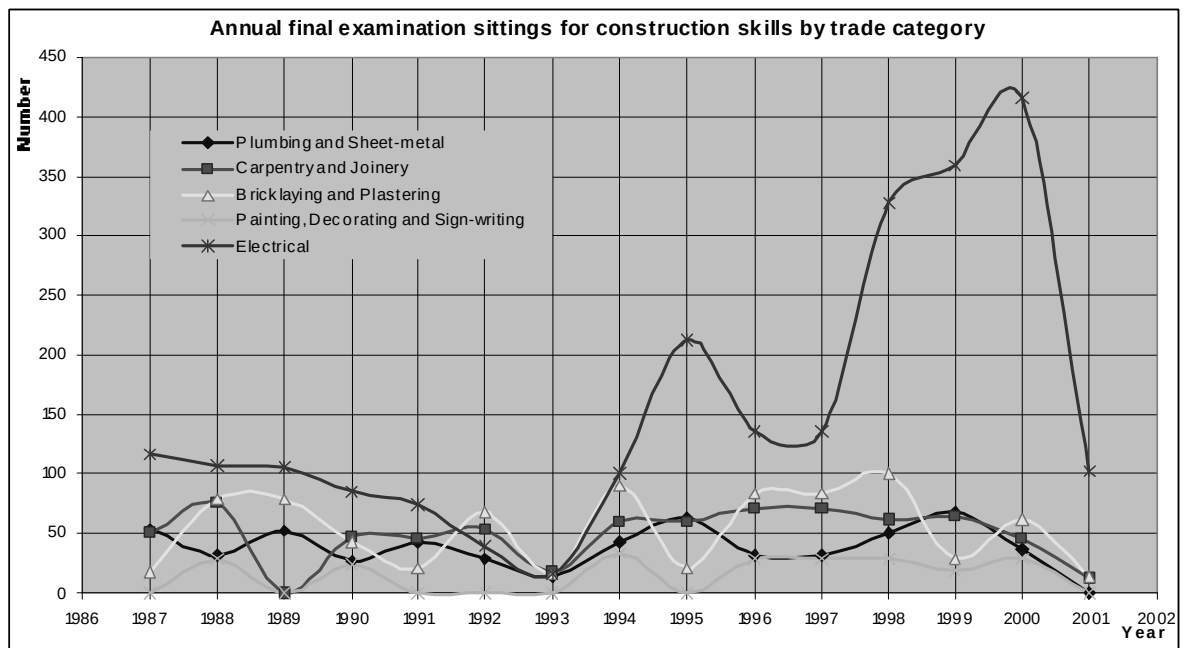
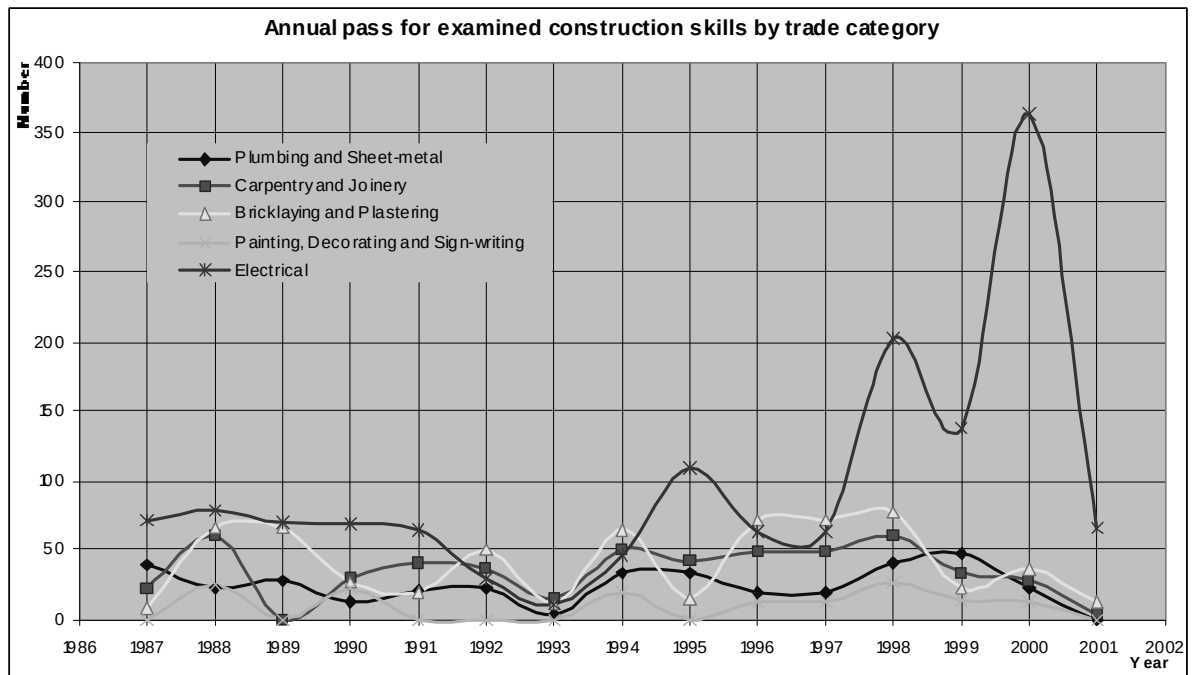
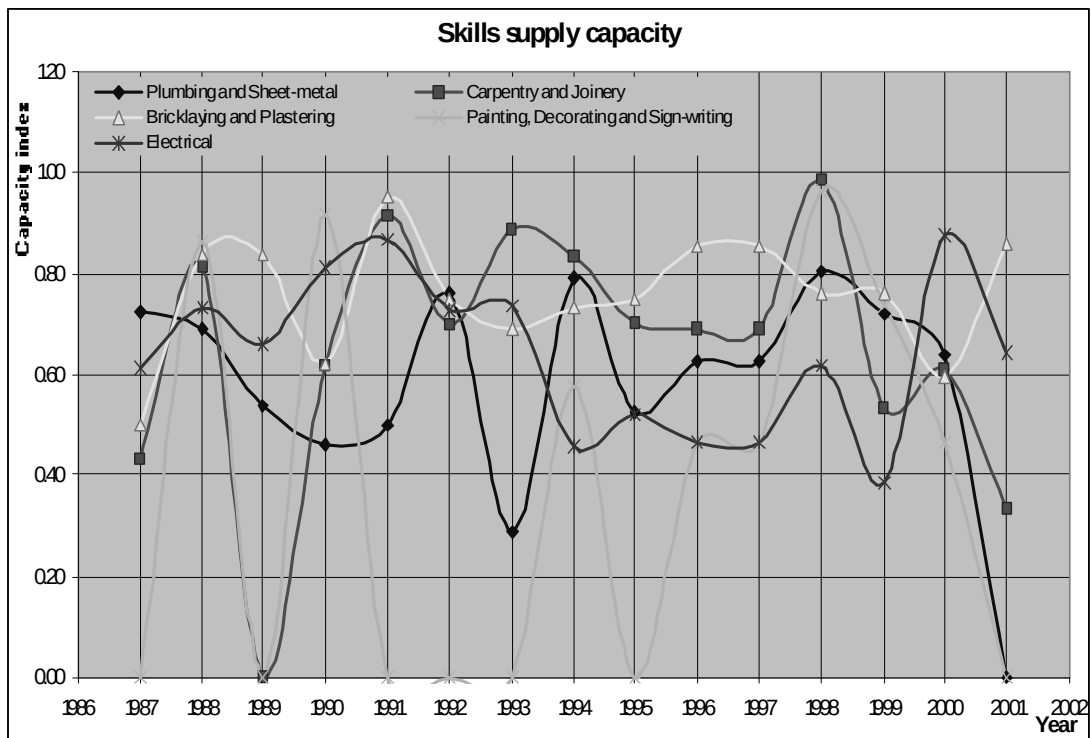


Figure 4. Skills demand profile for construction crafts in Zambia



5. Skills supply profile for construction crafts in Zambia

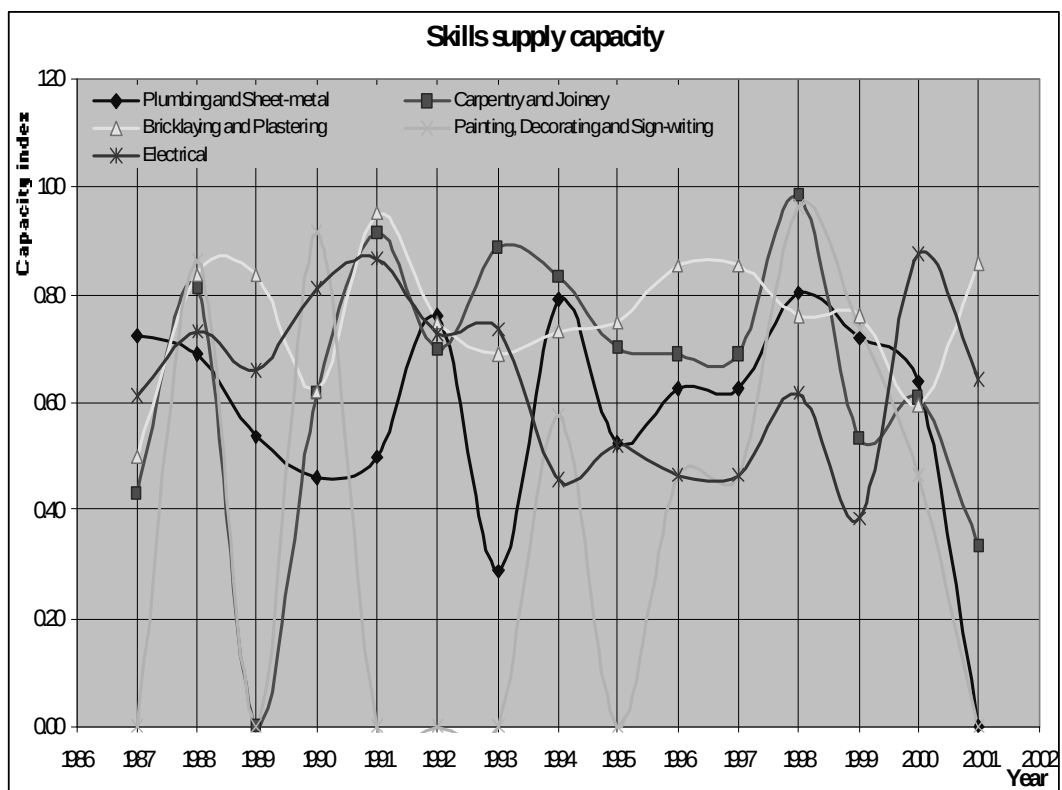


Figure 6. Skills capacity profile for construction crafts in Zambia

6. Discussion

With the exception of electrical trades there was a stable level for the demand and supply of skills in construction from 1987 to 2001. The electrical trades reflected a surge in demand and supply of skills 1998. The returned figures in 2001 for the electrical trades however, indicate that although the growth in demand and supply from 1998 was sustained over a protracted period, it could still be viewed as a noise.

The capacity indices for the different skill categories however, show a consistent under capacity with indices averaging a range between 0.4 – 0.8. In very many cases the indices closer to 0.8 reflect peaks that distort the stable trend. More recent indices closer to 2001 present a case of an exacerbating under-capacity across all the skills categories, notwithstanding the dramatic growth in numbers for the electrical trades.

The low indices across the various trade categories present a very strong case for improving the pre-examination activities for the different skills. This would call for a greater appreciation of the conditions that influence such inefficiency. More significantly, it would be useful to conduct a similar exercise for other countries, particularly, ones' that share a similar context to enable the Zambian construction industry to assess how it measures up.

7. Conclusion

The future effectiveness of the construction industry in every country depends on the quality of the workforce it educates and trains. The analysis of the Zambian construction industry demand and supply of skills in the trade categories shows a gross under-capacity across the existing areas where training is offered. The demand supply analysis presents a method for evaluating the efficiency for developing and utilising skills in any industry or sector through the use of the skills capacity index (SCI). Such an index could also provide a basis for cross-industry comparative analysis.

Acknowledgements

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Section V

Means for improved
competitiveness

Managing Preliminary Estimates in a Changing Economy

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Abstract

The accuracy of preliminary estimates has a tremendous impact on the ability of a state highway agency (SHA) to develop a functional construction budget for a given year. Consistent overestimation or underestimation of construction costs can lead to fiscal complications that may mean that a SHA is able to construct fewer projects than anticipated or fewer than otherwise possible. Fundamental economics are an additional consideration that sometimes affect both the SHA and the private contractors beyond their engineers' ability to generate accurate unit costs.

In practice, simple principles such as the level of competition, availability of work, and availability of financial resources can influence a contractor's bid price. A random sample of 100 projects per year was taken from six arbitrarily selected states over a six-year period. The engineer's preliminary estimate and the award price were recorded and the accuracy of the preliminary estimate was expressed by their difference as a percent of the estimate. The difference was then regressed against the number of bids submitted for the project, current levels of three leading economic indicators at the time of the project's letting and the state in which the project was constructed. The result of this study was a refined regression equation that predicts the accuracy of the engineer's estimate as a function of the number of bidders, some of the economic indicators, and the state.

Keywords: Preliminary, Estimate, Accuracy, Economy, Highway, Department of Transportation, Let, Letting, Prebid

1. Introduction

Managing and understanding the accuracy of preliminary estimates carry tremendous consequences for those involved in the development of the construction budget for state highway agencies (SHAs). If an agency is unable to accurately forecast the cost of constructing its projects, then it is impossible for it to develop a proper, functional budget. Several state construction budgets are now in excess of \$2 billion annually. The Florida Department of Transportation (FDOT) estimates its fiscal year 2003-2004 budget to be \$6.3 billion with approximately 40% or \$2.52 billion going towards construction. [1] It follows that accuracy in preliminary estimation has a significant effect on citizens who fund construction through their tax dollars and who rely upon the infrastructure for their well-being.

This study analyzes data from six randomly selected states over a period of six years from 1997 to 2002. A sample of 100 projects was taken each year per state. The research team kept the ratio of bridge-to-highway-to “other” consistent from state-to-state, and the projects were chosen randomly within their category. The projects’ preliminary engineer’s estimate, award price, time of letting, and number of bidders were recorded. The accuracy of the estimate was measured by the award price as a percent of the engineer’s estimate as seen in Equation 1. This measure is known as the “A/E Ratio.”

$$\text{A/E Ratio} = (\text{Award Price}) / (\text{Engineer's Estimate})$$

Economic data including the Dow Jones Industrial Average (DJIA), Federal Funds Rate, and the Government Printing Office’s (GPO) New Construction Rate were summarized and recorded by month. The accuracy of the estimate was compared to the number of bidders and the economic data through a linear multivariable regression.

2. Data Collection

2.1 Project Data

The project data, including the engineer’s estimate, award price, time of letting, and number of bidders, were gathered from the Construction Office or Records and Information Office of six SHAs. Not all of the states originally contacted had the requested data available in a summarized format suitable for this study. Florida, Minnesota, Ohio, Oklahoma, North Carolina, and a Pacific Coast State (that requested not to be identified in this study) were the first SHA’s able to supply compatible data. One state grouped its project letting information into years instead of months and, as a result, two separate sets of regressions were run to maintain consistent variability throughout the regressed data. Because some SHAs in practice do not accept bids outside of a 20% range of their estimate, all projects with A/E Ratios below 0.8 or above 1.2 were assumed to have contained amendments not reflected in the engineer’s estimate and thus were not considered in the analysis.

2.2 Economic Indicators

Three financial indicators were selected to evaluate the economic environment at the time each project was let. The first indicator was the DJIA monthly close price. [2] The DJIA is a broad and frequently referenced indicator of the strength of the United States’ economy and it is also a fair proxy for contractors’ ability to procure the capital necessary to begin a project. Second, the Federal Funds Rate was used because it is a direct representation of an enterprise’s ability to obtain financial capital and because it is a corollary to the strength of the general economy. The Federal Funds Rate sets a base rate for the exchange of funds between banks and it is used to establish the rate at which banks lend money to businesses and individuals. Next, the New Construction Rate was obtained from the U.S. Government

Printing Office because it is an indicator of the activity and availability of work in the construction industry. [3]

2.3 Number of Bidders

Finally, the number of contractors that submitted a bid on each project was recorded and used to indicate the level of competition. The basic principals of a free economy suggest that increased levels of competition will have an inverse effect on the price of a good or service.

3. Data Analysis

A statistical analysis of the data was performed in two stages. First, the A/E ratio, grouped by month of letting, was analyzed versus the number of bidders, monthly economic indicators, and state where the project was constructed. Second, the monthly project data was regrouped by year and combined with data from the state providing it only on an annual basis. The yearly project data were analyzed against the number of bidders, the yearly economic indicator data, and the state where it was constructed.

The statistical analysis consisted of two parts. First, the correlations between the dependent variable (A/E Ratio) and the independent variables (number of bidders, DJIA, Federal Funds Rate, new construction rate, and state) were determined to gain a basic understanding of the relationship between the variables. Second, the linear multivariable regression functions were developed and refined by removing the statistically insignificant independent variables.

General statistical analysis (Table 1) of the full monthly data indicates a significant amount of variance as shown by the standard deviation ($\sigma = 0.09100 = 9.100\%$) and the range between the minimum and maximum statistics for all variables. It is significant to note the mean A/E ratio ($\bar{x} = 0.9624 = 96.24\%$) is less than one. This indicates the award price was less than the engineer's estimate by an average of 3.76%. The yearly descriptive statistics are consistent with the monthly values.

These results agreed with prior research. Fisher et al. analyzed 567 projects performed by 17 companies and summarized the results of their study by stating the following:

“The community average for the actual cost versus original authorized cost is 0.92. This indicates a tendency to slightly overestimate costs and thus have a project with a cost underrun. Assuming the ideal value is 1.0, the company with the most accurate cost-estimation procedure would be the company to benchmark against in this area.” [4]

Table 1. Descriptive Statistics

(A.)	N	Minimum	Maximum	Mean	Std. Deviation
A/E Ratio	1986	.80	1.20	.9624	.09100
Number of Bidders	1986	1.00	16.00	4.2296	2.06119
DJIA	1986	6583.48	11497.12	9718.9584	1233.86838
Federal Funds Rate	1986	1.73	6.54	4.9735	1.26221
New Construction Rate	1986	577.10	881.60	756.4639	95.32818

(B.)	N	Minimum	Maximum	Mean	Std. Deviation
A/E Ratio	2931	.80	1.20	.9614	.09199
Number of Bidders	2931	1.00	17.00	4.3091	2.18418
DJIA	2931	7437.57	10688.04	9434.0387	1148.96420
Federal Funds Rate	2931	1.67	6.24	4.6233	1.46370
New Construction Rate	2931	653.40	860.90	777.4132	77.01802

3.1 Correlations

Pearson Correlation data was taken from the correlation table generated by the SPSS statistical software package (Table 2). The analysis shows the strongest relationship exists between the A/E ratio and the number of bidders. The number of bidders along with the DJIA and new construction rate showed a negative coefficient of correlation indicating an inverse relationship. The federal funds rate showed a positive coefficient indicating a direct relationship. The magnitudes of the Pearson coefficients, however, indicate low correlations between all independent variables except for the number of bidders.

Table 2. Correlation Tables

Monthly Data		AE Ratio
A/E Ratio	Pearson Correlation	1
	Sig. (2-tailed)	.
	N	1986
Number of Bidders	Pearson Correlation	-.230
	Sig. (2-tailed)	.000
	N	1986
DJIA	Pearson Correlation	-.068
	Sig. (2-tailed)	.003
	N	1986
Federal Funds Rate	Pearson Correlation	.055
	Sig. (2-tailed)	.015
	N	1986
New Construction Rate	Pearson Correlation	-.061
	Sig. (2-tailed)	.006
	N	1986

3.2 Monthly Regression

Although only one independent variable, the number of bidders, showed a significant Pierson Coefficient of Correlation, all independent variables were used in the initial regression.

The initial regression had an adjusted R^2 of 0.066 indicating that 6.6% of the variance in the dependent variable (A/E ratio) is explained by the independent variables (number of bidders, DJIA, Federal Funds rate, new construction index, and the state where the project was constructed) used in the regression equation (Table 3).

The initial regression equation can be written as a single equation (Equation 2) with values of zero or one used for the state variables (where a value of one indicates the project was built in that state). The results of the regression can also be written as a series of equations (Equations. 3-7) specific to each state where values of zero and one are already entered where appropriate and the equation is simplified by combining the constants.

Table :. Evaluation of First Monthly Regression Model Fit

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.264(a)	.070	.066	.08795
Predictors: (Constant), Number of Bidders, DJIA, Federal Funds Rate, New Construction Rate, State 6, State 4, State 3, State 2				

$$Y = .996 - (.009)x_1 - (3.623 \times 10^{-6})x_2 + (.005)x_3 + (1.102 \times 10^{-5})x_4 + (.009)x_5 - (.009)x_6 + (.005)x_7 + (.019)x_8$$

$$Y = .996 - (.009)x_1 - (3.623 \times 10^{-6})x_2 + (.005)x_3 + (1.102 \times 10^{-5})x_4 \quad \text{Florida}$$

$$Y = 1.005 - (.009)x_1 - (3.623 \times 10^{-6})x_2 + (.005)x_3 + (1.102 \times 10^{-5})x_4 \quad \text{Minnesota}$$

$$Y = .987 - (.009)x_1 - (3.623 \times 10^{-6})x_2 + (.005)x_3 + (1.102 \times 10^{-5})x_4 \quad \text{Ohio}$$

$$Y = 1.001 - (.009)x_1 - (3.623 \times 10^{-6})x_2 + (.005)x_3 + (1.102 \times 10^{-5})x_4 \quad \text{Oklahoma}$$

$$Y = 1.015 - (.009)x_1 - (3.623 \times 10^{-6})x_2 + (.005)x_3 + (1.102 \times 10^{-5})x_4 \quad \text{North Carolina}$$

Where Y is the A/E ratio, X_1 is the number of bidders, X_2 is the DJIA, X_3 is the Federal Funds Rate, X_4 , is the new construction rate, and X_5 , X_6 , X_7 , and X_8 are equal to one if the project was constructed in Minnesota, Ohio, Oklahoma, and North Carolina respectively.

At an alpha level (") of 0.10 only three of the regression coefficients are significant to the model. The number of bidders, federal funds rate, and State 6 (North Carolina) had p-values (Table 4) less than alpha so a second regression was run with only these independent variables.

3.3 Refined Monthly Regression

The second regression had a R^2 of 0.062 indicating that 6.2% of the variance in the dependent variable (the A/E ratio) is explained by the three remaining independent variables (number of bidders, Federal Funds rate, and State 6) used in the regression equation (Table 5). All of the remaining variables had p-values less than alpha (Table 6) indicating that they were significant to the regression model.

TABLE 4. First Monthly Regression Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	t	(P-value)
		B	Std. Error	Beta		
1	(Constant)	.996	.022		45.777	.000
	Number of Bidders	-.009	.001	-.207	-9.321	.000
	DJIA	-3.623E-06	.000	-.049	-1.249	.212
	Federal Funds Rate	.005	.002	.069	2.835	.005
	New Construction Rate	1.102E-05	.000	.012	.286	.775
	State 2	.009	.007	.043	1.435	.151
	State 3	-.009	.007	-.035	-1.247	.213
	State 4	.005	.007	.022	.786	.432
	State 6	.019	.006	.096	3.045	.002
a Dependent Variable: A/E Ratio						

TABLE 5. Evaluation of Refined Monthly Regression Model Fit

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.252(a)	.064	.062	.08813
a Predictors: (Constant), Federal Funds Rate, Number of Bidders, State 6				

TABLE 6: Refined Monthly Regression Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	t	(P-value)
		B	Std. Error	Beta		
1	(Constant)	.976	.009		104.623	.000
	Number of Bidders	-.010	.001	-.219	-9.976	.000
	State 6	.018	.004	.088	4.006	.000
	Federal Funds Rate	.004	.002	.062	2.827	.005
a Dependent Variable: A/E Ratio						

The refined regression can, again, be expressed as a single equation (Equation 8) or as a state-specific equation (Equation 9). States without a specific regression equation do not vary significantly from the general regression model and the general equation should be used for purposes of analysis of data from these states.

$$Y = .976 - (.010)x_1 - (.004)x_2 + (.018)x_3 \quad \text{General Eqn.}$$

$$Y = .994 - (.010)x_1 - (.004)x_2 \quad \text{North Carolina}$$

Where Y is the A/E ratio, X_1 is the number of bidders, X_2 is the Federal Funds rate, and X_3 is State 6 (North Carolina).

3.4 Simple Monthly Regression

In practice, it is commonly understood in the construction industry that projects with a high number of bidders tend to be bid at a lower price. In order to estimate the impact of this study's consideration of additional economic indicators and state-specific adjustments, a simple linear regression was run with only the number of bidders.

The simple regression had a R^2 of 0.053 indicating that 5.3% of the variance in the dependent variable (the AE ratio) is explained by the number of bidders (Table 7). Given that there are an almost infinite number of variables that can affect the accuracy of a preliminary estimate, a low R^2 was expected. The fact that the R^2 equals 5.3% with "number of bidders" as the only independent variable and only 6.2% with all of the other variables added shows that the number of bidders alone accounts for about 85% of the R^2 of the general equation. This, along with the extremely high number of variables makes the number of bidders a statistically significant factor in the accuracy of preliminary estimates given the sample tested. The size of the sample also lends credence to this conclusion. [5]

Table 7. Evaluation of Simple Monthly Regression Model Fit

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.230(a)	.053	.052	.08858
a Predictors: (Constant), Number of Bidders				

The simple regression equation (Equation 10) expresses the A/E Ratio, Y, as a function of the number of bidders, X_1 .

$$Y = 1.005 - (.010)X_1 \quad \text{General Eqn.}$$

3.5 Yearly Regression

All independent variables were again used in the initial yearly regression. The initial regression of the yearly data had an adjusted R^2 of 0.065 indicating that 6.5% of the variance in the dependent variable (A/E ratio) is explained by the number of bidders, DJIA, Federal Funds rate, New Construction Index, and state variables used in the regression equation. (Table 8)

Table 8. Evaluation of First Yearly Regression Model Fit

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.260(a)	.067	.065	.08898
a Predictors: (Constant), North Carolina, New Construction Rate, Number of Bidders, Minnesota, Ohio, Oklahoma, Federal Funds Rate, Pacific Coast State, DJIA				

As explained in the monthly regressions, the initial regression equation can be written as a single equation (Equation. 11) with values of zero or one used for the state variables (where a value of one indicates the project was built in that state) or as a series of state specific equations (Equations. 12 - 17).

$$Y = .989 - (.009)x_1 - (1.006 \times 10^{-5})x_2 + (.006)x_3 - (.018)x_6 - (.009)x_7 + (.002)x_8 + (.011)x_9$$

(variables $x_4 + x_5$ had a coefficient of 0.00 so they were removed from equation 5.1)

$$Y = .989 - (.009)x_1 - (1.006 \times 10^{-5})x_2 + (.006)x_3 + (0.00)x_4 \quad \text{Florida}$$

$$Y = .989 - (.009)x_1 - (1.006 \times 10^{-5})x_2 + (.006)x_3 + (0.00)x_4 \quad \text{Minnesota}$$

$$Y = .971 - (.009)x_1 - (1.006 \times 10^{-5})x_2 + (.006)x_3 + (0.00)x_4 \quad \text{Ohio}$$

$$Y = .980 - (.009)x_1 - (1.006 \times 10^{-5})x_2 + (.006)x_3 + (0.00)x_4 \quad \text{Oklahoma}$$

$$Y = .991 - (.009)x_1 - (1.006 \times 10^{-5})x_2 + (.006)x_3 + (0.00)x_4 \quad \text{Pacific Coast State}$$

$$Y = 1.00 - (.009)x_1 - (1.006 \times 10^{-5})x_2 + (.006)x_3 + (0.00)x_4 \quad \text{North Carolina}$$

Where Y is the A/E ratio, X_1 is the number of bidders, X_2 is the DJIA, X_3 is the Federal Funds Rate, X_4 is the New Construction Index, and X_5 , X_6 , X_7 , X_8 , and X_9 are equal to one if the project was constructed in Minnesota, Ohio, Oklahoma, a Pacific Coast State and North Carolina respectively. At an alpha level (") of 0.10, five of the nine regression coefficients are significant to the model. The number of bidders, DJIA, federal funds rate, and States 3 and 6 (Ohio and North Carolina) had p-values (Table 9) less than alpha so a second regression was run with these independent variables.

Table 9. First Yearly Regression Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig. (P-value)
		B	Std. Error	Beta		
1	(Constant)	.989	.030		33.275	.000
	Number of Bidders	-.009	.001	-.213	-11.627	.000
	DJIA	-1.006E-05	.000	-.126	-3.046	.002
	Federal Funds Rate	.006	.002	.099	3.003	.003
	New Construction Rate	.000	.000	.085	1.731	.083
	Minnesota	.000	.006	.002	.071	.943
	Ohio	-.018	.006	-.074	-3.150	.002
	Oklahoma	-.009	.006	-.034	-1.454	.146
	Pacific Coast State	.002	.006	.006	.267	.789
	North Carolina	.011	.006	.045	1.879	.060
a Dependent Variable: A/E Ratio						

3.6 Refined Yearly Regression

The second regression had a R^2 of 0.064 (Table 10) indicating that 6.4% of the variance in the AE ratio is explained by the remaining independent variables (the number of bidders, DJIA, federal funds rate, and States 3) and 6) used in the regression equation (Table 11).

Table 10. Evaluation of Refined Yearly Regression Model Fit

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.255(a)	.065	.064	.08902
a Predictors: (Constant), North Carolina, DJIA, Federal Funds Rate, Number of Bidders, Ohio				

The refined regression can, again, be expressed as a single equation (Equation 18) or as a state-specific equation (Equations 19, 20) when the state regression varies significantly from the general regression model.

Table 11. Refined Yearly Regression Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig. (P-value)
		B	Std. Error	Beta		
1	(Constant)	1.032	.015		70.496	.000
	Number of Bidders	-.009	.001	-.208	-11.532	.000
	DJIA	-4.998E-06	.000	-.062	-3.481	.001
	Federal Funds Rate	.003	.001	.050	2.819	.005
	Ohio	-.016	.005	-.067	-3.635	.000
	North Carolina	.012	.004	.053	2.868	.004
a Dependent Variable: A/E Ratio						

$$Y = 1.032 - (.009)x_1 - (4.998 \times 10^{-6})x_2 + (.003)x_3 - (.016)x_4 + (.012)x_5 \quad \text{General Eqn.}$$

$$Y = 1.016 - (.009)x_1 - (4.998 \times 10^{-6})x_2 + (.003)x_3 \quad \text{Ohio}$$

$$Y = 1.044 - (.009)x_1 - (4.998 \times 10^{-6})x_2 + (.003)x_3 \quad \text{North Carolina}$$

Where Y is the A/E ratio, X_1 is the number of bidders, X_2 is the DJIA, X_3 is the Federal Funds rate, and X_4 and X_5 are States 3 and 6 (Ohio and North Carolina) respectively.

3.7 Simple Yearly Regression

Again, in order to gauge the impact of this study's consideration of additional economic indicators a simple linear regression was run with only the number of bidders. The simple regression had a R^2 of 0.050 indicating that 5.0% of the variance in the dependent variable (the A/E ratio) is explained by the number of bidders (Table 12).

Table 12. Evaluation of Simple Monthly Regression Model Fit

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.224(a)	.050	.050	.08967
a Predictors: (Constant), Number of Bidders				

The simple regression equation (Eqn. 21) expresses the A/E Ratio, Y, as a function of the number of bidders, X_1 .

$$Y = 1.002 - (.009)X_1 \quad \text{General Eqn.}$$

4. Application of Equations

The refined regression equations can be used alone or in a confidence interval to predict expected values for estimation accuracy in individual projects. In practice, a budgeting officer in a SHA would input the appropriate economic and state data into the regression equation and record the A/E ratio it generates. The budgeting officer would then adjust the engineer's estimate by multiplying the engineer's estimate for the project by the A/E Ratio predicted by the regression equation as shown in Equation 22.

$$\text{Adjusted Estimate} = (\text{A/E Ratio})(\text{Engineer's Estimate})$$

5. Validation of Equations

Both the monthly and yearly regression models had low R^2 . In the refined regression models this indicates that only 6.2% (monthly) and 6.4% (yearly) of the variance in the percent difference between estimates (A/E Ratio) is explained by the variance of the independent variables. From a purely statistical perspective these values are quite low. However, because of the many other extraneous factors that lead to errors in project estimation, a low value of R^2 was expected and does not in any way detract from the value of the model, as explained earlier. The more important question is whether use of the model increases the accuracy of preliminary estimates.

By applying the regression equation to make adjustments on the project estimates used in this study it can be shown that this model significantly improves the accuracy of the engineer's estimate. Further, the fully adjusted regression equations that include all

significant variables provide a greater reduction in the spread (error) between the engineer's estimate and the award price than both the unadjusted estimate and the

estimate adjusted by only considering the number of bidders. This can be observed by comparing the difference between the engineer's estimate and the award price with the difference between the fully adjusted engineer's estimate (considering all significant economic and state data) and award price, and with the engineer's estimate adjusted by the number of bidders and the award price.

The sums of the absolute values of these errors for each state during the six years considered in this study are seen in Table 13.

Table 13. Results of Using Correction Algorithms

Method of Adjustment (Model)	Sum of Errors, All Six States
Unadjusted Estimate	\$234,850,879
Fully Adjusted	\$ 59,532,648
Adjusted Only With Number of Bidders	\$ 79,079,338

Note the fully-adjusted estimate has the lowest error value. Conversely, the straight sum of the errors for all years considered in this study allows the overestimations and underestimations to balance out resulting in the "number of bidders" regression providing the greatest reduction in error. However, the fully-adjusted regression provides better results when considering the standard deviation. The fully adjusted models for both the monthly and yearly regressions show standard deviations lower than the standard deviations for the "number of bidders" regression. This helps explain why when each state is considered individually the fully adjusted regression most frequently provides the smallest error of the three models.

6. Summary and Conclusions

A study was conducted using relevant data from approximately 3600 highway construction projects. The goal was to measure the accuracy of the preliminary estimates of six SHAs and, using statistical analysis, develop an algorithm that can be used by SHAs to improve the accuracy of their preliminary estimates.

There was great statistical similarity between the states in their ability to accurately estimate the cost of highway construction projects. The result of the analysis on the accuracy rate of the different state DOTs in preliminary estimates agreed with recognized prior research. Details of this portion of the research is beyond the scope of this paper.

A preliminary estimate accuracy model was derived by use of accepted statistical regression practice. Several potential “predictors” were analyzed and the ones that contributed to improved accuracy were retained in the equation as independent variables. The original list of potential predictors included the number of bidders and three leading economic indicators, the DJIA, the Federal Funds Rate, and the New Construction Rate. The number of bidders was, by far, the predictor that had the greatest impact on the models’ performance, but the most accurate model included all four of these, plus the states, as independent variables.

When each state is considered individually, as would be done in practice, two models, the one using only the number of bidders, and the fully-adjusted regression model provided significant improvements in accuracy of the engineer’s estimate, though no model was able to achieve a reasonably high R^2 . The fully-adjusted model performed somewhat better than the one using only the number of bidders. Of course, any agency using this model should use their own historical data to determine which variables to include in their customized equation. In any event, the fact that either of these two models can be used to improve a DOT’s preliminary estimate accuracy overrides concerns about the low R^2 . What the low R^2 does, however, is point to the probability that some other variable or variables may be discovered with future research that would improve the performance of the model. The research team will continue to search for those variables.

Also of interest was the finding that none of the economic indicators proved to be consistently statistically significant to the accuracy of preliminary estimates. Given the fact that the U.S. economy experienced both a boom and a recession during the time period of this study, it can be inferred that the state of the economy does not have a significant effect on the accuracy of preliminary estimates.

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Cost Savings of Long-Term Performance-Based Maintenance Partnering

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Abstract

Dutch housing associations are for many reasons considering the application of performance-based maintenance partnership forms. With this they expect to manage maintenance processes efficiently and effectively.

If a contract is performance-based, the contractor has contract-related incentives to improve its way of working in terms of performance. That will result in direct and indirect cost-savings. Direct project costs represent the expenditure incurred during the actual performance of (long-term) maintenance activities. The indirect project costs are all costs in connection with the organization and performance of the maintenance activities, but which cannot be expressed as direct project costs. In other words, these are the process costs incurred by both client and contractor.

Indirect cost reductions can be realized because the long-term performance-based approach enables maintenance contractors to assume responsibility for certain activities which they are better equipped to perform than their clients. In the traditional approach, many activities are duplicated, i.e. conducted by both client and contractor, because information is lost following the once-only tendering process. In the performance-based approach, clear agreements are made with regard to which party is responsible for which activity during the cooperation period.

Ten projects show that the total indirect costs are lower in the performance-based approach than in the traditional working method. The costs of the initial processes in half of the projects are higher in the performance-based approach than in the traditional approach. The 'Evaluation and After-care' phase is more expensive in every project when using the performance-based approach. The fact that the indirect costs of the performance-based approach are lower overall than those of the traditional approach is entirely due to the reduction achieved in the subsequent phases. The performance-based approach offers the lowest indirect costs to the client. It offers not only a financial advantage in the subsequent processes, but in the initial process too. The indirect costs to the contractor are also lower in the performance-based approach than in the traditional working method, although the savings are somewhat more modest than those enjoyed by the client.

Keywords: cost-savings, long-term co-operation, maintenance, partnering, performance-based

1. Introduction

The professionalism of Dutch housing associations have led to a noticeably greater attention for maintenance processes and partnership forms in the supply chain for maintenance [3, 6, 7]. The growth in the size of the holdings for which an individual housing association is responsible is an important factor in considering the adoption of performance-based partnership forms for maintenance. Some larger housing associations have as many as 40,000 dwellings under their management, which renders it more or less essential to explore alternative means whereby maintenance processes can be managed efficiently and effectively. An additional factor is that the housing associations have chosen to re-focus on their core business, and a number now regard maintenance as a secondary process for which outsourcing, provided it is organized in a responsible manner, is preferable. Another reasons for considering performance-based partnering is the emergence of a strategic housing stock policy and the adoption of quality management systems. The appropriate partnership forms for a housing association depends on its size, organisational structure, business-like approach, the type of maintenance and building components involved and especially its goals for partnering.

In the traditional approach, tendering is a multiple, competitive process. Dutch housing associations generally invite three to five maintenance contractors an offer, based on technical specifications of the work. These contractors act as suppliers of capacity. By contrast, in the performance-based approach, it is assumed that the client conducts a single-phase tendering procedure. The performance-based approach centres on a set of desired performances. Maintenance contractors become active participants in the overall maintenance process. They assume certain risks and responsibilities with regard to the quality and costs of maintenance activities, doing so for a long period wherever possible.

Both clients and contractors cite a number of disadvantages attaching to the traditional process and advantages attaching to new procurement methods [8]. Clients emphasise the reduction of financial risks at the longer term and steering the maintenance processes on main points by a long-term performance-based agreement. Contractors underline improvements of performance and service and innovations in the whole maintenance process by having continuity in orders and sustainable relationships with clients. Self-motivation of contractors to increase performance is essential [2].

2. Research project

The OTB Research Institute for Housing, Urban and Mobility Studies, which is part of Delft University of Technology in the Netherlands, is doing research to the application of performance-based maintenance agreements by Dutch housing associations. The research project is entitled 'Performance-based cooperation in the technical management of housing stock'. Main Dutch housing associations, real estate maintenance contractors and branch organisations contribute to this project, which consist of several ongoing studies.

One study is into performance-based maintenance agreements for several building components and organization's maintenance activities and involves seven large, innovative housing associations and the Dutch Building Research Foundation (SBR). The study involves input from consultants and contractors specializing in exterior surfaces. Clients and contractors require

guidelines for an effective, efficient and transparent performance-based procurement processes and agreements. OTB Research Institute is working alongside the parties concerned in developing appropriate guidelines, with a focus on exterior surfaces and flat roofing. Those guidelines consist of flow charts and decisive performance requirements [8].

Another study is into direct and indirect cost savings by performance-based long-term cooperation between clients and contractors [7]. A breakthrough of performance-based maintenance agreements is obstructed by a lack of knowledge of clients and contractors, desired flexibility in maintenance policy by clients and their desired low market prices. In many cases the contract period is restricted to a maintenance interval, this being the period between the two years in which planned maintenance activities are scheduled.

Long-term, performance-based cooperation offer many advantages compared to the traditional tendering approach. One of the main benefits is that long-term performance-based cooperation is likely to reduce both direct and indirect costs. The essential preconditions are long-term involvement and freedom in the maintenance design and process, giving opportunities for product and maintenance process improvements and innovations.

The OTB Research Institute for Housing, Urban and Mobility Studies was asked by the WVB, a Dutch federation of property maintenance companies, to conduct a cost comparison of long-term performance-based cooperation against the traditional approach. The study distinguishes between direct and indirect cost components, and identifies both direct and indirect cost reductions. The research question was: what are the costs for both client and contractor when conducting exterior maintenance on a number of building complexes over a period of at least two maintenance intervals, comparing such costs under a long-term performance-based cooperation between client and contractor to those incurred when using the traditional method? The study involved modelling and case studies. The first step in the research was to develop calculation models that would compare the direct and indirect project costs of each method at individual project level. These models are based upon knowledge about the maintenance procurement processes, the traditional approach and the long-term performance-based co-operation form, and upon the flow charts of these processes developed in the related study.'

The outcome of the research will assist in discussions around the transition of the building sector from a one-dimensional orientation on costs, to process and value maximization. Therewith, impetus to unwelcome cooperation between building contractors in tendering processes can decrease [1].

2.1 Case studies

In order to make a thorough comparison of the direct and indirect maintenance costs involved in each method, ten actual cases were studied. Each case involves exterior maintenance of housing blocks owned and managed by a housing association. Presumably the size and scope of the project will influence the direct and indirect project costs. Here, a distinction was made between 'simple' and 'complex' projects, depending on the scope and type of maintenance work involved, and the lead-time of the (initial) process.

The cases studied vary in terms of the characteristics of each housing block, size, maintenance history and original quality, the working methods of client and contractor, etc. Accordingly, they are not directly comparable one against the other. However, each case enables a comparison to be made between the long-term performance-based and traditional approach in terms of direct and indirect project costs.

The cost comparison assumes a performance-based working method, with the applicable basic premises in terms of level of quality and maintenance period. The contractors will have produced a maintenance scenario for this period, together with the relevant costing and budget. The notional direct and indirect costs of the traditional working method can be closely estimated, based on the quality level and maintenance period. The maintenance history of the building will play a significant part here. It is assumed that the direct costs of painting – including preventative maintenance work – are cyclically recurrent.

3. Traditional contracting and long-term co-operation

Traditionally technical specifications are formulated by the housing association, being the basis of the multi-tendering process. The housing association supervises the maintenance work in detail. A final acceptance control also involves an examination of performance directly related to the quality of the workmanship. Measurement of client satisfaction might be done by the housing association.

In a long-term performance-based cooperation form the housing association and the maintenance contractor jointly specify decisive performance requirements for several housing complexes (housing blocks), concluded in a framework agreement [6]. The contract duration is a maintenance scenario covering several maintenance intervals, eventually lasting the expected exploitation period of a housing complex.

The contractor works out the desired performances, fitting them into the actual technical state of the housing complex and the expected service life. The technical solutions are laid down in maintenance scenarios and activity plans. A maintenance scenario covers several intervals of returning maintenance interventions, for example paintwork. The best maintenance scenario is chosen, based upon net present values and total costs of ownership. The scenario and the performance criteria are laid down in a performance agreement. In a performance-based partnership form the primary purpose of control and supervision by the housing association is to review the performance achievements and to identify problems with the necessary action. The contractors themselves monitor the degradation processes of building components by performing performance measurements. In case of fabric maintenance and paintwork this may for example concern the cracking of substrates and the degree of blistering of paints. They also monitor the process and especially the customers satisfaction during maintenance interventions and thereafter. They keep responsibilities for laid down performances and client satisfaction during the contract period. Performance control by independent third parties, may take the form of a random check rather than a full inspection of all performance criteria. During the contract period the maintenance scenario might be adapted. The housing association's objectives are likely to change over time, just as external circumstances may change.

Flow charts are presented to depict the process steps that have to be taken by housing associations and maintenance contractors when pursuing performance-based co-operation. Figure 1 gives a picture of the traditional procurement process model, used as a reference model. Figure 2 gives a picture of performance-based cooperation for maintenance.

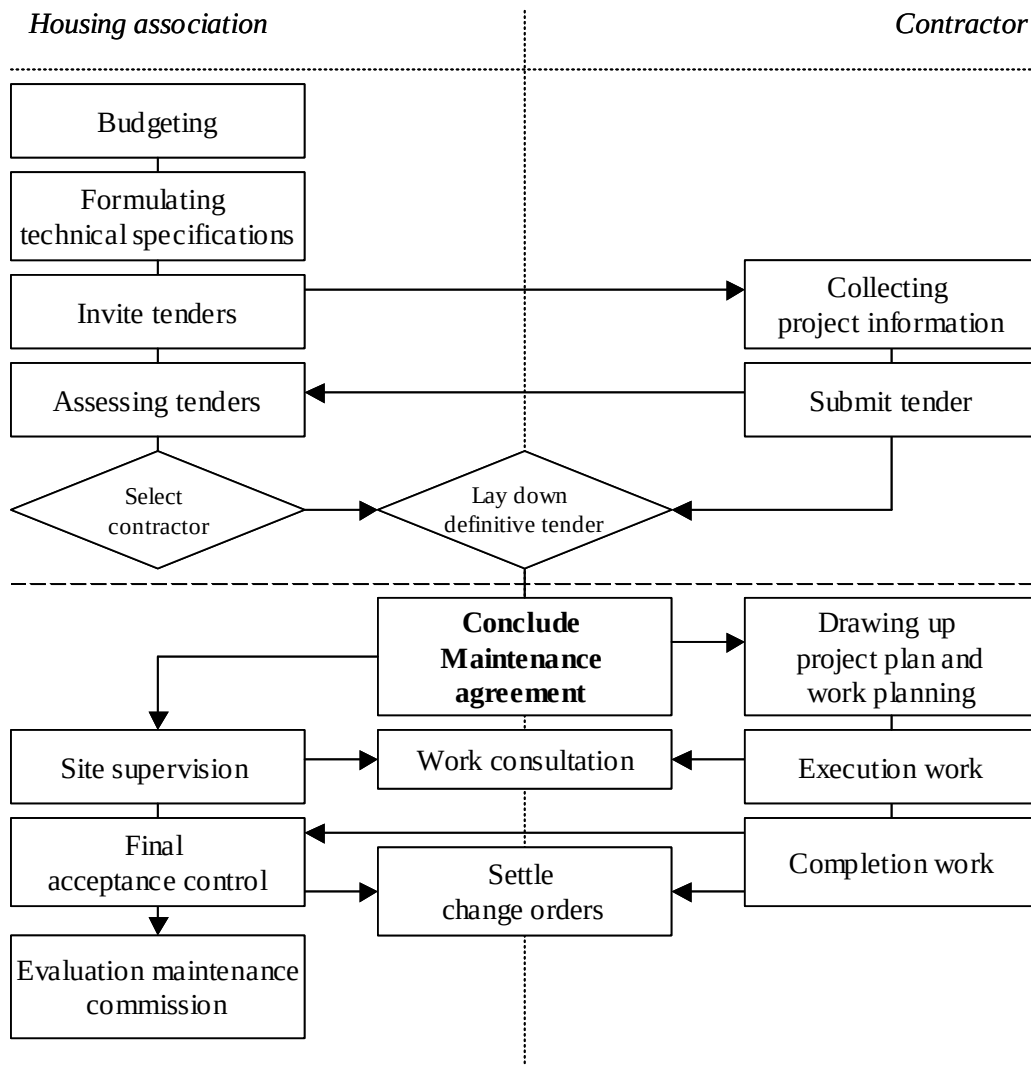


Figure 1 Process model traditional approach

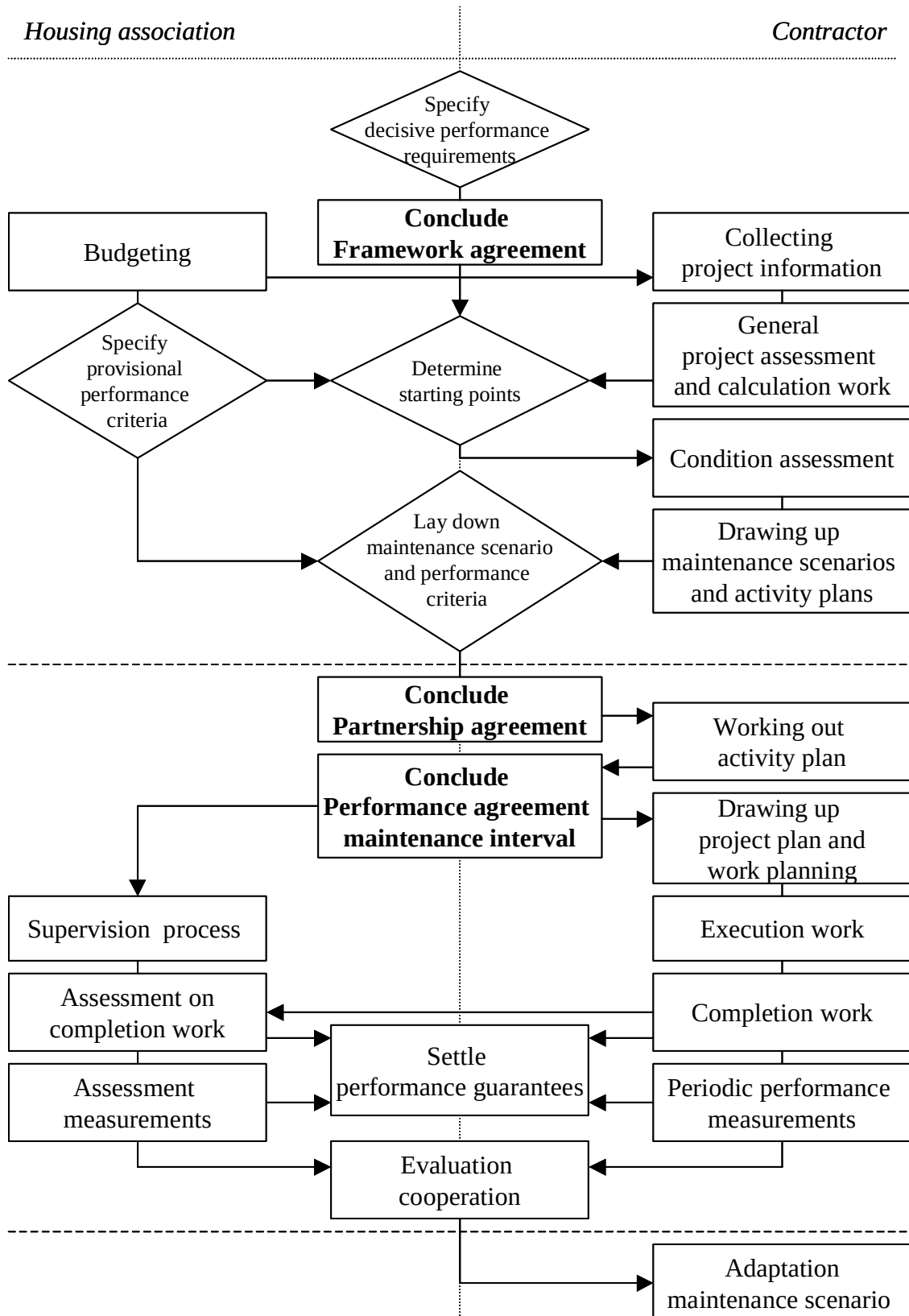


Figure 2: Long-term performance-based cooperation

4. Indirect costs model

Direct project costs represent the expenditure incurred during the actual performance of (long-term) maintenance activities. The indirect project costs are all costs in connection with the organization and performance of the maintenance activities, but which cannot be expressed as direct project costs. In other words, these are the process costs incurred by both client and contractor. Third parties, such as consultants or inspection agencies, may perform some activities, the costs involved being charged to the client and/or contractor. For the client, the overall maintenance costs consist of the direct and indirect project costs for the (long-term) performance of maintenance activities, together with the project-related costs of the services of consultants or inspection agencies, where these are not included in the direct or indirect costs.

Table 1: Schedule of activities calculation model indirect costs, initial process

	Traditional		Performance-based	
	Client	Contractor	Client	Contractor
Specification, Selection and Contracting				
Budgeting				
Formulating technical specifications				
Formulating performance criteria				
Invite tenders contractors				
Collecting and collating project information				
Condition assessment				
Reporting condition assessment				
Collecting external advice				
Consultation				
Drawing up maintenance scenarios				
Invite tenders subcontractors				
Assessment bids subcontractors				
Calculation maintenance scenario				
Formulating bid				
Assessment bids contractors				
Cancel contractors				
Consultation				
Assign work				
Confirm work				
Work and Supervision				
Drawing up project plan and work planning				
Reporting work				
Work consultation				
Site supervision				
Supervision process				
Consultation and information tenants				
Supervision process				
Final acceptance control				
Reporting completion work				
Settle change orders				
Evaluation and After-care				
Evaluation process				
Assessment customer satisfaction				
Performance measurement				
Reporting performance measurements				
Consultation performance measurement				
Settle performance guaranties				
Subsequent calculation				

In practice, it has proven somewhat difficult to identify the indirect costs involved in the traditional and performance-based working methods according to the above definitions. This is because these costs are generally incorporated in the bid price, perhaps by means of underlying unit prices. This applies not only to the process costs previously mentioned, but also the indirect costs for secretarial support, purchasing of material, taking stock, etc. In fact, these non-process-related indirect costs will be approximately the same for both the traditional and performance-based working approach. For pragmatic reasons, it was therefore decided to base the direct costs on the tender price of each method. The bid price is therefore assumed to include all project-related indirect costs. In addition, a separate comparison of the indirect process costs for each method was made.

4.1 Calculation models

Calculation models were produced to render the direct and indirect project costs visible. The calculation model for the direct costs enables the direct long-term maintenance costs at project level to be determined on the basis of both the traditional and the performance-based approach.

The indirect project costs will depend on the process activities that must be conducted by the client and contractor respectively throughout the maintenance period of the complex. The initial process and the subsequent processes consist of all activities conducted during a maintenance interval. Following the initial process, one or more subsequent processes will take place. It is assumed that these subsequent processes will be equal in scope and cost, although the actual maintenance activities undertaken in each can of course vary.

The activities in the initial and subsequent processes can be clustered into three phases (see Table 1):

- Specification, selection and contracting;
- Work and supervision;
- Evaluation and after-care.

The indirect cost model is based on a differentiation in hourly charges per activity, with the level of charges depending on the various wage scale groups applied by both client and contractor. The model assumes that each party will have three such groups.

In calculating the net present value of both direct and indirect project costs, the study took into account both the annual price rises due to inflation and the relevant depreciation factor.

5. Anticipated cost reductions

5.1 Direct cost reductions

The direct cost savings offered by long-term performance-based maintenance cooperation can be realized by:

- planning the maintenance activities according to the existing level of quality, the desired performance level and the service life of a housing complex, taking performance degradation into account;
- conducting maintenance activities on a 'just-in-time' or 'condition-based' basis, according to the agreed performance level ;
- ensuring better coordination between work to the substrates and to the finishing (e.g. undercoats and final painting).

A performance-based cooperation form offers a better guarantee of actually achieving the advantages of condition-based maintenance than the traditional approach, since it is the contractor who conducts the performance measurements and who also bears the risks relating to the timely performance of maintenance activities. The deterioration can be predicted more accurately, and hence the controllability of costs is enhanced. In the initial process, a thorough analysis of the causes of defects will be conducted. During the maintenance period, the performance level will be monitored by means of performance measurements. Based on these measurements, the maintenance activities will be carried out 'just-in-time'.

The performance-based method offers the contractor greater opportunities to coordinate the maintenance activities to the requirements of the client during the duration of the maintenance period, and to coordinate maintenance activities with each other. This is the result of the contractor's long-term involvement in, and responsibility – including financial responsibility – for the maintenance project under the performance-based partnering agreement. The fact that the same contractor is responsible for both the paintwork and maintenance work to the substrates is also important. The contractor will select the solution offering the lowest costs over the entire service life. In the traditional approach, this service-life cost approach is more difficult [4]. It may therefore be assumed that the performance-based method will encourage the use of more sustainable materials.

The direct costs can be reduced not only in terms of savings on manpower and materials, but also – and especially – in terms of incidental costs such as the hire of scaffolding and site costs. Scaffolding hire now represents a growing proportion of the total direct project costs. Longer maintenance cycles enable this type of expenditure to be reduced significantly.

5.2 Indirect cost reductions

Indirect cost reductions can be realized because the long-term performance-based approach enables maintenance contractors to assume responsibility for certain activities which they are better equipped to perform than their clients. In the traditional approach, many activities are duplicated, i.e. conducted by both client and contractor, because information is lost following the once-only tendering process. In the performance-based approach, clear agreements are made with regard to which party is responsible for which activity during the cooperation period.

Process improvements and indirect cost reductions will become particularly apparent following an initial period, once both parties have gained some experience with the new method. The costs of collecting project information, consultation, inventories, inspections and the production of alternative maintenance scenarios are likely to be high. Due to the continuity of the performance-based partnering agreement, however, maintenance contractors can improve their internal

business processes, with more efficient logistical deployment of manpower and equipment, and more efficient purchasing of materials.

6. Direct and indirect cost savings projects

6.1 Comparison of indirect costs

Table 2 shows the differences in indirect and direct costs of the projects between the performance-based approach and the traditional approach in percentages. In every project, the total indirect costs are lower in the performance-based approach than in the traditional working method (18-72%). However, the costs of the initial processes in half of the projects are higher in the performance-based approach than in the traditional approach. Further analysis reveals that the each of the subsequent part-phases within the initial process will vary, and may be more expensive or less expensive. Only the 'Evaluation and After-care' phase is more expensive in every project when using the performance-based approach.

The fact that the indirect costs of the performance-based approach are lower overall than those of the traditional approach is entirely due to the reduction achieved in the subsequent phases, being in excess of 26%. The phases 'Specification, Selection and Contracting' and 'Work and Supervision' become markedly less expensive. The 'Evaluation and After-care' phase is markedly more expensive in every case when the performance-based approach is adopted.

It may be seen that the performance-based approach will offer the lowest indirect costs to the client. It offers not only a financial advantage in the subsequent processes, but in the initial process too. The indirect costs to the contractor are also lower in the performance-based approach than in the traditional working method, although the savings are somewhat more modest than those enjoyed by the client. The initial process is more expensive within the performance-based approach. That this method is nevertheless less expensive overall for the contractor is due to the cost reductions in the subsequent processes. The situation in complex cases is almost similar to that in the simple cases.

6.2 Comparison of direct costs

In all cases, the direct costs of the performance-based approach are lower, or at worst the same, as in the traditional approach. However, it should be noted that the maintenance scenarios used were based on several assumptions. Clients and contractors believe that the maintenance intervals could be extended if working with the performance-based system, from six to seven years, for example. Accordingly, in a maintenance scenario of thirty years, there would be only four maintenance intervals rather than the current five. This view is based on experiences with performance-based partnering and the results of performance measurements. The performance of adequate preventative maintenance would also obviate the need for building components to be replaced. This potentially large financial advantage was incorporated into only a few of the case studies.

In a traditional multiple, competitive tendering process a lower price may be the outcome compared to price, based upon agreed unit prices in performance-based partnering. This is especially the case in very competitive markets, like the Dutch maintenance market at present.

However, on the long term and under changing market circumstances, clients and contractors believe that this will have no effect.

Cost savings of indirect costs may be unimportant compared to the direct costs. Our findings prove not. The indirect costs are in the proportion of 12 to 25% in the traditional approach and 4 to 20% in the performance-based approach. We think that proportion is very significant.

Table 2: Cost savings performance-based approach compared to the traditional approach

Project		Dwellings	Indirect costs									Direct costs
			Client			Contractor			Total			
			Ini	Seq	Tot	Ini	Seq	Tot	Ini	Seq	Tot	
Koekoekstraat	S	28	-21	-65	-60	+33	-55	-44	+ 4	-60	-53	-25
Vrijmoedhof	S	92	-16	-37	-32	+27	-17	- 7	+ 5	-26	-19	0
Guldenslag	S	111	+17	-56	-36	+32	-48	-27	+26	-51	-30	-10
Platte Daken	S	178	-61	-64	-63	+13	-20	-12	-28	-44	-40	0
Geroflat	S	360	-40	-56	-52	+18	-13	- 6	-15	-38	-32	-19
Lelie	S	68	-22	-72	-62	+30	-27	-15	+ 4	-49	-38	-14
Eksterstraat	C	103	-46	-72	-65	+18	-49	-28	- 7	-59	-44	-13
Celebesstraat	C	28	-24	-47	-36	-25	-29	-27	-24	-27	-31	- 8
Eekhoornweide	C	45	-33	-40	-37	+18	-23	+ 2	- 5	-33	-18	- 9
Molenhoek	C	27	-41	-92	-82	+24	-92	-70	+11	-92	-72	- 5

S = simple project, C= complex project. Ini = initial process, Seq = Subsequent process.

7. Business operations

The performance-based partnering approach has consequences for all aspects of business operations, organizational structure, organizational culture, the necessary knowledge and expertise, information flows, and the availability and use of methods and instruments on the part of both client and contractor. The costs and returns of these factors are difficult to quantify.

7.1 Client's business operations

The client's initial selection of contractors is likely to cost more time in the performance-based approach than in the traditional method. The selection will not be for each individual project, but the client will divide the projects among a number of pre-selected contractors. Standard activities and unit prices can be agreed between the client and the selected contractors, to be established by means of a framework contract (which will also cover other project-related matters).

Prior to the initial phase of the first project (or projects) the client and contractors will be required to devote considerable time to seeking out the most appropriate partnership form(s), agreeing unit prices and normative performance indicators, and drawing up the relevant framework contracts. However, these activities are also part of the traditional working method, albeit under different names. Like selection, the evaluation of contractors and the assessment of customer satisfaction will also take place outside the confines of individual projects, although project-related aspects will also be taken into account in the evaluation.

7.2 Contractor's business operations

Within the performance-based approach, the contractor acts as a consultant to the client. This entails new activities, such as providing advice on maintenance strategies, the production of maintenance scenarios, performance measurement and conducting customer satisfaction surveys. These activities demand a different type of knowledge and expertise on the part of the contractor. The maintenance contractors must be able to achieve a sufficient level of turnover under performance-based partnering agreements in order to be able to perform these 'advisory tasks' in a satisfactory manner.

Within the performance-based partnering approach, new projects will often require the client to conduct a single-phase tendering procedure. This greatly increases the likelihood of the offer being accepted, compared to the competitive tender procedure common in the traditional approach. This enhanced likelihood of acceptance represents a marked reduction in operating costs for the contractor. Moreover, because maintenance activities are assigned to the contractor for a long period (covering a number of maintenance intervals), it is no longer necessary to re-bid for each period. This continuity will result in lower indirect project-related costs throughout the subsequent process.

8. Conclusions

Long-term, performance-based partnering offers many advantages compared to the traditional tendering approach. One of the main benefits is that long-term performance-based cooperation reduces both direct and indirect costs. The essential preconditions are long-term involvement and freedom in the maintenance design and process, giving opportunities for product and maintenance process improvements and innovations.

Our research findings show that indirect costs are lower in a performance-based approach than in a traditional working method. The fact that the indirect costs of the performance-based approach are lower overall than those of the traditional approach is entirely due to the reduction achieved in the subsequent phases. The performance-based approach offers the lowest indirect costs to the client. It offers not only a financial advantage in the subsequent processes, but in the initial process too. The indirect costs to the contractor are also lower in the performance-based approach than in the traditional working method, although the savings are somewhat more modest than those enjoyed by the client.

A long-term performance-based cooperation form offers a better guarantee of actually achieving higher performance and lower direct costs. In practise maintenance intervals are extended if working with the performance-based system, from six to seven years.

Most benefits of a performance-based partnering approach are not easy to quantify. For contractors a performance-based approach meaning a single-phase tendering procedure offers great benefits. An enhanced likelihood of acceptance represents a marked reduction in operating costs for the contractor.

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Construction Risk Identification

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Abstract

The management of risks in projects is a growing area of concern in the construction industry. Both the identification and analysis phases of the risk management process are considered the most important, for they can have a big impact on the accuracy of the risk assessment exercise. Currently it is assumed that construction project managers rely largely on experience to identify projects risks. These decisions, influenced by individual perception and attitudes, are made primarily under conditions of uncertainty. How individuals respond to risky or uncertain situations therefore requires an understanding of how individuals intuitively assess the situation they perceive, before expressing a response. The ProRIde project interviewed fifty-one construction project managers using Active Information Search (AIS) as a data collection method and cognitive mapping as a data-capturing tool. Our results suggest that the role of experience in the risk identification process is much less significant than is commonly assumed to be. By contrast, level of education and style of enquiry do play a significant role in risk identification performance. These findings suggest the potential for a more thorough approach to risk identification.

Keywords: project risk management, risk identification, active information search and cognitive mapping.

1. Introduction

Risk management has become an important area of interest in the field of construction project management over the past decade. Interest in the management of risk has increased as competition between firms, and as the size and complexity of project has grown. This has led to the development of best practice standards, tools and techniques. Both the risk identification and risk analysis phases of the risk management process (RMP) are generally considered the most important as these can have the biggest impact on the precision of the risk assessment [1-3]. While the analysis process and its tools and techniques are well developed, such analysis is dependent on risk being accurately identified in the first instance. However, compared with the analysis phase, the process of risk identification is poorly understood and the tools and techniques are less developed. The aim of the ProRIde research funded by the UK Engineering and Physical Sciences Research Council (award GR/N51452/01) is to provide a better understanding of the project risk identification process. Thus we focus our research on the ways in which construction project managers identify risks; our aim is to provide the basis for a more rigorous approach to the identification phase of project risk management.

2. Project Risk Management: An Overview

Interest in project risk management has increased as the size and complexity of projects has grown and as competition between businesses intensifies. The rapidly changing context and its influence on the way projects develop has made the RMP an ever more important challenge. Numerous best practice standards such as *A Guide to the Project Management Body of Knowledge* (PMBOK® Guide)[4], *Project Risk Analysis and Management Guide* (PRAM) [5], *RAMP: Risk Analysis and Management for Projects* guide [6] and the British Standards Institution guides [7; 8], as well as specialist tools and techniques have been developed focussing on a more effective RMP. These standards share a basic conception of the RMP (Figure 1). This generic model consists of four basic sub-processes located in the context of clearly defined project objectives, which are iteratively looped through the project lifecycle: identify and classify the risks, analyse the risks, respond to the risks and monitor the risks. There is also a growing body of research on the process as a whole, with increasing advocacy of risk management maturity models [9].

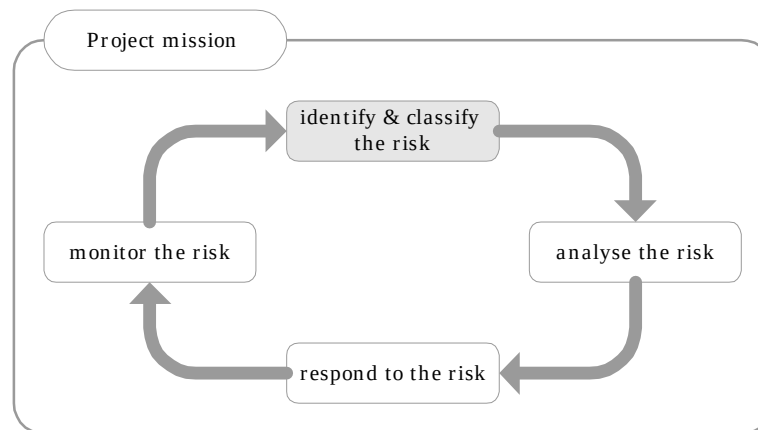


Figure 1: A generic model of the risk management sub-processes [10]

The identification phase, where the question of what might happen is addressed, has been the subject of much less research compared with the analysis phase. The most recent exceptions include research on the effectiveness of risk identification tools at group level [1] and the influences on risk identification and assessment in construction design management [11]. However, risk identification remains a poorly understood process and its tools and techniques are less developed compared to those used in the risk analysis phase [12; 13]. The focus of the literature is on the tools and techniques used for assisting in risk identification, such as risk registers, risk breakdown structures (RBS) and brainstorming. The widely used risk register is a list of all the risks that have been previously identified; its development is typically ad-hoc. For this to be of practical use, the register has to be filtered for a particular project under scrutiny and the results prioritised. However, it is not clear how this is done and how reliable the results are [14]. There appears to be a complete lack of connection with the literature on knowledge management as a tool for capturing organisational learning from projects [15]. Gaining such understanding requires the systematic analysis of data for a large number of projects, but such data sets are difficult to acquire – Dalton [16] reports on one attempt to fill this gap. RBS provide a hierarchical structure of potential risk sources [17] from which a list of risks can be drawn through

a brainstorming session. Brainstorming [18] is project specific and requires a group of experienced practitioners to creatively consider possible risk sources. The list is then more analytically considered and key risks identified. The difficulties with brainstorming include the selection of the appropriate experts and their number, bringing these experts together frequently enough to be of use to a dynamic project lifecycle, and the avoidance of “groupthink” dynamics.

In construction projects there are some standard risk areas that need to be considered and assessed, but each new project also brings specific project related risks, which need to be identified. The difficulty is the lack of accurate systems for identifying risks in a construction project. The studies that have been carried out over the past decade on the use of risk management practices in construction and other industries [1; 2; 19-23] indicate that over this time: checklists, brainstorming and interview sessions have been the most commonly used risk identification tools; other techniques are rarely used due to lack of knowledge and doubts about their applicability in the construction industry; there is limited progress on the wider application of tools and techniques; there is concern that in practice the distinction between the risk management process phases is blurred and existing tools are not sufficient. Research currently assumes that the construction industry relies heavily on historical data and the judgement of key actors involved in the project to identify risks. For instance, Chapman [11], and Al-Tabtabai and Diekmann [24] state that the identification of risks relies on the individual judgement and insight of the various actors involved in a project, which is dependent on their knowledge, professional training, role, level of responsibility and length of exposure to the construction industry. The premise of both research and practice in project risk management is that experience is *the* key to risk identification.

3. ProRide: the Method

Project risk identification is part of the more general problem of judgement under uncertainty [25]. To address this problem in a project context, we draw upon a critique of the predominant perspectives in this area –*Expected Utility Theory* [26]. Here the decision-maker rationally evaluates the probabilities against a final asset position before choosing a course of action. However, this theory has been criticised for its assumption that rationality is possible under such conditions, because evidence has been found that decision-makers use flawed heuristics in decision-making, which are subject to systematic biases [27; 28]. Within this perspective, Kahneman and Tversky [29] proposed their *prospect theory*, a system in which decision-makers assign values to gains and losses rather than to final assets and to decision weights rather than to probabilities. This produces the distinctive s-curve value function of the theory. While there have been important debates within the heuristics and biases literature [30], this probabilistic approach to decision-making has been widely accepted. However, the heuristic and biases critique of expected utility theory has been criticised on methodological grounds due to the artificial nature of the decision problems [31]. In essence, decision-makers are presented with well-defined problems with all required probability distributions available. In practice, an active information search is required by decision-makers to tease out the nature of the problem situation and assign the appropriate decision weights to the data. This naturalistic approach is much closer to the sort of situation facing project risk decision-makers than those of perfect

information envisaged by expected utility theory and bounded rationality envisioned by prospect theory. The research methodology used in this research is based on active information search (AIS).

AIS was developed to study judgement and decision-making in naturalistic tasks. These are ill structured problems of information rich domains, where causal relations and attributions and the decision-makers' control belief are relevant [31]. At its core AIS is a process tracing technique of information search and collection, carried out in the context of an interview where the interviewee is presented with a scenario of a problem. After the review of the scenario the interviewee asks the facilitator questions in order to obtain information. These questions are recorded and answers are provided in printed form. Huber's model of how individuals reach a decision in a naturalistic situation assumes that the decision maker constructs a simple mental representation of the situation and alternatives, which can change in the course of the decision process. This research utilises the developments in these techniques proposed by Ranyard et al. [32] and Williamson and Ranyard [33; 34].

These developments do not, however fully address the issue of the recording of the cognitive processes revealed by the AIS technique. For this reason, we turned to cognitive mapping as a data recording and analysis method. Cognitive mapping [35] is an interactive decision support tool used to analyse the complex or messy processes through which decisions emerge. A cognitive map is a graphical model that structures the way and individual makes sense of their experiences. The map is represented by concepts (distinct phrases) and links between concepts, thus creating a system of concepts that communicate the nature of a problem. Although cognitive mapping has already been used in the project risk management area [36] [37], its application to the problem of project risk identification and its combination with an active information search methodology is novel.

The ProRIde AIS interview procedure [38] lasted between one and a half and two hours and was structured in three stages: 1) introduction and warm-up; 2) AIS/scenario exercise; 3) summary. The introduction informed the interviewee of the aim of the project, the structure of the interview process and what was expected of the interviewee. The aim was to clarify the exercise to the interviewee, but at the same time information was kept to a minimum so as not to influence the outcome of the AIS exercise. The warm-up exercise aimed to clarify the dynamics of the main exercise (AIS), such as thinking aloud and using questions and answers. The aim of the summary was to obtain a retrospective view of the risks identified.

The aim of the AIS exercise was to produce a response from the practicing managers that would match, as much as possible, their natural behaviour. The scenario, based on a real construction project, was developed by the research team in collaboration with the project manager of the real project. The scenario described a building project under a Design and Build contract that was currently in progress; participants were given limited information about its location, team, cost, client and project status with a focus on schedule and budget risks. The limited information meant that the potential of the scenario to shape the interviewees' responses was kept to a minimum and would compel the interviewee to request additional information from the facilitator. This process needed to occur in order for the AIS method to work. Each interviewee

was asked to assume that they were part of the project team and that they had to take over the project at short notice. Each interviewee then went through the AIS process described above with the aim of identifying the main risks in the project.

4. ProRide : Initial data analysis

Potential interviewees were initially identified by our four collaborating UK construction firms. These firms comprised: two large international construction firms, one large UK national construction firm, and one medium-sized London-based construction firm. The criteria for the selection of interviewees included individuals with a minimum of two years experience in a construction management position and who could potentially take over a project at short notice. As the interviews progressed, the four firms provided our research team with a list of twelve-to-twenty potential participants. To select the interviewees, our research team used a judgment sampling based on professional role. We interviewed fifty-one (4 female, 47 male) practicing construction project managers from the four collaborating firms. The first five interviews constituted a face validity exercise for both the risk propensity questionnaire and AIS approach. Two interviews could not be conducted properly due to time constraints; we have excluded this data from the analysis. We used for this analysis the data from 45 of our interviews. Although our sample is not random, we believe that it is reasonable to suggest that our findings offer fairly typical results for middle-level managers in the UK construction industry. We have no reason to believe that it is systematically biased in any particular way; we believe that the results can be generalized to other project managers on asset acquisition projects.

4.1 Active Information Search Analysis

Both the scenario and summary stages were tape-recorded; from this, transcripts were generated. The verbal reports (sequential transcripts) contain data on the lines of reasoning and type of information searched for and used during the scenario exercise. Due to the volume of data gathered (15-20 pages per transcript) we recognized that we needed to do more than analyse the content. Therefore, we used Decision ExplorerTM (cognitive mapping software) to graphically represent the AIS data. This type of graphical representation can still be considered a cognitive map because it represents “*people in relation to their information environment*” [39]. For the purpose of clarity, we will refer to these as *information search maps*.

Our maps were built by transcribing the information directly into Decision ExplorerTM. Starting at the beginning of the tape, we entered sequentially numbered concepts (distinct phrases) into Decision Explorer and linked these to represent a chronological relation (concepts following in time). A concept could be a question or statement from the interviewee or an answer from the facilitator. The sequence of concepts and links was broken when a new question was asked about a new or different theme; the new concept then marked the start of a new line of inquiry and reasoning. During this stage, we developed a coding framework for three distinct variables: concept variable, process variable and outcome variable. The concept variable was coded as answers (facilitator’s input), questions and statements. The process variable indicates the approach taken to search and collect information; this could be in a *linear* or *feedback* mode. A

linear style approach was evident when the interviewees asked a series of single independent questions without follow-up. A feedback-style approach was evident when the interviewees asked a series of related questions in an investigative manner. The outcome variable is the risks identified by the interviewees. To improve coding reliability, two coders independently examined the information search maps. The comparison between coded maps indicated a high percentage of agreement (.99) between the two coders.

Each coded map contained between 200 and 600 concepts. To help manage the data, we used the Decision ExplorerTM cluster analysis option, in which individual information search maps were segmented into groups of concepts (called clusters). Concepts were grouped based on the strength of linkage. Each cluster describes the sequence and style of information search an interviewee went through during a particular theme of the scenario. In this sense, each cluster describes a specific theme; and each is given a title to capture its contents.

In order for the *information search maps* to be compared, it was necessary to summarise them further. Therefore, a *summary information search map* was created for each interviewee using VISIOTM. These summary maps contain data about the information that was sought (cluster titles), the sequence of the information search (arrows), the number of questions asked per theme (cluster size and number in parenthesis), the style of information search used (feedback, linear), the approaches used (assessment, self orientation, further action), the risks identified, and feedback loops (dashed links). Figure 2 provides an example of an individual summary information search map.

To read the summary information search map start at the bottom left side and work your way through by following the arrows. We can see that this interviewee searched for information related to the schedule and sectional handover in the first instance (cluster 1). This information was sought using a feedback style approach (arrowed circles), where 3 questions were asked (number in parenthesis). A feedback style was the main style of information search used (more than 50% of clusters are feedback); this led to the identification of three risks (coded as b,c,d). A linear style approach was used to cover permit aspects and one risk (coded as a) was identified through this approach. By reading the cluster titles we can see that the scope of information search was limited to very particular aspects of the project, such as things on the ground and design. Self-orientation was a common strategy used to navigate through the information acquired during the task (clusters 7,15,16,17,18,19,21). In total four risks were identified with limited scope and impact.

The project manager who managed the real-life construction project on which the scenario was based is a member of the research team. We were able, therefore, to benefit from his detailed knowledge of the scenario's background to assess the potential impact that each of the risks identified by the interviewees would have on the scenario project. In other words, we benefited from hindsight knowledge in establishing the potential impact of each risk event identified by the interviewees. This procedure allowed a risk identification performance (RIP) measure to be developed. All identified risks were entered into a matrix and rated individually on a 1 (very low) to 5 (very high) impact scale. The rated matrix was independently reviewed for

consistency. The total number of risks identified by each interviewee weighted by their potential impact gave us the RIP measure for each interviewee. It is important to note that the RIP measure is not an indication of absolute level of performance, but a relative measure, constrained by our choice of scenario. Due to the use of hindsight, it was not believed to be appropriate to allocate a probability of each risk event occurring to complement the impact. The RIP forms our dependent variable in the subsequent quantitative analysis of the information search maps.

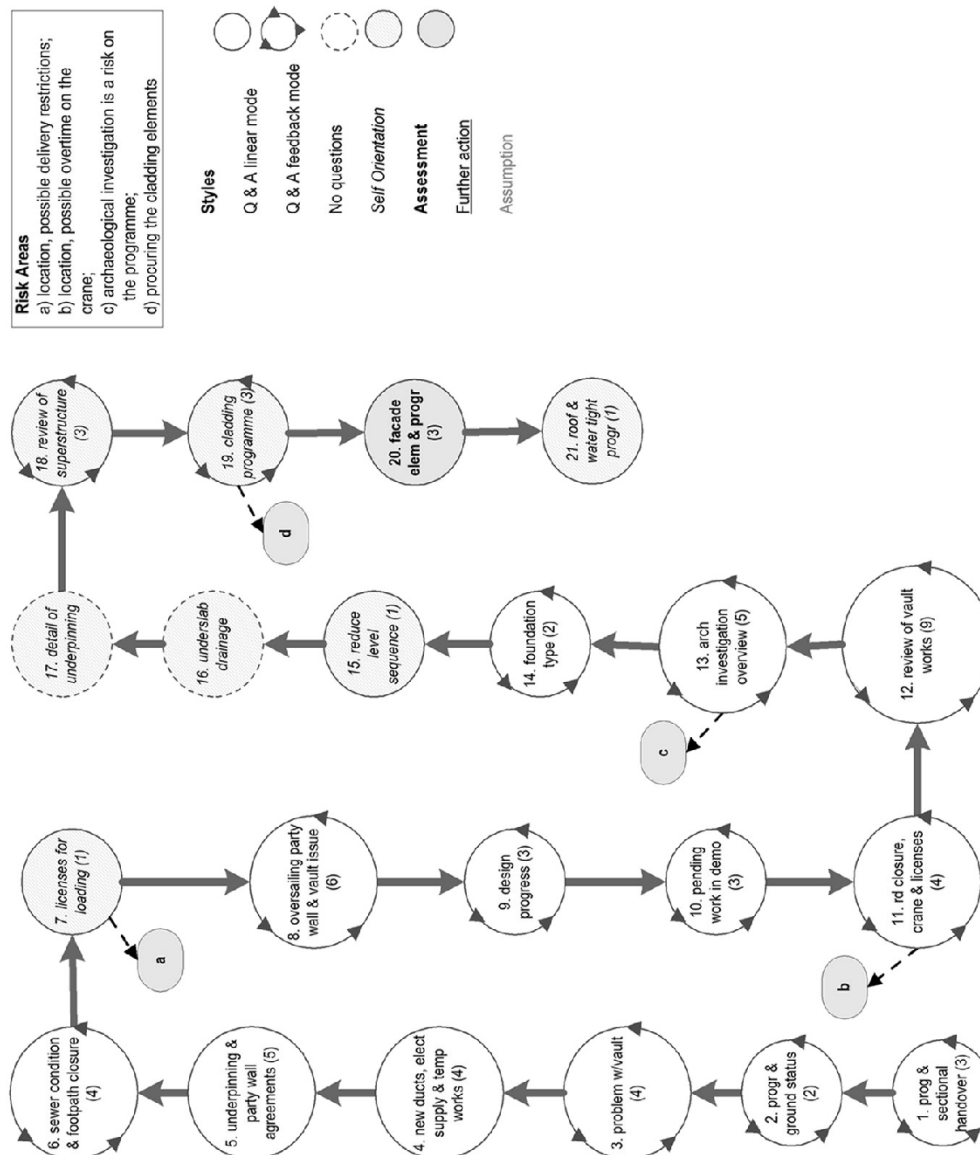


Figure 2: Summary Information Search Map : Feedback style

5. Quantitative results

The individual summary maps provide an overview of the individual risk identification process. These provide data on the information that was sought, the sequence of the information search, and the strategy used for the information search; these also detail which decisions were based on prior experience or training and which were based on information collected during the exercise.

When combined with the results from the risk propensity questionnaire, these provide the data set for the first phase of our research. In this analysis, simple frequency counts and statistical tests are used to explore the patterns in the data set. This quantitative analysis will be complemented by a qualitative analysis of the maps at a later date.

*Table 1: RIP and Demographic Factors (n = 45 * significant at 5% level in all tables)*

Independent Variable	t- test	Spearman's Rho	Pearson r, Point-biserial r_{pb}, Biserial r_b
Years in management role			r = -.186
Years in current job title			r = -.198
Age			r = -.160
Risk management training	t = 1.157	$\rho = -.212$	$r_{pb} = -.174$
Role	t = -.819		$r_b = .166$
Education	t = -2.211 *	$\rho = .291 *$	$r_{pb} = .320 *$

The risk propensity questionnaire contained a number of standard demographic variables measuring age, experience, education background and level of risk management training which allow us to test these assertions. In our analysis, we treated RIP as the dependent variable and the demographic factors seriatim as the independent variable with a null hypothesis that there is no association between the two. Our review of the data determined the choice of statistical test; the results are summarised in Table 1. As can be seen, we cannot reject the null hypothesis at the 5% level except for the education coded as whether the interviewee was a graduate or not. Experience measured by years in current job title, years in a management role, and age are not significantly associated. Similarly, whether the interviewee has had risk management training or whether his or her role is commercial or production orientated displays no significant association with risk identification performance.

We then took the RIP measure as the dependent variable and style of information search (feedback or linear) as the independent variable with a null hypothesis that there is no association between the two. The results are summarised in table 2. As can be seen we can reject the hypothesis at 5% level for style ratio (ratio of linear/feedback clusters), linear clusters (negatively associated) and feedback cluster (positively associated). This suggests that, as more feedback style of information search was used the higher the RIP score obtained and the inverse for a linear style.

Having identified information search style as significant, we took information search style (feedback and linear) as the dependent variable and experience as the independent variable with a null hypothesis that there is no association. The results are summarised in tables 3 and 4. As can be seen, we cannot reject the null hypothesis at 5% level. This suggests that feedback and linear

styles of information search are not significantly associated with experience, measured in number of years in a management role, years in current job title and age.

Next, we took the styles of information search (feedback and linear) and style ratio as the dependent variable and educational attainment (graduate and non-graduate) as the independent variable with a null hypothesis that there is no association. As can be seen in table 5, we cannot reject the null hypothesis at 5% level except for style ratio correlated with educational attainment. Box plots show that style ratio and education were related with more non-graduates tending to have a higher style ratio (more linear style). This suggests that higher educational attainment encourages the use of a feedback style of enquiry in risk identification.

Table 2: RIP and Process Variable

Independent Variable	Pearson <i>r</i>
Style ratio	$r = -.313 *$
Linear clusters	$r = -.274 *$
Feedback clusters	$r = .310 *$

Table 3: Feedback style and experience

Independent Variable	Spearman's <i>Rho</i>	Pearson <i>r</i>
Years in management role	$\rho = -.042$	$r = -.049$
Years in job title	$\rho = .032$	$r = -.002$
Age	$\rho = -.040$	$r = -.027$

Table 4: Linear style and experience

Independent Variable	Spearman's <i>Rho</i>	Pearson <i>r</i>
Years in management role	$\rho = -.241$	$r = -.232$
Years in job title	$\rho = -.099$	$r = -.076$
Age	$\rho = -.099$	$r = -.114$

Table 5: Information search styles and education

Dependent Variable	Point-biserial correlation	<i>t</i>-test
Style ratio	$r_{pb} = -.268 *$	$t = 1.1794 *$
Feedback cluster	$r_{pb} = .052$	$t = -.344$
Linear cluster	$r_{pb} = -.117$	$t = .775$

From these data, therefore, we can conclude that there is a significant difference in project RIP between those educated at graduate and non-graduate level; and an association between the style of information search (feedback and linear) and RIP. This finding is both counter-intuitive and interesting. It is counter-intuitive, because it suggests that experience plays no role in project risk identification performance. It is interesting because it suggests that education and training

can improve project risk identification performance - years of experience is not subject to managerial intervention to improve performance, but it is possible to train staff. However, the lack of correlation with whether the interviewee had experienced risk management training suggests that existing training programs are not all that they might be. In addition, we find that the process style in which information is gathered also contributes to the RIP. In this case, a feedback style, that is, an iterative investigative approach to information gathering contributes to a better RIP. Again, this suggests the potential for staff training.

6. Conclusions

This paper describes a method for studying how project managers in the construction sector go about identifying risks. The review of the risk management literature showed that the risk identification phase of the risk management process, although one of the most important is poorly understood and that the tools and techniques available are less developed than the ones used in the analysis phase. The review also highlighted the construction industry's concerns about the lack of formal methods to identify risks, as well as their lack of knowledge and doubts about the suitability of the ones available. Understanding how project managers identify risks, that is, the means by which they use their knowledge, expertise, and training, places the inquiry in the area of judgement under uncertainty. The review of the development and critiques of key decision-making theories pointed towards the importance of the use of active information search for teasing out the nature of a problem situation. As a result, the methodology used to study the risk identification process is a conversation-based Active Information Search in combination with cognitive mapping.

Both feedback style and educational background have been highlighted as significant. In sum, the results show that interviewees with a high use of feedback style of information search performed better at identifying high impact risks. Or to put the point the other way round – experience appears to contribute little to effective project risk identification. More detailed analysis of the results suggests that more experienced project managers are more likely to rely upon what might be described as a “checklist mentality”, rather than addressing themselves to the details of the particular project they are being asked to manage.

This paper has provided some insights and better understanding into the way that construction project managers identify risk. The method has allowed us to capture the initial thoughts and process. The findings suggest that the preconceptions about the importance of experience of actors in the initial phase of risk identification may well be misguided. We are presently building on these results to do a more qualitative analysis of the ways in which individuals identify project risks, and are also starting to explore the group dynamics of project risk identification.

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Leveraging Shared Knowledge to Achieve Sustainable Competitive Advantage within Construction Alliances

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Abstract

Alliances within construction have increased significantly in number and in the volume of activity that they have undertaken in recent years. Although writers in the field highlight benefits of developing knowledge sharing as a core capability to create and maintain sustained collaboration and sustainable competitive advantage, a majority of the alliances engage in short-term orientated work processes targeting short-term commercial advantages. This paper contextualises this phenomenon within construction alliances and investigates the business logic of developing knowledge sharing as a core capability. The case study conducted reveal that the alliances concentrated on short-term commercial advantages to the detriment of longer term sustainable competitive advantages. Therefore, initiatives taken to improve high quality interactions among alliance participants and thereby sustain inter-firm relationships have not yielded the anticipated benefits.

Keywords: Alliances, knowledge sharing, cognitive-mapping, collaboration, construction industry

1. Introduction

The concept of alliancing is well established in many industries as a means of gaining mutual benefits out of shared competencies and capabilities for firms. Alliances in various forms such as joint ventures, licensing agreements, distribution and supply agreements, research and development partnerships and technical exchanges exist in many industries [1]. Bleek and Ernst [2] points out that on a global scale, the volume of alliance activity has increased at 25% per annum in the first half of 1990's. A later study done by Contractor and Lorange [3] asserted that "the alliance phenomena is here not (*only*) to stay but is set to grow rapidly". In the construction

industry too the concept of alliancing has gathered momentum as an appropriate procurement route for large-scale projects [4, 5].

Although there is an increase both in the incidence of alliances as well as in the number of studies been undertaken on various related issues, it is argued that most of the alliance collaborations are short-term focused and alliance partners devote most of their time on resolving issues related to contractual matters, profit sharing and accounting problems [6], which can be to the detriment of sustaining their relationships for more long-term benefits [7]. Alliances in the construction industry, too, are often saddled with this problem of people involved having a short term 'project based mindset' [8]. The need to adopt a longer term perspective for alliance development is the main focus of this paper. A case study is presented, which investigate the utility of developing a long term orientated core capability through shared knowledge within joint venture alliances in construction.

2. Literature review

Although Prahalad and Doz [9] have pointed out that alliances create synergies between resources of firms in their progression towards achieving sustainable competitive advantage, many alliances are plagued with high degrees of instability and poor performance. Ingirige and Sexton [10] argue that short-termism is a major problem in alliances generally and in construction in particular. Even during the tenure of construction projects the alliances seek commercial advantages [11] rather than building up relationships through collaboration. This emphasis erodes future benefits arising out of collaboration. Further, this tendency results in activities being targeted at controlling the relationships rather than nurturing them. Also factors such as partner opportunism [12] encourages alliances to build up their strategy to focus on short-term measures to control the relationship in the alliance.

Anderson [13] demonstrates the element of short-termism by devising an input – output continuum to measure alliance performance in terms of short-term measures and longer-term orientations. Short-term measures locate themselves towards the output end of the continuum while the longer-term orientations, towards the input end. Through this continuum, she posits that alliances could either perform well in input measures through their current actions and perform poorly in the output measures, or vice versa. This shows that success in the short-term does not automatically guarantee long-term good performance and a performance which is overly long-term orientated might result in inefficient performance in the short-term. It is therefore inferred from her work that a balance short and long-term approach in alliance strategy is advocated.

Drawing upon March [14], the strategy of seeking significant short-term benefits, can be seen as reducing opportunities for alliances to engage in explorative work that adds more value in the future out of collaboration and increasing exploitative work of the existing skills and capabilities

targeting existing opportunities. The rationale of this behaviour is linked to certainty of results, speed at which results are gained, proximity and clarity of feedback tied with exploitation rather than exploration of new opportunities, new skills and capabilities. As both exploration and exploitation compete for scarce resources, due to the proximity and speed of results tied up with exploitation, efforts are directed usually towards exploitation strategies.

3. Research Problem and Hypothesis

The work of March usefully rationalises the dichotomy between short-term and long term orientations in alliance strategy. This shows the dilemma faced by alliances in general that certainty of results, speed at which results are gained, proximity and clarity of feedback tend to send alliances seeking short-term commercial advantages rather than strategic opportunities, which sustained collaboration presents. To a certain degree in construction alliances, this situation is exacerbated as a result of more short-term orientated project based outcomes compared to alliances in other industries. Hence the unique opportunity that the concept of an alliance brings in harnessing of core capabilities through collaboration between people in different companies and takes the knowledge from project to project is often under exploited.

From the discussion, the following research problem is articulated in the following hypothesis.

“Currently there are concerted efforts in construction alliances targeted at performing collaboration as a means of gaining short-term competitiveness and this emphasis will have a negative impact on alliances’ long-term progress towards sustainable competitive advantage, if these efforts are not concentrated on leveraging collaboration as a core capability”

4. Case study methodology

The study adopts the case study approach for investigating the business logic behind the development of knowledge sharing to achieve sustainable competitive advantage within construction alliances. Case study approach is adopted based on the exploratory type and nature and the content of the stated research problem [15]. Further, the capability of the case study approach to rely on the use and triangulation of multiple sources of data justifies the use of the approach [16]. The unit of analysis for this study is taken as the collaborative links at different levels between the alliance participants of the chosen construction alliance case study.

Face-to-face interviews were held with respondents and the interviews were recorded and transcribed for analysis. The interview results were triangulated utilising senior managers (SMs) and project managers (PMs) occupying two different levels in the managerial hierarchy (triangulation of data sources), utilising two different forms of interview guidelines (triangulation of data collection methods) and utilising two different forms of data analysis methods

(triangulation of data analysis techniques). The text in transcriptions were manually coded based on the criteria of:

- (i) Efforts and activities that influence alliances' progress towards achieving long term sustainable competitive advantage; and
- (ii) Efforts and activities that influence alliances' achievement of short term competitiveness.

The SM interviews were further analysed utilising the cognitive mapping technique. Cognitive mapping is a technique that helps to structure, organise and analyse data by creating a map indicating the perceptions of people being interviewed [17]. Software was used to aid the mapping process known as "Decision Explorer©. By attaching a meaning to the statements proffered by the interviewees, some of their concepts were clustered, highlighted and presented in a unique way to derive a meaning. The constructed maps help in understanding some of the key issues and identifying any emerging patterns of people's perceptions on knowledge sharing.

The major limitation of this study is to do with external validity within the case study research approach adopted. The conclusions of this study can be generalised only to the type of alliance discussed under the case study.

The process of analysis is further explained in the case study discussion and analysis.

5. Case study discussion and analysis

5.1 Introduction

This case study forms a part of the Channel Tunnel Rail Link (CTRL) project. CTRL covers mainly civil engineering work involving a 109 km long stretch of road and associated structures running from Folkestone, through Ashford in Kent, to a new terminal at St. Pancras station in Central London. Data collection under this case study focuses only on contract 342 of the CTRL project. The total project, as well as the case study project, follows a target cost contract under the New Engineering form of Contract (NEC), where the contractor is reimbursed its actual costs plus a fee for overheads and profits. Under this contract any total cost over run or cost saving, when compared to the target cost, is shared between the contractor and employer in a pre-agreed way. The objective of this contract is to motivate the parties to decrease costs, without affecting quality or delivery in order to maximise contractor profitability and client savings.

The project started in January 2002 and is scheduled to be completed in January 2006. The contract sum of the 'contract 342' project is £120 million. This does not include the feasibility, design and project management components of the cost to compare with the total cost of the

project. However, in UK construction terms the scale of the project (as identified by the contract value) is sufficiently large and complex to demand the formation of joint ventures among contractors.

The case study focuses on section two of the CTRL project. The main contractor of the project is a contractual joint venture between HO (UK) Limited and NH Construction Limited. This alliance is referred to as HN Alliance (the true identity of the alliance and its partners are withheld for purposes of confidentiality). NH Construction Limited classifies the contractual joint venture (between HO and NH) as a joint arrangement, which does not create a separate entity. The joint arrangement is based on a 50:50 profit sharing agreement between HO and NH for the execution of Contract 342. These details indicate that this alliance belongs to the 'one-off project partnering' type or contractual type of joint venture.

A major task of this project is the sliding of two prefabricated structures (designed by the contractor) below the North Kent railway line. The first structure is a 2300 tonne open base box culvert 56 metres long and 8.5 metres high. The second structure is a three span bridge weighing 9100 tonnes, which now carries the North Kent line over the future CTRL lines. This bridge is one of the heaviest ever slid in the country. The unusual step of sliding the bridge complete with deck and full foundations was taken in order to minimise disruption to the existing railway.

5.2 Alliance partners

HO (UK) Limited and NH Limited are the main alliance partners. Both companies engage in international construction projects. HO's main base is in Germany and HO(UK) is the branch company in the UK, whereas NH Limited is a UK based contractor having projects on a worldwide scale. RLE is a consortium which is entrusted with the role of design and project management of the construction of the CTRL. HO, NH and RLE completed Contract 420 of the CTRL project in 2001. A significant number of people particularly the SMs and part of the PMs working in the case study project (Contract 342) continued from the previous Contract 420. The organisation chart of the alliance is depicted in Figure 1 which includes the people who were interviewed under the case study

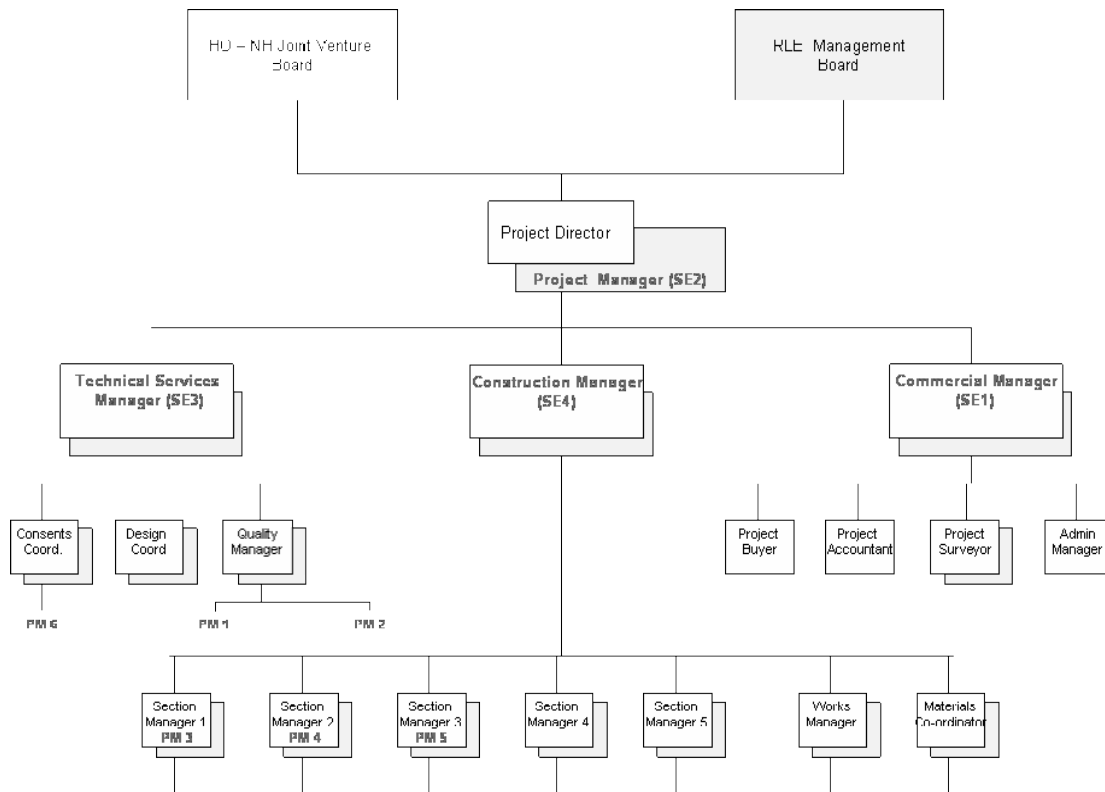


Figure 1: Cognitive map depicting SM perspectives

5.3 Data collection

Interviews lasting for more than one hour were conducted with senior managers (SMs) and project managers (PMs) according to the methodology set out earlier. SM1 is the commercial director representing HO company, SM2 is the client's advisor representing RLE, SM3 is the technical services manager representing HO company and SM4 is the construction manager representing NH company.

SM1, as the commercial director, deals with the entire procurement role for the project. Apart from procurement of materials, contracts management including management of sub contracts and accounting roles also come under the purview of SM1. SM2 performs the distinctive role of the client's advisor on behalf of RLE and covers areas such as verifying the payments due each month, and performs roles such as interacting on the design and project management of the project. As SM2 represents RLE, she has an indirect relationship with HN alliance, however the day to day interactions with the HN alliance staff justifies the selection of SM2 in the interview process. SM3 as the technical services manager is in charge of technical issues such as quality control for the project. SM4, as the construction director, is in charge of all the section managers for the construction of the project. In addition, six middle and junior level managers were

interviewed. They are denoted as PMs for purposes of reference in this chapter. Individually they are referred to as PM1, PM2, PM3, PM4, PM5 and PM6.

5.4 Methods of Collaboration

Since the alliance operated in a construction site, the team mainly utilised face-to-face meetings for collaboration purposes. Apart from the regular site meetings, they initiated face-to-face meetings when the engineers and section managers face unanticipated problems in the project to brainstorm ideas on how to solve the problems. These meetings are called “early warning meetings.” Decisions are reached based on the discussions at the meetings. Once a solution is found, the meeting is concluded. The discussions at these meetings are problem focused and only encourage ideas, which are focused on the problem. These meetings take place on an adhoc basis as problems arise. Apart from the face-to-face meetings, the alliance also utilised emails, a shared file server (known as the ‘I’ drive), an electronic document management system and an Intranet for purposes of sharing and collaboration.

6. Results and Discussion

Responses received from both SMs and PMs were coded based on how they are linked to short / long term orientations based according to the criteria set out in the methodology. A cognitive map was built around SM perspectives and is detailed in Figure 2. PM perspectives are detailed in Table 1.

SM perspectives (see the two combined SM view points given in Figure 2) indicate the role of risk sharing in the alliance as creating both a negative and a positive knowledge sharing climate within the alliance. SM1’s comments highlight the criticality of events associated with the significant level of design tasks undertaken by the contractor. Integration of design and construction roles under the new NEC contract has increased the number of critical activities actioned against the contractor in the construction programme compared to forms of traditional contracts where design and construction is usually separate and the contractor only performs a construction role (for small scale projects, design and build type of procurement system is used, which integrates design and construction). Under a traditional contract, the detailed design deadlines are met by designers who are separately responsible to the client. Therefore, the integration of a major part of the design with construction increases the occurrence of a delay in the project compared to a traditional contract where the contractor only executes construction work. However, SM1 shows how some of their strategies attempt to build up a learning relationship by making them learn from each others’ experiences among the people working in different sections of the project. Further, the awareness of the consequences of a delay prompts SM4 to suggest that the management has to adopt strict measures to limit the number of meetings

including actively participated “early warning meetings” so that a significant amount of resources are deployed at achieving critical deadlines. This strategy is adopted at the expense of sustaining the early warning meetings. Frequent visits by the members of the board of directors for site progress reviews also influence the alliance staff to show tangible results in terms of project’s progress on an ongoing basis. Such behaviour indicates that the alliance participants have reduced opportunities to participate in activities that sustain knowledge sharing within the alliance.

SM2 however, advocates a duality of views on collaborative tasks to sustain the alliance relationships. Whilst she agrees that at the top management level collaborative tasks such as brainstorming workshops are carried out which attempt to sustain the alliance relationships, she expresses scepticism whether such practices filter down into the middle and junior management levels. SM3 rationalises the decision to collaborate based on the joint venture route as a measure of sharing the risks of the project. SM3’s statement on the Intranet (see concept 14 in Figure 2) where it is mentioned that he prefers to email someone and get the information rather than look for it in the Intranet shows how a short term orientated practices manifest in reduced usage of the Intranet.

PMs on the other hand believe that the alliance route and its short term orientated work practices have a negative influence attached to it as it reduces their opportunities to sustain explorative collaborations with their colleagues. Instead they have to release a significant amount of their resources for carrying out exploitative tasks that are related to achieving project deadlines

Overall, PMs agree that the methods of capturing shared knowledge is inadequate. PM3 mentioned that a presentation was done on the “bridgeslide” operation, but it consisted of only superficial type of knowledge. PM5 contributes to this argument and points out that some of the SEs published papers related to completed projects in internal HO bulletins. However, this was done on an adhoc basis. PM3, PM4 and PM5 agree that due to the absence of an appropriate mechanism to capture knowledge, the knowledge exist only in their minds and the knowledge travels with them rather than the companies

Table 1: PM perspectives on knowledge capturing and sharing

	PM1	PM2	PM3	PM4	PM5	PM6
Role of the alliance and how it influences knowledge capturing, sharing and transfer	1. All the engineers (junior managers) are ready to use electronic documents (drawings). But middle managers upwards are fighting a battle.	1 lot of duplication between the RS UK system and the 'infoworks' system, due to contractual conditions	1. I only use the site query facility in the Intranet	1. This particular area is site specific. There is no database produced to capture great ideas. Perhaps it is only the people who have experience and the knowledge who walks away with them rather than with the company. Also I am site based and not aware as to what is going on in the head office.	1. We capture knowledge and when we got to work at another site we take the knowledge with us.	1. We do voluntary knowledge capturing to our head offices.
	2. The intranet is perceived by many people as a glorified phonebook. Therefore does not relate to what I am doing and I don't use it.	2. A majority of the people do not have access to the Intranet. But the Intranet fulfils my needs, All I want to know is there in the Intranet	2. Bridge slide experience involved 100's of day to day incidences. There were many "bright ideas". However these only exist in our minds. There was no capturing of this new knowledge. Although a presentation was done on the bridgeslide, this is just a one off exercise.	2. designers send design queries through the Intranet.	2. Email has become a tool to prove that you are doing your job.	2. Telephone is used to check whether a person is available before going to a face-to-face meeting.
				3. We get a lot of emails, telephone calls and we have to attend a lot of meetings. Usage is pretty even.	3. Intranet and the discussion forum facility in the Intranet (Site query facility) is not used much, The reason is that so many people are involved and difficult to keep a track.	3. Design coordination involves liaison with a large number of people.

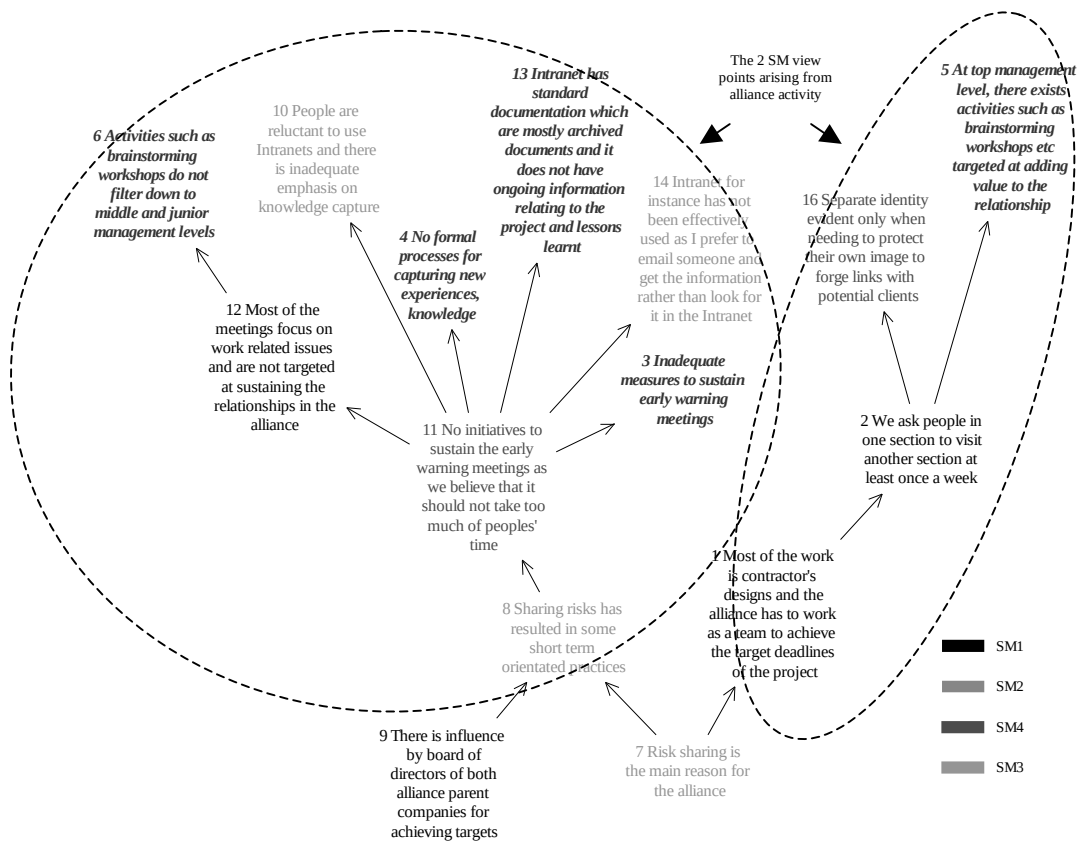


Figure 2: Cognitive map depicting SM perspectives

The SMs communicate tasks to the PMs utilising short messages in the form of instructions via email (SM - PM), which are adequate for the PMs to execute the work involved. While it ensures that the tasks that need to be performed by the PM's are successfully executed and the project deadlines are to a large extent satisfactorily achieved, the process reduces the opportunities for SMs and PMs to engage in an evolving dialogue. Therefore the philosophy of programme management and achievement of key deadlines and milestones draws heavily upon the resources of the alliance particularly with respect to the input that PMs can make towards activities that add value in the long run.

The overall alliance direction therefore is significantly focused on short term orientated commercial advantages rather than long term sustained collaboration. Although SM-SM collaborations are framed with a view to long term orientation, the SM - PM and PM - PM collaborations are significantly short term orientated. The hypothesis set out in this paper has therefore been confirmed. The next section provides the conclusions of this paper.

7. Conclusions

Review of literature on alliances show that the concept is gathering momentum within the construction industry. Initially this paper argued that efforts and activities conducted by construction alliances are short term orientated and this significantly affects their performance in the longer term. The empirical investigation as detailed in the paper supports this theoretical justification within the HN alliance. The case study results provide added support to the claim that the short term orientation existing within construction alliances has adversely affected the core capability development process and resulted in reduced scope in achieving sustainable competitive advantage. The study therefore confirms the existence of the “project based mindset”, among senior, middle and junior managers within construction alliances. This overly narrow project focus constrains the process of achieving sustainable competitive advantage. The study reveals that the longer term aspects of collaboration in construction alliances are not adequately appreciated or understood in practice or in theory. This research addressed the value of long term collaboration and improving effectiveness and efficiency of interactions between construction alliance participants to improve knowledge sharing, thereby influencing construction industry practices. Although long-term partnering trends have emerged in construction, the research findings indicate that they have failed to fully break the “project based mindset” mould in construction.

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Output differences of specialist firms in the UK building industry: a contingency approach using the heating and ventilation industry

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Abstract

The construction sector is comprised of several specialist sub-industries, each with its own specific characteristics. Many of the firms in these sub-industries are the subcontractors that form the interface between construction and material suppliers. The specialist firms in the building industry tend to carry out the transformation of materials into finished structures. There is therefore a need to understand the complexity of the fragments of the construction process in order to manage it effectively.

Making use of detailed published data, the time series of the output of various sub-industries from 1959 to 1997 are compared. Output at constant prices and indices of output are used to show that different specialist industries' patterns of growth varied greatly. Using a contingency approach, the heating and ventilation industry can be used as an example of one specialist sub-industry, to show how the output of one industry differed over time from the output of the industry as a whole. This approach linking historical events and conditions to changes in heating and ventilation output produces evidence of sub-sector behaviour that may not necessarily apply to other parts of the building industry.

However, changes in any one specialism are only partly caused by changes in the construction industry as a whole. Other economic factors and technical changes affecting heating and ventilation firms alone imply that it is not appropriate to generalise about all firms in construction. An appreciation of these sub-sectoral differences would assist in the management of the construction procurement process.

Keywords: construction industry, contingency approach, specialist firms, heating and ventilation industry.

1. Introduction

Much research into the construction industry has focused its attention, though not exclusively, on main contractors, as has most of the literature, including text books like Raftery (1991), Ruddock (1992), Gruneberg (1997) and Myers (2004) or even the more advanced works like Ball (1988), Hillebrandt (1984) and Hillebrandt and Cannon (1989 and 1990) and papers such as Kale and Arditi (2001). Most commentaries on the construction industry are given from the point of view of main contractors, usually assuming them to be large firms. Although Latham (1994) and Egan (1998) both refer to subcontracting, the former is mainly concerned with the problems of main contracting and the latter is focused on clients' needs.

They examine the construction industry from the point of view of main contractors who engage subcontractors to carry out specialist work packages. However, this perspective has become increasingly obsolete as main contractors have, with one or two exceptions, shed direct labour and used less and less of their own equipment. Although their management role ensures that main contractors retain a high percentage of the construction costs of clients, a smaller proportion of the actual building process is undertaken in-house than previously.

Although there are indications that a few large UK contractors may be reversing this trend, the strategy of survival of main contractors has been to use specialist contractors, to employ labour only subcontractors, and to hire plant. Currently, main contractors have transformed themselves into management contractors providing professional management skills and knowledge. Therefore a gap, though by no means a vacuum, has opened up in the literature concerning the central role of specialist firms in the construction industry. Relatively little work has been carried out on subcontractors apart from Hillebrandt (1971), Clarke (1981), Ive (1983), Gray and Flanagan (1989) and more recently Hughes, Gray and Murdoch (1997) and Constantino, Pietroforte and Hamill (2001).

Gray and Flanagan (1989) describe building work on site as a process of assembling prefabricated components. It is a mixture of many trades and techniques, materials and plant. As the number of manufactured components increases, the firms supplying these are often used to assemble them on site employing their own dedicated and trained workforce. Other firms specialise in fixing particular types of components supplied to them by particular manufacturers. This is the case, for example, with heating and ventilating contractors.

It is not possible to generalise about subcontractors in construction because of the large variety of types and sub-industries in which they operate. For example, the form of subcontracting depends on the variety of functions and roles the subcontractors are expected to undertake. Gray and Flanagan (1989) define four categories of subcontractor according to their contribution to the building process. Their four types are;

- fix only
- supply and fix
- design, supply and fix, and
- full design, manufacture, supply and fix.

Alternatively, the population of construction industry subcontractors could be divided according to type of technology, materials used, skills or differences in capital structures. As firms in specialist building markets often have little in common with specialist firms in other sub-industries, what may be true of one sub-industry does not necessarily apply to another. Specific technologies, labour skills and capital structures mean that any in-depth research must focus on firms within a particular specialism, such as heating and ventilation firms.

If construction firms are different the question is how different are they? One indicator may be differences in output of different specialisms compared to construction output as a whole. Total construction output is the aggregate of all firms engaged in construction work. If there were no differences between them, then all specialisms would respond to changes in construction output in the same way. In this paper time series of total construction output and the output of specialist sectors over time are shown to differ. Taking heating and ventilation firms as an example of one specialism, the unique circumstances of one sub-industry are discussed.

Following the method statement the growth pattern of total construction output is compared to the output growth patterns of the different specialist firms from 1959 to 1997. This is followed by a section, which deals with the particular case of heating and ventilation engineers in the same period. The concluding section summarises the findings and confirms the differences between specialist contractors require different approaches to each specialist market.

2. Method

This paper represents a first examination of existing data and is purely indicative. The data sources used are taken from the DETR Housing and Construction Statistics (now the DTI, Annual Construction Statistics). Data on the heating and ventilation industry has been taken from the Annual Reports of the Heating and Ventilating contractors Association (HVCA).

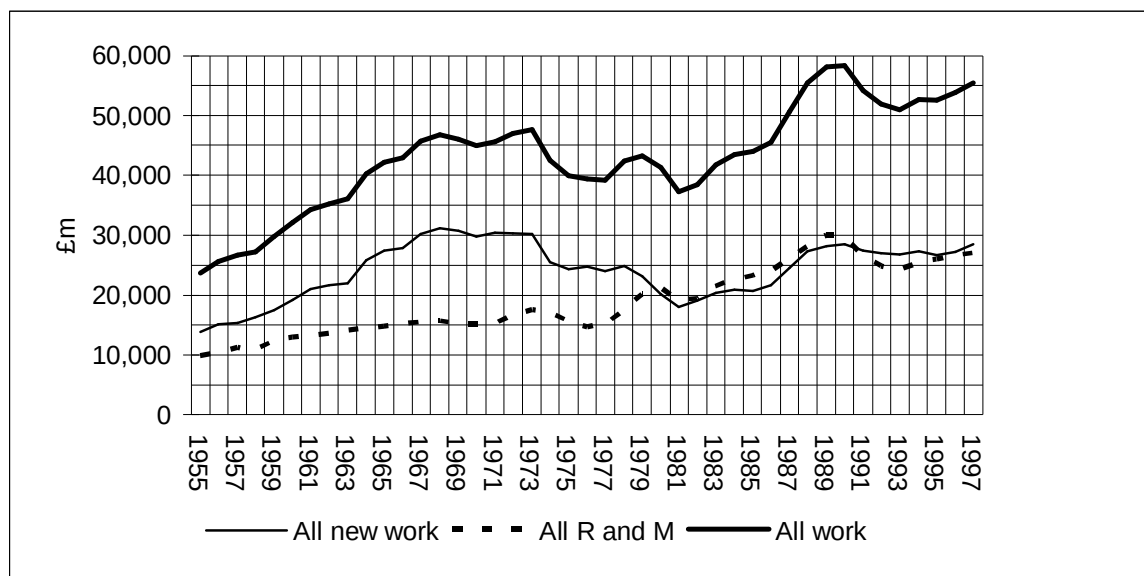
The method used to deflate the data is based on the implied deflators calculated from the DETR's constant price and current price data and has been referred to in this paper as the Gross Construction Price Index, GCPI). The paper combines data on a large number of different specialisms within construction and this time series data is compared visually.

The particular circumstances of the heating and ventilation industry since 1945 can be traced using the annual reports of the Association of Heating, Ventilating and Domestic Engineering Employers (AHVDEE), which became the Heating and Ventilating Contractors Association.

3. Comparison of the output of the construction industry and specialist construction industries

If firms in different specialisms respond to changes in construction demand in the same way, then patterns of growth in the different specialisms would follow the pattern of growth of construction output. The long-run trend in construction output in the UK since 1945 can be divided into three periods. The first was the period of immediate post-war reconstruction, which lasted until approximately 1950. The second was the long boom from circa 1950 to circa 1968. The third period lasted from 1968 and can be characterised as a long period of instability. The third period of instability itself can be divided into three shorter phases. The first phase from 1968 to the early 1980s was a period of declining output in construction. From 1981 until 1990 construction witnessed expansion. In 1991 the construction industry experienced the start of a recession with recovery only beginning to appear by 1994.

Figure 1 uses the DETR series of total construction output in Housing and Construction Statistics. The time series show total construction output, new work and repair and maintenance from 1955 to 1997.

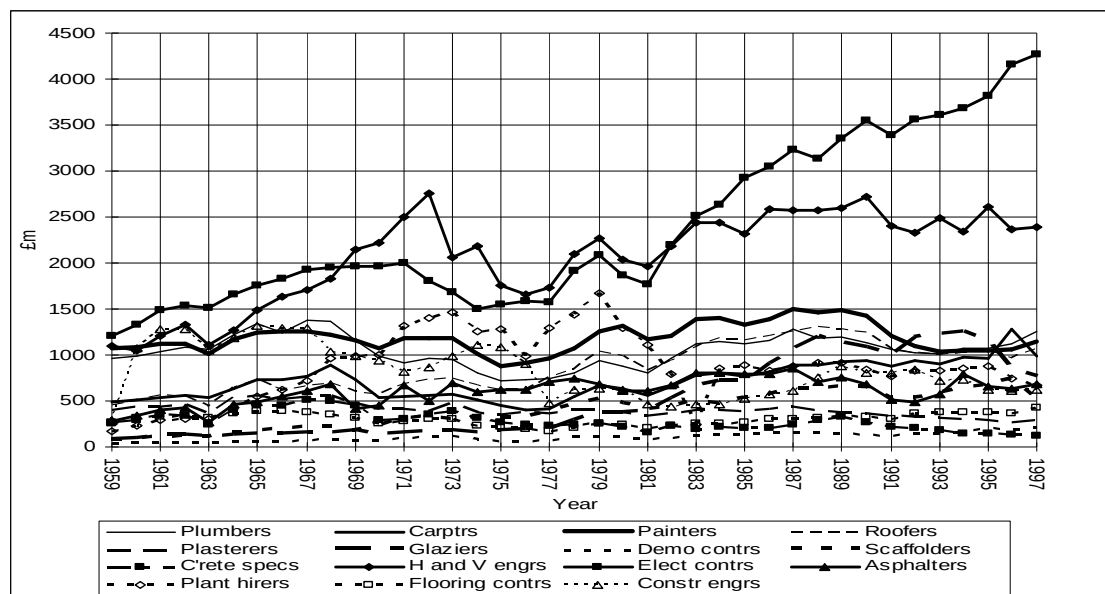


Source: Data at 1995 prices provided by DETR.

Figure 1: Total construction industry output, new work and repair and maintenance 1955-1997

Although demand, output and costs of the construction industry as a whole clearly encounter variations, the size of these variations at the aggregate level, according to Ball (1988 p.98), are not 'peculiarly volatile'. Real annual new work rose steadily from £13,800m in 1955 to £31,200m in 1968. The year of greatest new build output in real terms was 1968. From 1955 to 1968 repair and maintenance rose steadily from £9,900m to just over £15,700m but then became

more volatile. During the 1980s repair and maintenance even represented a higher percentage of construction output than new build. The output of firms and specialisms depends on their mix of new build and repair and maintenance. As each specialism differs from the others in terms of the proportion of new build and repair and maintenance they undertake, changes in their annual total outputs are also different.



Source: Private Contractors Census, Table 3.3, Housing and Construction Statistics, Annual
Notes: Carptrs = Carpenters and joiners; Demo contrs = Demolition contractors; Scaffolders = Scaffolding specialists; C'rete specs = Reinforced concrete specialists; H and V engrs = Heating and ventilating engineers; Elect contrs = Electrical contractors; Asphalters = Asphalt and tar sprayers; Flooring contrs = Flooring contractors. Constr engrs = Construction engineers

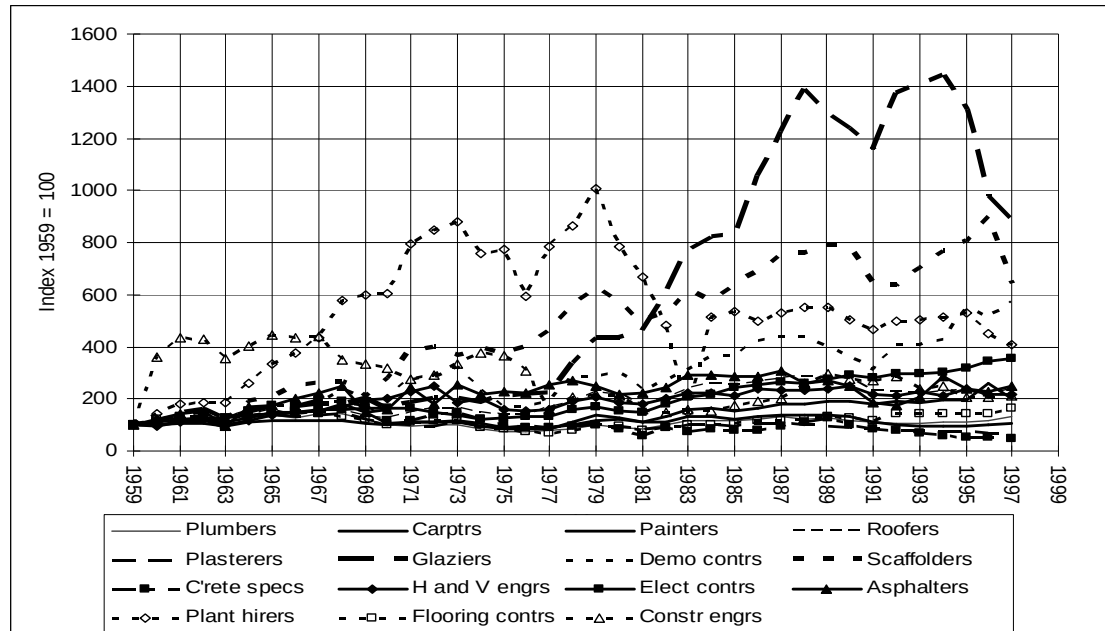
Data deflated using the GCPI 1995 = 100.

Figure 2: Work done by a number of specialisms in the construction industry 1959 to 1997

Figure 2 shows the value of work done by a number of different specialisms within construction. In particular the graph highlights the growth of heating and ventilating contractors and electrical engineers. Always the largest two specialisms, together they increased their size relative to the other trades. Other trades appear to grow at a much slower rate. However, although heating and ventilation output can be seen to increase rapidly in the period up to 1972, since 1972 it remained more or less at a similar level of output. In contrast the value of electrical engineering work done continued on a long run upward trend.

Figure 2 confirms the received wisdom that mechanical and electrical contractors increased their relative share of construction output between 1959 and 1997. The value of output of all the remaining specialist trades tended to remain below £1.5bn, most showing little tendency to grow in real terms between 1959 and 1997. However, Figure 3 shows more clearly that between 1959 and 1997 changes in the value of output of different trades were greatest in the glazing trade,

scaffolding and plant hire. Output of electrical contractors and heating and ventilating engineers did not grow significantly more than in most other trades. Figures 2 and 3 demonstrate that all trades were not equally affected by changes in overall demand.



Source: Private Contractors Census, Table 3.3, Housing and Construction Statistics, Annual Data deflated using the GCPI 1995 = 100.

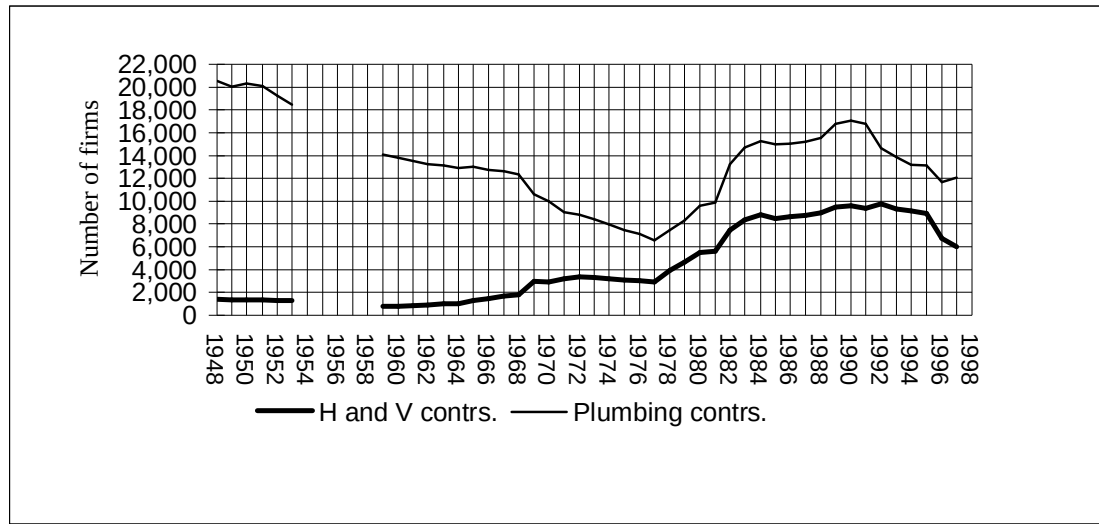
Figure 3: Work done by a number of specialisms in the construction industry 1959-1997

Demand for construction services is a major determinant of construction output. However, other influences play an important role in the performance of different sub-industries. Thus changes in technology and improvements in productivity may have enabled firms to produce more buildings and structures per annum. However the value of construction output may not have risen to reflect the increased output if the real unit cost of construction declined, a phenomenon more obvious in the computer hardware industry where unit prices of personal computers declined while the power of computers increased. The following section traces the particular circumstances of the heating and ventilation industry as an example of the particular factors, which affect specific industries and lead to performance differences.

4. The heating and ventilation industry

Heating and ventilation contractors assemble specialised equipment to heat or ventilate buildings. In 1949 the Council of the Association of Heating, Ventilating and Domestic Engineering Employers (AHVDEE) conceded that the heating and ventilating industry formed 'a very small part of the industrial whole and was a very recent development as a branch of engineering' (AHVDEE, 1949 p.119). Since the Second World War the number of firms in the heating and

ventilating industry grew from less than 2,000 to a peak of almost 10,000 firms in 1992. Figure 4 contrasts the growth of the number of firms in the heating and ventilation industry compared to the number of firms in plumbing, a closely allied specialism. From 1948 to 1977 the number of plumbing contractors fell while the number of heating and ventilating firms grew moderately. Since 1977 the number of firms in both specialisms followed similar patterns, due to changes in employment patterns towards casualisation of labour and the formation of a large number of small enterprises, which occurred throughout the construction sector.



Sources: Annual Private Contractors' Census and Housing and Construction Statistics, DETR

Figure 4: Heating and ventilating contractors and plumbing firms, 1948-1996

To view the relative importance of the heating and ventilating specialist subcontractors compared to the industry as a whole in terms of the number of firms and employment, Table 1 provides the number of firms operating in various years. The percentage of employment in each type of firm is also given for 1985, 1990 and 1996. Heating and ventilation only constituted 6 per cent of employment of all trades in 1985, dropping to 5 per cent by 1996. Relative to the rest of construction the heating and ventilating firms did not increase their share of employment although as Figure 2 shows, output more than doubled in real terms.

The particular circumstances affecting the heating and ventilation industry can be best explained by the economic influences occurring at different times. In the late 1940s, for example, the heating and ventilating sector was cushioned to some extent by the need to save fuel as coal prices were tending to rise. There appears to have been a rather chaotic switch from coal to oil fired installations and back again to coal. In themselves these shifts by no means harmed heating and ventilating contractors. Conversion work meant full order books for contractors and full employment in the trade, a level of demand that was expected to continue (AHVDEE, 1948, p.99).

Table 1: Number of heating and ventilating contractors compared to different types of building firms between 1973-96 and employment in 1985 and 1996

Trade	Number of firms ¹					Emp. % ²	
	1973	1977	1985	1990	1996	1985	1996
General builders	39659	31889	67475	78981	50615	34	26
Building and civil engs.	2364	2054	3623	4773	4984	15	9
Civil engs.	2114	1633	2662	3742	10781 ³	6	8
Total main trades	44137	35576	73760	87496	66380	55	43
Heating and ventilation contrs.	3284	2906	8461	9624	6697	6	5
All other trades	49155	39160	85604	112673	90238	39	52
Total all trades	96576	77642	167825	209793	163315	100	100

Source: Housing and Construction Statistics 1978-88 and 1987-97 Tables 3.1(b) and Table 3.5 (b)

Notes: ¹ Table 3.1(b)

² Percentage of total construction employment

³ There is a discontinuity in the series in the series of civil engineers between 1995 and 1996 relating to increased coverage especially of firms with 7 or fewer employees, which accounts for the rise in the number of firms.

Thus the heating and ventilating industry may not have followed the same cyclical pattern as the rest of the building industry in the years immediately after the war. After the immediate post war expansion in building work, the government cut spending on construction without an increase in private sector demand to compensate. From 1948 to 1951 total construction output actually fell in real terms (Smyth, 1985, p.124). This was followed by a period of growth in construction output, which began in 1951, and continued steadily though slowly until the end of the 1960s.

The heating and ventilating industry also remained relatively steady and growing throughout the 1950s. This expansion continued into the 1960s and beyond reaching a peak in 1973, according to DTI output data. The comments in the Council's 1962 Annual Report were characteristic of the optimism in construction at this period. According to the Annual Report of the AHVDEE total output of construction had increased by 5% in 1961, with heating and ventilating work probably increasing more, in spite of periods of slack due to declining industrial orders (AHVDEE, 1962, p.13).

Indeed, optimism was expressed due to the increasing content of mechanical services in buildings. The turnover of the heating and ventilating industry continued to expand. This growth had been mainly in the domestic heating sector, while demand for heating and ventilating systems in new office developments at the time declined, according to the HVCA (HVCA, 1964 p.7). The increase in domestic work was largely a result of advertising campaigns by the oil, coal and gas industries, rather than any specific marketing activity on the part of the heating and ventilating industry itself. Although materials were still readily available and apparently giving no cause for

concern, worries about skill shortages on and off site were beginning to be expressed (HVCA, 1965 p.7). Skill shortages are a sign that an industry is approaching full capacity, affecting its ability to maintain its rate of growth.

5. Heating and ventilation and total construction

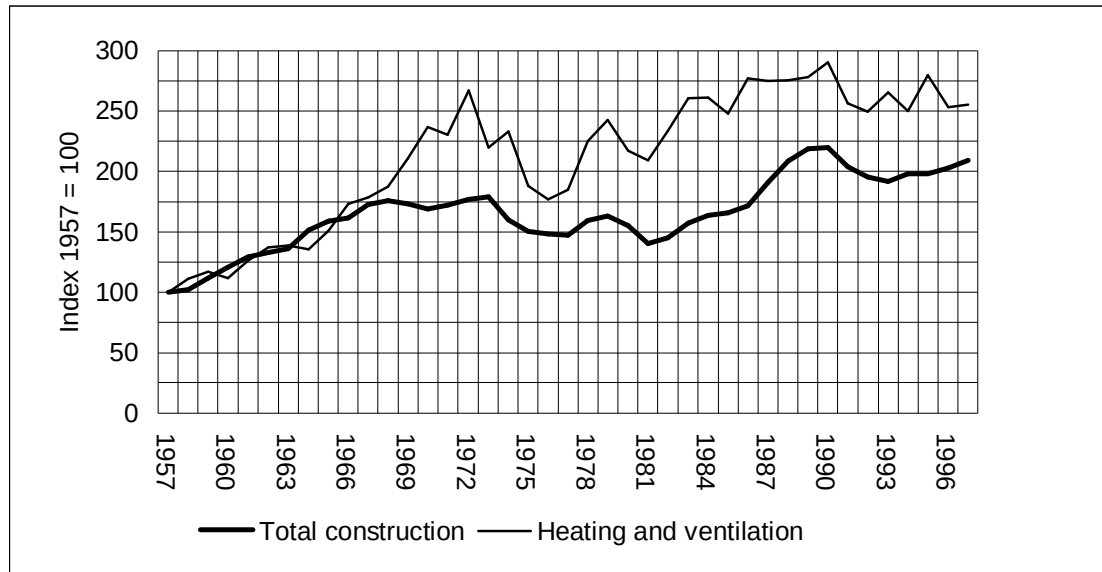
The experience of firms in the heating and ventilation industry was not the same as firms in the rest of construction. Figure 5 illustrates the similarities between construction output as a whole and the heating and ventilation industry between 1955 and 1997. There is evidence that the heating and ventilation industry did not follow the pattern of construction output in the short run. However, in the long run movements in construction tend to be reflected in the heating and ventilation industry. The long run expansion from 1955 to the early 1970s, followed by the decline in the mid 1970s and the recovery from 1981 to 1990 are all apparent in Figure 5. However, in several years the direction of change in the heating and ventilating industry is the opposite of construction as a whole. This implies that while demand for construction influences demand for heating and ventilating engineers in the long run, in the short run factors other than construction demand play a significant role.

For example, in 1969 construction demand declined but the HVCA maintained that total demand for the heating and ventilating industry had been comparatively unaffected (HVCA, 1970 p.7). Indeed, according to DTI output data, while construction output fell slightly between 1968 and 1970, heating and ventilating industry output actually rose by around 15 per cent per annum in the same period. Increases in oil prices in the early 1970s may have caused problems in terms of inflation and the balance of payments. However, for firms in the heating and ventilating industry it meant they were employed to adapt buildings in response to the changed relative energy prices. This provided a respite for heating and ventilating firms during one of the worst declines in output since the Second World War. This respite occurred although the domestic consumer market was constrained to some extent by government credit restrictions in force at the time, a factor, which did not affect all parts of the construction industry equally.

Again the particular circumstances of the heating and ventilation industry can be seen in the period between 1974 and 1977 when total construction demand was in decline. The HVCA reported that demand for heating and ventilating continued at a high level in 1974. This may have been related to additional work caused by the sudden rise in oil prices in 1973, stimulating demand for non-oil heating systems after a time lag of a year. Nevertheless, by 1976 even the heating and ventilating industry reflected the decline in the rest of construction. The HVCA guessed that the output of the heating and ventilating industry had dropped by 5-10 per cent between 1976 and 1977 and was on a downward trend (HVCA, 1977 p.31).

In 1982 the decline in construction output halted, but demand for construction remained at low levels throughout the year and a record number of HVCA members went out of business because

of the level of competition, and continuing over-capacity combined with cash flow problems (HVCA, 1984, p.8). Those heating and ventilating contractors who had survived the recession, like other firms in the construction industry, were prepared to tender at extremely low prices for the limited opportunities available. However, the HVCA reported that towards the end of 1982 demand began to increase and by early 1983 construction orders were over 15 per cent above the level of a year before (HVCA, 1984, p.8). Moreover, recovery of demand for heating and ventilating was far more rapid than for construction as a whole.



Source: Heating and ventilating industry, HCS; Construction industry output data supplied direct by DETR HVI data deflated using the GCPI. CI data at 1995 prices

Figure 5: Annual output of the construction and heating and ventilation industries 1957- 1997

Between 1992 and 1997 heating and ventilating contractors experienced highly volatile changes in demand. Their output increased by 10 per cent between 1994 and 1995 but dropped by a similar proportion the following year. In the same period recovery from the recession of the early 1990s in the construction industry as a whole was slow and steady. Heating and ventilation contractors were engaged on a large number of large speculative office developments which, by 1994 and 1995 required their services.

We have noted a number of specific factors influenced the performance of heating and ventilating contractors, such as increases in the demand for mechanical services in buildings, changes in the relative energy prices, and shifts in work between different types of buildings. Nevertheless, much of what occurs in construction occurs in response to changes in demand for its services, not only in the types of buildings specified but also the total value of building work. This brief history has demonstrated that it is insufficient to predict changes in the heating and ventilation industry by only examining demand for construction as a whole.

6. Conclusion

The fragmentation of the construction industry into specialist sub-industries can be shown to exhibit completely different performance patterns. These divergent patterns lead to complexity in terms of the composition of the construction industry not only in terms of shares of the total output of the construction industry but also in terms of the numbers of firms active in each sub-sector.

This has been an indicative paper highlighting the need for further research into small and medium sized enterprises in the construction industry and much more work and analysis of the different specialist firms and markets throughout the sector. There is a need to know the characteristics of each market, the operating methods used by firms and the historically contingent institutional arrangements which determine the way business is conducted in each sub-sector of construction.

This paper has dealt with some of the particular economic factors influencing the heating and ventilation industry. However, these factors are only a partial explanation. Technical factors also play a role. Technical change, innovation and new products also play a part in affecting demand for the services of heating and ventilation firms, the productivity of the workforce and the profitability of firms, and these factors are unique to each specialism.

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A Review of Competition in South African Public Private Partnership Procurement

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Abstract

This paper reviews the procurement of Public Private Partnerships (PPPs) in South Africa focusing on the competition for their award. It uses the legislative and regulatory frameworks and the relevant guidance documentation in place that govern PPP procurement and the subsequent service delivery as evidence of the practices in South Africa. The paper comments on: the ensurance of competition intensity through the attraction of an appropriate number and quality of private parties to bid for a PPP, avoidance of erosion of the client's bargaining power in the preferred bidder stage, and prevention of anti-competitive collusion and predatory behaviour by the bidders. The review reveals that the foundations for PPPs in South Africa offer sophisticated solutions for fostering competition in PPP procurement. These solutions include: the use of prequalification to select the appropriate private sector bidders, the utilisation of bid bonds to ensure the bidders' commitment to the procurement process, the appointment of a reserve bidder to maintain client's bargaining power in the preferred bidder stage, the execution of due diligences early on in the procurement process to prevent changes in the details of the project during the uncompetitive negotiations leading to financial close, and the use of public sector intervention to prevent collusion and/or predatory behaviour. Thus, South Africa appears to have a robust procedure in place for organising PPP bidding competitions. However, there is a distinct lack of evidence on the level of competition that this procedure induces on actual projects and, thus, it is not known whether it enables public sector clients to obtain improved value-for-money PPPs in practice. As a result, this paper calls for future research into PPP bidding competitions in South Africa.

Keywords: Public Private Partnership (PPP), procurement, competition, bidding, auctions, South Africa

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1. Introduction

According to the South African National Treasury (2004a, 4), a Public Private Partnership (PPP) is “*a contract between a public sector institution and a private party, in which the private party assumes substantial financial, technical and operational risk in design, financing, building and operation of a project.*” In line with the established construction industry terminology, this paper refers to the public sector institution that procures a PPP as the client. The private party that either pursues or undertakes a PPP is often a consortium of private sector actors governed by a complex set of contracts and arrangements. These actors can range from contractors to facilities management service providers and financiers.

A public sector client procures a PPP in order to generate benefits to society. In a PPP, the private party provides a support service (e.g. serviced healthcare accommodation) to the client that it consumes as part of its core service (e.g. healthcare) provision to the public. Alternatively, the private party may provide a core service (e.g. transportation) to the public directly. The private party is compensated for its support or core service provision either by the client or the client may permit it to recover user charges from the consumers of the service. The compensation may also be a combination of these two approaches (National Treasury, 2004a). A private party competes for a PPP because it anticipates that the revenues it would obtain as a result of being awarded the project will be greater than the costs it will incur for fulfilling its obligations under the contract and, thus, make a profit.

This paper reviews the competition for PPPs in South Africa. It uses the legislative and regulatory framework and the relevant documentation used to govern PPP procurement and the subsequent service delivery as evidence of the practices in South Africa. The paper explains the underlying logic of the prescribed practices and, through analysis, highlights a number of issues that require further investigation. Section 2 explores the role of competition in the procurement process. Section 3 discusses the role of a robust legislative and regulatory framework and associated guidance documentation in fostering competition. Section 4 investigates the client's strategies to enhance competition by improving the quantity and the quality of private parties participating in bidding competitions. The client's tactics to deal with decreased competitive pressure in the preferred bidder stage are examined in Section 5 and its ability to manage collusion and predatory behaviour of the private sector actors is explored in Section 6. The last section concludes the paper.

2. Competition and PPP Procurement

A client organises a bidding competition in procuring a PPP in order to improve its value-for-money. The National Treasury (2004b) sees value-for-money as the difference between the risk-adjusted cost of procuring a project that would generate an identical level of benefit to society as the proposed PPP using traditional methods and the lowest cost that a private party is willing to accept for undertaking the PPP. By awarding a PPP competitively, the client is able to increase its bargaining power in relation to the private sector and either extract greater benefits, reduced

costs or both from the private party that wins the contract to undertake the project. This increases the value-for-money of the PPP. The private party is willing to offer improved value-for-money to the client because by doing so it also increases its likelihood of being nominated the preferred bidder out of the private parties pursuing the project.

In terms of auction theory, the bidding competition for a PPP is a first-price sealed-bid auction (McAfee and McMillan, 1987; Riley, 1987; Milgrom, 1989). The private parties submit proposals of fully priced solutions for the project. The details of these proposals are known only to the bidders themselves, hence its name as a sealed-bid auction. The private party that is willing to undertake the PPP on the most economically advantageous terms to the client (i.e. provide the best value-for-money when benefits are measured against a specific bid evaluation criteria) is awarded the contract. The winner will be compensated in accordance with the principles it used to price its proposal. The fact that the client uses the winner's pricing (as opposed to the pricing of the bidder with the second-best proposal) as the basis for compensation clarifies why the auction is referred to as a first-price auction.

Klemperer (2002) argues that what really matters in auction design is the client's ability to foster competition for the contract and that the finer points of auction theory are of secondary importance to the success of the auction, i.e. its ability to yield value-for-money. As a result, this paper does not question the decision of the National Treasury to use a specific auction format for the award of PPPs in South Africa. Instead, it takes the first-price sealed-bid auction as a given and focuses on exploring the common pitfalls in organising such auctions that may compromise the level of competition in PPP procurement and, consequently, result in sub-optimal value-for-money.

It must be acknowledged that a client can also procure a PPP through negotiation as opposed to a bidding competition. However, the National Treasury (2004c) takes an unfavourable view of a negotiated contract award that a client can follow particularly when the client has received an unsolicited proposal from a private party because of lack of competitive pressure is likely to compromise the value-for-money of the project. According to Klein (1998), a negotiated award may be appropriate in order to either save on the cost on transacting (i.e. the cost of organising a bidding competition) or to speed up the implementation of the PPP and, thus, bring forward the stream of benefits that flows from the project. Klein (1998), however, agrees with the National Treasury (2004c) that a negotiated procedure is likely to compromise the transparency of procurement that may result in a number of problems such as increased scope for corruption. Thus, the National Treasury (2004c) recommends that if a client receives an unsolicited PPP proposal with merit, it should organise a bidding competition for a similar project. Klein (1998) points out that the downside of such practice is that it will discourage unsolicited proposals from private parties even if they might yield great benefits to the public sector if implemented.

3. Legal and Regulatory Framework and Associated Guidance

According to Sader (2000), many developing countries lack the legal and regulatory framework for the effective procurement and governance of PPPs. As a result, a private party pursuing a PPP opportunity cannot be certain that its up-front investment in the project-facility used in service provision will be protected over the project term from unanticipated public sector intervention. Considering the fact that the duration of a PPP contract can be several decades, this is a significant risk. A change in Government may, for example, result in a unilateral decision by the client to renegotiate the contractual terms of the project. The risk of such an event may deter some private parties from entering a bidding competition for a PPP and, thus, decrease the competitive pressure in procurement by either reducing the quality or the number of private parties that want to bid for the project. Consequently, the client will be unable to extract a project that is the maximum possible value-for-money from the private sector.

According to the National Treasury (2004a), the foundations of PPPs in South Africa are laid down in the National Treasury Regulation 16 to the Public Finance Management Act (PFMA) 1999. Treasury Regulation 16 was first issued in May 2000 and, subsequently, it has been continuously revised in order to take into account the PPP procurement experience being accumulated. In February 2005, 12 PPP projects have reached financial close in South Africa (National Treasury, 2005). These pieces of legislation and regulation provide a solid foundation for PPPs.

In addition, in March 2004, the National Treasury (2004d) laid down the basic contractual terms for PPPs into a document titled: *Standardised PPP Provisions*. These provisions are in effect guidelines for drafting a standard PPP contract that sets out the risk allocation between the client and the private party. In entering into a PPP contract, the client must comply with the provisions unless it can demonstrate to the National Treasury that deviating from them will improve the value-for-money of the project without shifting the balance of risk towards the public sector.

Moreover, in August 2004, the National Treasury issued a guidance document on the procurement and governance of PPPs. The document, containing nine modules, is titled: *National Treasury PPP Manual*. It sets out the various steps in great detail that the client must take in obtaining services through PPPs. The outline of these steps is illustrated in Figure 1. By February 2005, seven of the modules had been published with the publication of the two remaining modules expected in the near future.

In summary, the private parties bidding for and undertaking PPPs in South Africa are protected by legislation and regulation and can rely on established procurement and governance procedures and contractual terms. These include best practice procedures that must be followed for organising a bidding competition (National Treasury 2004c), for managing the contractual relationship with the private party over the project term (National Treasury 2004e), and for ensuring the transparency of the client's actions (National Treasury (2004f). This reduces the

uncertainty associated with the future revenues that will stem from the PPPs that the private parties are pursuing, which is likely to make them more willing to bid for the projects.

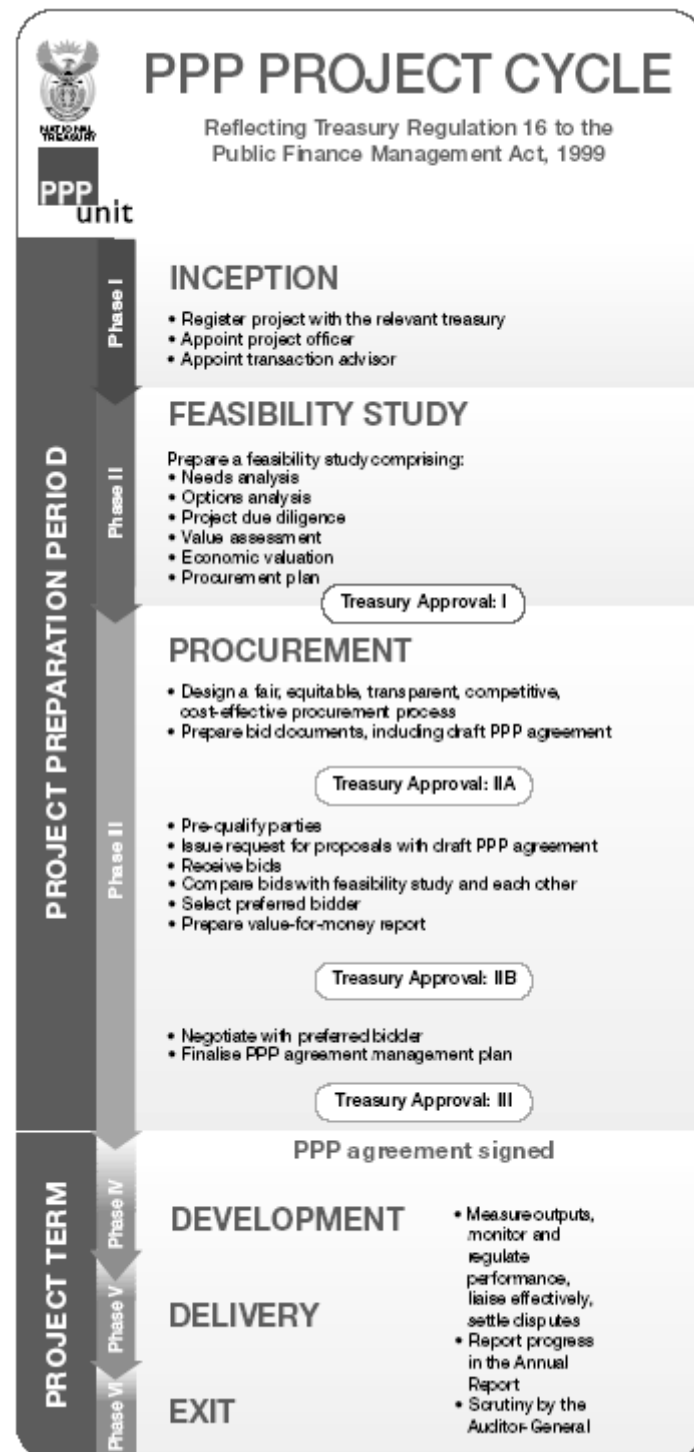


Figure 1. The PPP Project Cycle in South Africa (National Treasury, 2004a).

A reduction in the uncertainty of revenue from a PPP increases its *expected value* as it increases the certainty that the private party will receive the anticipated revenue from the project in full (event 1) and decreases the likelihoods of events (2 to n) that would compromise the anticipated revenue. The mathematical expression of expected value of the revenue is given in Formula 1.

$$R_{EV} = R_1 \times p_1 + \dots + R_n \times p_n \quad (1)$$

where, R_{EV} is the expected value of revenue from the PPP,
 R_1 is the value of revenue in event 1,
 p_1 is the probability of event 1,
 R_n is the value of revenue in event n , and
 p_n is the probability of event n .

The expected values of revenues in Formula 1 are present values discounted at the opportunity cost of capital of the private party bidding for the project. The probabilities of all possible revenues (in events 1 to n) must equal one. It must be noted that a similar expression to Formula 1 can be devised for the expected value of costs the private party will incur in undertaking a PPP. It must be noted that the expected values of revenue and cost may vary due to reasons other than government intervention such as technological innovation. However, such risks are not specific to PPPs in South Africa.

4. Intensity of Competition

According to Klemperer (2002), the economic benefits from an auction can be compromised due to inadequate level of competition, which can be caused by either inappropriate number of bidders or low quality of bidders.

A PPP can be considerable in size and complexity and in all cases client procures the PPP using an output specification. This is a specification that describes the project deliverables in terms of service outputs, rather than technical inputs which is the traditional approach within the industry. Some degree of input specification may, nevertheless, be required in all projects. The private parties develop their proposed solutions for the PPP within the constraints of the output specification (National Treasury, 2004c).

The cost that a private party will incur for developing a solution in response to the client's output specification is high when compared to the cost of bidding for traditional construction and facilities management service contracts (National Treasury, 2004c). Thus, the cost of entry to a PPP auction is high. This may deter some private parties from bidding for the PPP by building a significant barrier of entry to new entrants into the market and, thus reducing the pool of interested bidders.

In terms of the Expected Utility Theory (see e.g. Schoemaker, 1982) that sees actors either as *risk-neutral*, *risk-averse* or *risk-prone*, a risk neutral actor will only bid for a PPP if the expected

value of its profit is at least equal to its bid cost. Formula 2 gives the mathematical expression of expected value of profit. The probabilities of a successful and an unsuccessful bid must equal one. If the bidder is unsuccessful in the auction, its expected revenue and cost and, thus, profit are zero. A risk-averse private party will require its expected profit to be higher than its bid cost in order to participate in a PPP auction whereas a risk-prone actor will be willing to enter the bidding competition even if its expected profit is lower than its bid cost.

$$\pi_{EV} = p_S \times (R_{EV/S} - C_{EV/S}) + p_U \times (R_{EV/U} - C_{EV/U}) \quad (2)$$

where, π_{EV} is the expected value of profit from the PPP,
 p_S is the probability of a successful bid,
 $R_{EV/S}$ is the expected value of revenue of a successful bid,
 $C_{EV/S}$ is the expected value of cost of undertaking the PPP if successful,
 p_U is the probability of an unsuccessful bid,
 $R_{EV/U}$ is the expected value of revenue of a unsuccessful bid, and
 $C_{EV/U}$ is the expected value of cost of undertaking the PPP if unsuccessful.

The National Treasury (2004c) takes the view that the client should not normally compensate unsuccessful private parties for their bid costs. Thus, the private parties bid at risk and their bid costs will become sunk costs if they are not awarded the contract. However, the National Treasury (2004c) acknowledges that in cases where the cost of bidding is so high that private parties are unwilling to enter the bidding competition, the client may contemplate reimbursing the bidders with a pre-agreed percentage of their verifiable costs of compiling and submitting compliant proposals. This will reduce the bid cost in relation to the expected value of profit from the PPP and, thus, increase the likelihood that a greater number of private parties will enter the bidding competition. The National Treasury (2004c) also emphasises that the client should explore the possibility of sharing some bid costs among the private parties and, thus, decreasing the cost incurred by each bidder. An example of this would be a jointly funded ground condition survey.

The National Treasury (2004c) outlines a procedure for ensuring that the client has an appropriate number of private parties wanting to bid for the PPP. The client should advertise the project requesting expressions of interest from the private sector. At this stage, the client should have set out the basic parameters for the PPP and can use the feedback from the market to establish whether it will be able to organise an effective bidding competition for the project in its advertised configuration. If the market response indicates that there is likely to be an inadequate number of interested bidders, the client can then either abandon or re-scope the project.

Once the client has decided to proceed with PPP procurement, it should use prequalification to ensure that an appropriate number of competent private parties are invited to bid. This should ensure an appropriate level of competition for the project. According to the National Treasury (2004c), in prequalification, the client should assess the interested private parties in relation to their technical, financial, legal and Black Economic Empowerment (BEE) capabilities. BEE is the South African Government policy that seeks to promote historically disadvantaged

individuals. According to the National Treasury (2004g), a good BEE practice in PPP amounts to meeting or exceeding specific targets for equity participation, management control and subcontract award.

Under the National Treasury (2004c), at prequalification, the client should select three or four private parties to bid for the PPP. The National Treasury feels that such number of bidders will entice the highest achievable level of competition by providing the private parties with an acceptable probability of being successful given the high cost of bidding. On the one hand, if the number of bidders was to be higher, some competent bidders might be deterred from entering the competition due to low probability of success. On the other hand, if the number of bidders was to be lower, the most capable private parties would participate, but the competition would be limited due to the small number of bidders. Therefore, if the client invites too many or too few private parties to bid the intensity of the competition may be compromised.

A major problem in procuring PPP projects is that once the client has invited a number of private parties to submit proposals for the project, some of the bidders may choose to withdraw from the bidding competition – see e.g. Sader (2000). This is because it is only at this stage that the parameters for the solutions that the client is seeking are fully revealed to the bidders. As a result, the private parties are now in a position to better predict their likely success in the bidding competition. If they feel that the probability of a successful bid is not acceptable, they will abandon the pursuit of the project.

The National Treasury (2004c) recommends that the client uses bid bonds to mitigate the problem of bidder withdrawal. In other words, the client should require the prequalified private parties to deposit bonds that it will refund only if they submit compliant proposals. If a private party is unwilling to submit a bond, the client must not prequalify it to bid for the project. A bid bond should be at least equal to the cost the client would incur if it had to recommence the bidding competition (National Treasury 2004c). If a private party abandons the pursuit of the project, its bond becomes a sunk cost. However, the bond is only likely to be effective in deterring a private party from withdrawing, if it is higher than its cost of submitting a compliant proposal. If the bid bond is less than that amount, it remains advantageous for the private party to withdraw if it feels that it has no chance of becoming the preferred bidder. Therefore, the existing recommendation on the magnitude of the bid bond may be inappropriate. This is because even if the bid bond would compensate the client with the cost of restarting the bidding competition, a withdrawal due to an unsuitably low bid bond would have a negative impact on the society as it would delay the stream of benefits that flow from the project.

If the client fails to obtain its desired number of compliant proposals for the PPP, it must treat the option of procuring the project traditionally as a competing proposal. This option is known as the Public Sector Comparator (National Treasury, 2004c). The use of such a comparator may result in a number of problems due to the credibility of using traditional procurement as a genuine alternative. A traditionally procured project would have to be financed from public funds when the access to private sector finance is one of the primary reasons for the use of PPP. Thus, the credibility of such an alternative is likely to erode the bargaining power of the client. It must be

noted that the National Treasury (2004c) recommends that a PPP be abandoned or re-scoped if there is no appetite for the project in the market and that the client should use bid bonds. As a result, in theory, a situation where the client does not receive its desired number of compliant proposals should not arise.

5. Negotiations with the Preferred Bidder

Once the client has selected a private party as the preferred bidder, the actor is no longer subject to competitive pressure. As a result, the private party's bargaining power in relation to the client is considerably strengthened. This is because the client cannot change the preferred bidder easily without incurring significant sunk costs. These sunk costs are the costs that the client incurs in negotiating with the preferred bidder in pursuit of the financial close of the project. Therefore, if the solution for the project requires changes outside the parameters agreed at the appointment of the preferred bidder, the private party is able to extract a price for the changes that may exceed market prices as it is no longer in direct competition from other bidders.

In theory, the preferred bidder stage exists to allow the client and the private party to agree the outstanding finer details of the project. In addition, in project finance PPPs, the financier needs time to carry out a due diligence in order to satisfy itself that the level of risk in the project is in line with its expected returns from financing it. The negotiations and the due diligence should not affect the previously agreed details of the project (National Treasury, 2004c). However, it must be acknowledged that in practice this may not always be the case and that issues may arise, especially in the course of the financier's due diligence, that need to be agreed through negotiations, which may compromise the value-for-money of the PPP.

A number of strategies that the client can use to ensure that the value-for-money of the PPP is not compromised in its negotiations with the preferred bidder are outlined in the documentation (National Treasury 2004c). First, the client must appoint the private party with the second-best bid as its reserve bidder. This enables the client to commence negotiations with the reserve bidder if the negotiations with the preferred bidder break down due to the private party's abuse of its monopoly position. The appointment of a reserve bidder will slightly improve the client's bargaining power, but the problem is likely to persist nevertheless.

Second, the documentation requires both the client and the private party to carry out a number of due diligences prior to being allowed to proceed to the preferred bidder stage (National Treasury 2004c). The client must carry out a first due diligence on its bid documentation before inviting the private parties to prequalify and a second due diligence before requesting them to submit proposals for the PPP. The client must carry out the due diligences in order to obtain the approvals I and IIA from the National Treasury (see Figure 1) in order to be allowed to proceed with the project.

The client undertakes its due diligences at the stage where it can only assess its proposed contractual framework (i.e. the tailored standard provisions) and boundaries for the technical

solution for the project (i.e. the output specification). It is likely that these due diligences will resolve a number of issues that would have otherwise surfaced only in the due diligence carried out by the preferred bidder's financier at the preferred bidder stage.

In addition, the National Treasury (2004c) requires all the bidders to carry out a due diligence on their proposals before submitting them. If the private party with the most economically advantageous bid cannot demonstrate that it has undertaken the assessment, the client will be unable to obtain approval IIB from the National Treasury (see Figure 1) that it requires in order to nominate the preferred bidder. This is likely to decrease the likelihood of problems arising in the preferred bidder stage and, thus, compromise negotiations between the client and the private party. It must be noted that the requiring all the bidders to undertake a due diligence on their proposals will increase their bid costs, which might potentially deter them from entering the competition.

It must be noted that neither the client's nor the private party's due diligences early in the procurement process will remove the financier's need to carry out a due diligence in the preferred bidder stage. However, the financier will be able to draw on the assessments already undertaken and, thus, speed up the process. Nevertheless, it is possible that in the financier's due diligence previously undetected issues arise that need to be resolved through negotiation. Therefore, it is not known whether the erosion of value-for-money prevented by the stringent requirement to carry out due diligences early on in the process will be greater than the potentially lost value-for-money as a result of a possible reduction in competitive pressure caused by increased bid costs.

Once the client has agreed the detailed contractual terms and technical solution for the project with the preferred bidder, it must apply for approval III from the National Treasury (see Figure 1), which enables it to proceed to award the PPP contract (National Treasury, 2004c).

6. Collusion and Predatory Behaviour

Klemperer (2002) highlights collusion and/or predatory behaviour as major problems in organising effective bidding competitions. In other words, two or more bidders may act together in order to extract a high price from the client for undertaking PPP or one of the bidders may abuse its market power in order to prevent the other bidders from submitting genuinely competitive proposals. Such practices are likely to compromise the value-for-money of the project.

PPP procurement must comply with the Competition Act 1999 (National Treasury 2004c). The main purpose of the act is to foster competition within South Africa in order to increase the global competitiveness of the nation. In terms of the Competition Act, the South African Competition Commission may intervene to prevent collusion and/or predatory behaviour in procurement if, for example:

- collusion between two private parties limits competition,

- collusion between the actors of a private party limits the ability of the other bidders to compete for the project,
- a private party abuses its market dominance by, for example, undercutting the prices of other bidders in order to prevent them from obtaining a toehold and, thus, building a track-record in the PPP market, and
- actors that are either part of the same private party or different private parties merge thereby limiting competition

Under the National Treasury (2004c) guidance, the client should be proactive and seek to identify anti-competitive collusion and/or predatory behaviour that may be encountered during its procurement process and devise strategies for dealing with the identified situations as they arise.

In addition, the National Treasury (2004c) requires the client to give consent to a change of an actor in a private party in the course of the procurement process. The client should only allow such change if it increases the strength of the private party against its prequalification criteria. The ability to withhold consent is a powerful tool for the client to prevent collusion and/or predatory behaviour. However, it must be noted that it is also possible that if the client were to withhold its consent on a change of a consortium member, it might cause a private party to abandon the bidding competition with adverse consequences on the level of competition.

7. Conclusions

The legislative and regulatory framework and the associated guidance documentation used to govern PPPs over their project cycles in South Africa appear to foster competition. If public sector clients successfully implement all the prescribed measures on actual projects they are likely to result in improved value-for-money projects. There are, however, a number of issues inherent in the guidance documentation that require further investigation, such as whether the current recommendation on the magnitude of bid bonds is appropriate and whether the requirement for private parties to carry out a due diligence before being appointed the preferred bidder increases bid costs to the extent that it deters some of them from entering the bidding competition. In addition, it is not known how the procedures are implemented in practice. Thus, further research is also required in order to establish whether clients can translate the existing procedures for procuring and governing PPPs to value-for-money projects.

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Regulating Professions: Shifts in Codes of Conduct

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Abstract

Professional institutions were established by professionals, for professionals. The way that these professions evolved has led to a need for them to regulate themselves. This has resulted in the development of codes of conduct to which members must adhere, under threat of expulsion. Since these professions were established, the definition of ‘consumer’ or ‘client’ has changed radically. This has led to discrepancies between self-regulation and imposed government regulatory measures. Clients rely on professionals having a code of conduct to protect their interests, however these codes are under attack as they are often considered to be anti-competitive. Government is influencing the way these organisations conduct themselves, as is clear from changes in the profession’s codes of conduct over the last two decades.

Keywords: self-regulation, consumer, client, professional, competition.

1. Introduction

1.1 Overview

The development of the professions is an interesting but complex story. In the UK, many of the construction professions were created by entrepreneurial adventurers who forged new techniques and ways of working, and developed distinctive bodies of knowledge [1]. As the technologies involved were inherently dangerous, practitioners adopted models of self-regulation based on those of the existing medical professions, as well as the mutual cooperation model of the guilds. Practitioners felt the need to protect themselves from charlatans who would not only work more cheaply, but also bring the field into disrepute. Thus professional self-regulation is a two-edged phenomenon: public protection and protection of the profession [2].

Apart from regulating entry into the profession, the primary form of self-regulation for architects has been the publication of codes of professional behaviour. The idea behind this is that any member who behaves unprofessionally may be barred from practicing.

1.2 International relevance

UK government takes an ‘ad hoc’ approach to regulating the professions, in contrast to many European countries, where the regulation of professions is treated more systematically. Due to its unique history, the UK avoided the Napoleonic legal reforms which swept through the Continent in the early 19th century. As a result, the UK retained its political system intact since 1688, despite significant social and electoral reforms, whereas many European political systems have their origins in the 20th century.

In the UK, the status of many professions was formalised in the first half of the 19th century via the grant of royal charters to self-regulating institutes. For example, the Royal Institute of British Architects (RIBA) was established in 1834. After a period of self-regulation, the government introduced a regulatory body called the Architects’ Registration Council of the United Kingdom (ARCUK) in 1931, which was replaced by the Architects’ Registration Board (ARB) in 1997.

Paradoxically, while the title ‘architect’ is protected under UK law, there is no restriction on carrying out the functions of an architect. Thus individuals who are trained and registered as architects are subject to professional regulation. In contrast the unqualified may practice architecture subject only to the general law, as long as they do not call themselves architects.

While the RIBA does not currently have a statutory role, it functions as a professional society dedicated to advancing the cause of good architecture, as well as promoting architectural education and good practice. The RIBA is a self-regulating body, and its members must adhere to the RIBA Code of Professional Conduct, which has been subject to many revisions in the past 25 years.

This research is concerned with examining whether such a code is responsive to changes in the wider business, economic and legislative environment. The purpose of this ongoing PhD research is to track the significant changes to the RIBA code of conduct since the 1981 edition of the RIBA Code of Professional Conduct and Standard of Professional Performance, and identify the drivers of these changes.

The importance of this research is to trace whether these changes are responses to commercial or to regulatory pressures. For society at large, in other words, this raises the important question of whether professional codes of conduct focus on the public good, or on institutional survival, or a mixture of the two. This question has been debated within the RIBA and other construction professions since at least the 1970s [3] and continues to be topical. Even today, there are serious questions about the future of the professions in the construction sector [4].

1.3 Regulatory background

Article 81 of the Treaty establishing the European Community (EC) prohibits agreements or decisions by participants within a market sector ‘which have as their object or effect the

prevention, restriction or distortion of competition' [5]. Subsequent legislation has created more effective mechanisms for enforcing Article 81 within the UK. 'Since 1 May 2004 not only the European Commission, but also the Office of Fair Trading (OFT) has the power to apply and enforce Articles 81 and 82 of the EC Treaty in the United Kingdom' [6].

In 2000 in the UK, the Office of Fair Trading began conducting investigations into professions whose services constitute a significant portion of the economy. Such professions as accountancy, law and architecture fell into this category, while teaching and the medical professions were excluded [7]. The purpose of their investigation was to reveal whether the selected professions were carrying out practices deemed anti-competitive.

Perceived restrictions on competition targeted by the OFT included limitations on entry, demarcation, and conduct. The OFT's stated position was that '(a)part from those shown to be necessary for economic efficiency and consumer benefits, restrictions on competition should go' [8]. This portion of the research will focus on those restrictions which fall under the heading 'conduct,' including fixed and recommended fee scales and advertising.

The OFT's investigation brings to light the relationship which the client/consumer is meant to have with the professional. The OFT acknowledges that a high quality service is inherently supplied by a person who is qualified, which is the traditional basis of professional practice. However, they advance the thesis that a consumer and a client are one and the same, which marks a new departure in the history of the client-professional relationship. In deregulating the professions, the OFT is pursuing a consumer-centred agenda. This is reflected in the dual mandate of the Architects Registration Board (ARB), a statutory body set up in 1997: "Protecting the consumer and safeguarding the reputation of architects" [7]. The precursor to the ARB had itself been under threat, as the legislation concerning the protection of the term "architect" had been under threat for some time [9].

The frequent changes and amendments to the RIBA Code of Conduct since 1981 are a reflection of the forgoing influences and form the subject of this study. It is interesting to see how the profession has responded to these pressures, and it seems safe to assume that formal responses to perceived changes in the business environment of architects will be reflected in the way that a code of conduct is revised and amended. Thus, it is proposed to track the RIBA's response to the enforced deregulation of the profession through content analysis of successive editions of the code of conduct, to examine whether substantive changes are reflected by changes in vocabulary or scope of the code of conduct.

The RIBA has generally responded by complying with the OFT's requirements, deleting or amending clauses of the code, whilst resisting wholesale changes. However, January 2005 marked the publication of a completely rewritten Code. This research is intended to track both of these responses to the deregulation of the profession through content analysis. Content analysis is a research technique that is designed to elicit meaning and context from documents. The purpose is to examine the words and the meanings with documents, and in order to do this data collection

consists of identifying the presence, frequency, prominence, direction and intensity of particular ideas, words or phrases [10].

1.4 Research method

Based on the history and sociology of the key professions in the UK, the evolution of codes of practice are contextualised, with particular reference to advertising, property development, fee discounts/competition, professional indemnity insurance, client expectations, business exigencies for the practice, etc.

By using the content analysis methods of word frequency count and keyword-in-context, this research is an attempt to track changes in the RIBA Code of Conduct between 1981 and 2005. It is anticipated that patterns will emerge reflecting overall trends in professional regulation as well as shifts in professional practice.

2. Codes of conduct from 1981-2005 (total word and significant word count)

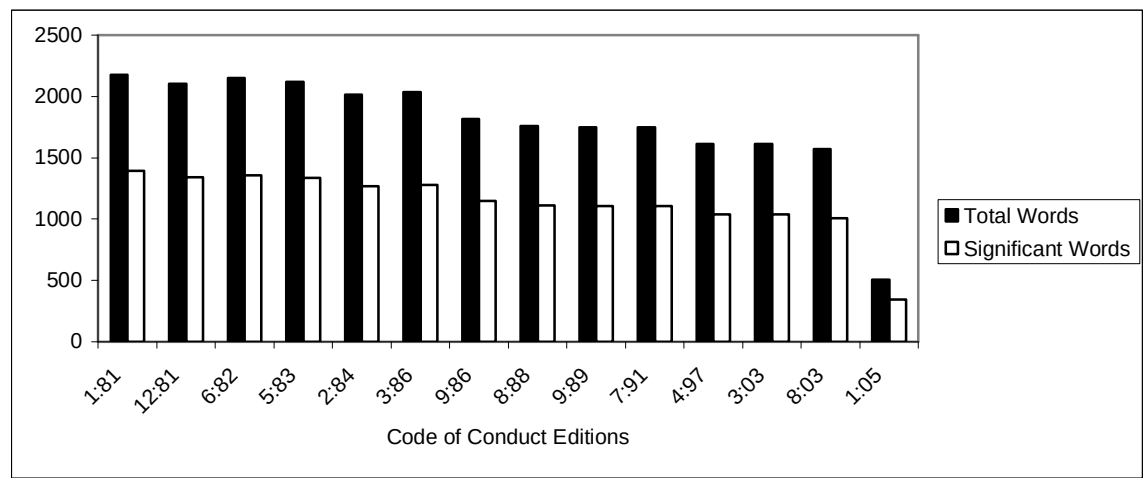


Figure 1: Numbers of words in successive editions of RIBA Code of Conduct

2.1 Methodology

The first part of the research entails mapping out the RIBA Codes of Conduct from 1981 to 2005 to observe how the content of the Codes have changed over the last twenty years. The objective is to see if there are any patterns that emerge out of the alterations in content within this timeframe. Figure 1 indicates a full word count of the contents from 1981 to 2005. The content of the Codes during this period have been edited to include only those words deemed significant

for the study. Table 1 shows which words were excluded from the total word count in arriving at the significant word count.

Table 1: Words excluded from the significant word count

a	be	doing	in	so
an	been	done	into	that
and	before	for	is	the
any	being	from	made	to
are	by	has	make	with
as	do	have	of	
at	does	having	on	

2.2 Observations

Based on Figure 1, the following observations can be made:

- § word pattern and count is fairly consistent from January 1981 until June 1991.
- § word pattern dramatically changes in April 1997, but remain constant in the subsequent 2003 editions.
- § there is a another dramatic shift in word pattern in the January 2005 edition, where word count dramatically drops.

It is apparent in Figure 1 that there is a sharp decrease in the word count from the 2003 edition to the 2005 edition, which indicates a major alteration to the content of the Code during those periods. This signifies a concerted effort to rewrite, not merely amend, since edits and simple revisions may usually be expected to cause only minor variations in document length.

3. Specific keywords

3.1 Methodology

In Figure 2, specific keywords in the research are counted within each of the Code editions. These words have been selected as they relate to the portions of the code that have previously been under question by government, such as the responsibilities of the professional to the public. Part of the investigation is to determine if their meaning and use has changed over time, or to see if their use has diminished.

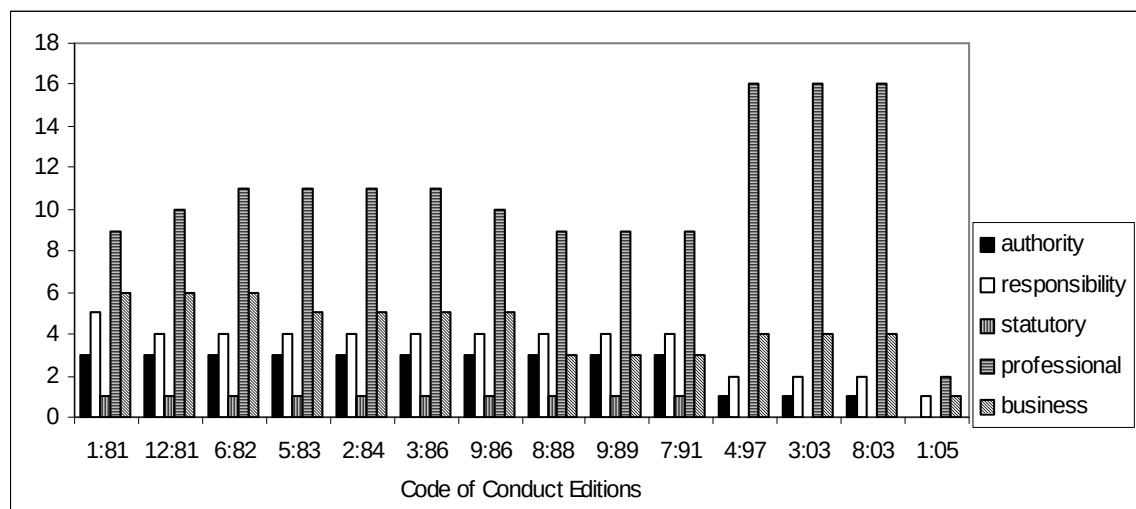


Figure 2: Number of occurrences of specific keywords across Code of Conduct Editions

Words have been selected for analysis that are expected to form part of the a meaningful message to members of the profession with references to:

- services provided to the client
- issues of professional integrity
- corporate (acting as a single body) as opposed to competitive behaviour

Potential conflicts between these categories are addressed at certain points in the various editions of the code of conduct. This particular avenue will be explored further in future research.

3.2 Observations

Based on Figure 2, the following observations on specific word count and pattern of use from 1981 to 2005 editions may be made:

- § the word count pattern is consistent in that there is a reduction in the use of terms from the January 1982 edition through to the January 2005 edition.
- § the word ‘professional’, whose use jumps dramatically from the April 1997 to the August 2003 edition, is an exception to the trend noted above. ‘Professional’ is then dropped completely in the January 2005 edition.
- § the word ‘authority’ is dropped entirely in the January 2005 edition.

Comparing the overall word count in Figure 1 and the specific keyword count in Figure 2, some specific keywords follow the trend discernable in the overall word count, while others follow their own pattern. For example, the specific keywords ‘authority’ and ‘responsibility’ follow the trend of the overall word count, whereas ‘professional’ has its own distinctive pattern.

4. Keywords in context

4.1 Methodology

Although word count is used as a method of analysis, further validation of results is necessary to indicate the use of the word in context and to identify distinctions of meaning. In Section 3, specific words were counted and observed. However, there are other specific words that occur which have alternate meanings depending on their context. The table in Figure 3 indicates examples of alternate meanings identifying the edition and the precise context in which the specific word is used.

4.2 Observations

As indicated in Figure 3, the word ‘competition’ is used in the contexts: ‘architectural competition’, ‘competition between members’ and ‘any form of competition.’ In note 2.9.6 of the January 1981 edition, “architectural competition” refers to a formal process where architects are invited to submit design solutions to a defined brief in order to win an award. In note 3.2.2 of the same edition, “competition with other members” refers to a member’s behaviour. It is considered ‘unprofessional’ for members to compete with each other on the basis of price or by questioning the reputation of another member.

COMPETITION	
January 1981 Edition	
note 2.9.6	An employing architect should permit the architects he employs to enter architectural competitions but they should not do so without the knowledge of their employer
note 3.2.2	It would be contrary to this Rule for a member to submit estimates of fees and expenses knowing that they would be used for the purpose of competition with other members .
January 2005 Edition	
RULE 2.2	Where members are engaged in any form of competition to win work or awards, they should act fairly and honestly with potential clients and competitors. Any competition process in which they are participating must be known to be reasonable, transparent and impartial. If members find this not to be the case, they should rectify the competition process or withdraw.

Figure 3: Example of key word in context

In rule 2.2 of the January 2005 edition, the term “competition” is used to refer to both a competition to enter into and competition among members for work. Thus, the word ‘competition’ has two different meanings in different contexts in the January 1981 edition, whereas in the January 2005 edition, it is used with both meanings in the same context.

Specific keywords may have different meanings attributed to them by regulatory bodies. For example, the Monopolies and Mergers Commission, a UK regulatory body, have investigated what they deem as “anti-competitive” behaviour in the professions, resulting in the eradication of fee scales [10]. The discrepancy in the use of specific words such as ‘competition’ by the profession and by regulatory bodies will be investigated in further research.

5. Code breakdown: principles, rules and notes

5.1 Methodology

The Code is broken down in Principles, which are further broken down into Rules and Notes. The table in Figure 4 is used to distinguish between types of amendment by means of graphical notation.

5.2 Observations

Each of the categories from the 1981 to the 2005 editions of the Code was tracked, as indicated in Figure 4. From 1981 to 1991 the majority of content appears to have remained unchanged. The following types of change in content were noted:

	1:81	12:81	6:82	5:83	2:84	3:86	9:86	8:88	9:89	7:91	4:97	4:97	3:03	8:03	1:05	1:05
PRINCIPLE 3																
RULE 3.1																
RULE 3.2																
RULE 3.3																
RULE 3.4																
RULE 3.5																
RULE 3.6																
RULE 3.7																
note 3.0.1																
note 3.1.1																
note 3.2.1																
note 3.2.2																
note 3.3.1																
note 3.3.2																
note 3.4.1																
note 3.5.1																
note 3.6.1 a)																
b)																
c)																
d)																
e)																
f)																
g)																
h)																
i)																
j)																
note 3.6.2																
note 3.6.3																

LEGEND		existed in January 1981
		no change
		amended
	...	moved
	3.3	moved from named location & amended
		new
	j	deleted in favour of individual judgement
	X	deleted

Figure 4: Example of mapping technique, illustrating changes to Principle No. 3

- content is unaltered (remains unchanged)

- amendments:
 - § content re-used, with slight amendments, maintaining original meaning
 - § content re-used, with amendments, altering original meaning
 - § re-written with an altered meaning
- moved as a result of ‘reshuffling’ but maintaining original content
- moved and amended
- deletions
- additions

The instances of major change in editions of the Code become apparent between the 1991 and the 1997 edition and then again in the 2005 edition, where the content is almost completely altered. Deletions appear to be particularly meaningful because it appears that the professional institution has responded to government demands primarily by ‘striking out’ content. Figure 4 illustrates the evolution of Principle no. 3, by way of example. There are also several instances of compulsory rules being replaced by a requirement to exercise professional judgement. This may indicate a more proactive approach to self-regulation, centred on the individual practitioner.

6. Conclusions

A review of the RIBA Codes of Conduct from 1981 through to 2005 has revealed a number of fundamental themes relating to professional regulation:

In the research carried out thus far, instances of deletions seem to be particularly meaningful because it appears that from 1981 to 1997 the professional institution has responded to government demands primarily by ‘striking out’ content. This appears to indicate a policy of minimum compliance to regulatory pressures.

The concept of ‘competition’ in particular is central to understanding the conflict between the interests of the profession, as represented by the RIBA, and the interests of the public, as advocated by the Office of Fair Trade. Thus the word ‘competition’ takes on various meanings in the editions of the Code of Conduct, in the context of the removal of competitive barriers.

Finally, in 2005 a re-written version of the RIBA Code of Conduct has addressed the deregulation of the profession by replacing mandatory rules with the use of professional judgement. This is a more pro-active approach to the regulatory pressure than the previously mentioned strategy of deletion.

Thus the methodologies of word count, keyword in context and a study of the categories of changes to the code appear to offer a promising direction in further research.

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Factors Affecting the Selection of Building Contract Payment Systems

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Abstract

The selection and development of an appropriate project cash-flow model can promote the Egan principles of integration and early project based planning. This is a fundamental concept behind a research project that aims to encourage the use of appropriate innovative payment systems in the UK building industry. The project, which is funded by the Engineering and Physical Science Research Council (EPSRC), investigates the potential advantages of using payment systems by linking them to project characteristics and performance. This paper identifies the alternative payment mechanisms available for use in the building industry; and investigates whether practitioners are providing appropriate advice to their clients on the selection of appropriate payment systems for their projects. The paper then considers data gathered through direct interaction with practitioners so as to explore current practice on the ground. This contact was iterative in its nature and this process was continued into the next stage of the project through the use of conference type discussions. The preliminary finding from this phase of data collection and analysis is that the payment system selection process itself lacks coherence and consistency. This lack of consistency in practice suggests an ad-hoc approach to the selection of payment systems, which could be a constraint on the delivery of post Egan change in practice. This interim finding reinforces the case for the research and the paper concludes by outlining the next phases of activity.

Keywords: building industry, cash-flow, Egan principles, payment system.

1. Introduction

For what can be regarded as a very long time now, the construction industry has been shown to be inefficient and unproductive which has been made more obvious by the success of other industries, such as manufacturing, that are sometimes using similar approaches. The Latham Report (Latham 1994) [1], for example has highlighted inadequacies in contracting *per se* whilst the Egan Report (Egan 1998) [2] featured major clients who are not happy with the traditional methods. The construction industry has been recognised as a financially higher risk industry (Ruddock, 1996) [3]. The nature of the industry is such that generally the

project construction team prefinances the project and then relies on being reimbursed for the works to progress diligently. Unfortunately though, many main contractors have faced severe financial difficulties when their source of cash flow to execute contracts slows down, and even in some cases, ceases altogether. Subcontractors and suppliers are often at the mercy of their main contractors who sometimes refuse to release their payments accordingly. The lack of money in the industry is made worse by the lack of trust amongst supply chain players.

It is thus paramount that the industry moves away from the non productive approaches it has been renowned for in the past. This should include establishing effective means of ensuring cash flows to the entire project construction team. This research project believes that payment systems can assist the building industry to be more efficient and productive. There are novel alternative payment systems that are effective contract management approaches. The issues raised in this paper can be a source of encouragement to clients and their advisers to endeavour in designing and choosing the appropriate payment systems for their projects so as to achieve better success in project delivery.

The paper starts by referring to literature review noting the pricing and payment systems in use in the global building industry and the forms of contracts in which they are applicable. This is then followed by consideration of the data from the interview survey focussing on the systems in use in the UK and the factors that influence practitioners' choices. Each of the eight most common factors is then discussed.

2. Pricing, payment and contracting systems

A study by Njie *et al.* (2005) [4] reviews relevant literature and identifies several pricing and payment systems used in the global building industry. These systems are illustrated in **Figure 1** with five systems categorised under payment systems exclusively for payment only and eight others under pricing systems for both pricing and payment. This research project assumes payment systems to refer to the approach in which building products and services are priced and paid for.

Standard forms of contracts for building works often require the client to make periodic payment of the agreed contract sum to the contractor. It is the principles behind these contracts with regard to their pricing/tender and payment procedures that this study is based on. **Table 1** from Njie *et al.* (2005) [4] illustrates the most common standard forms of building contracts with their associated existing payment systems. The novel payment systems such as the stage payments, incentive contracting, direct payment, trust accounts/funds, mobilisation advance payment and the mechanic's lien can be used with any contracting system. Standard forms for civil engineering projects, notably the ICE and FIDIC, use the same payment systems as their corresponding JCT contracts.

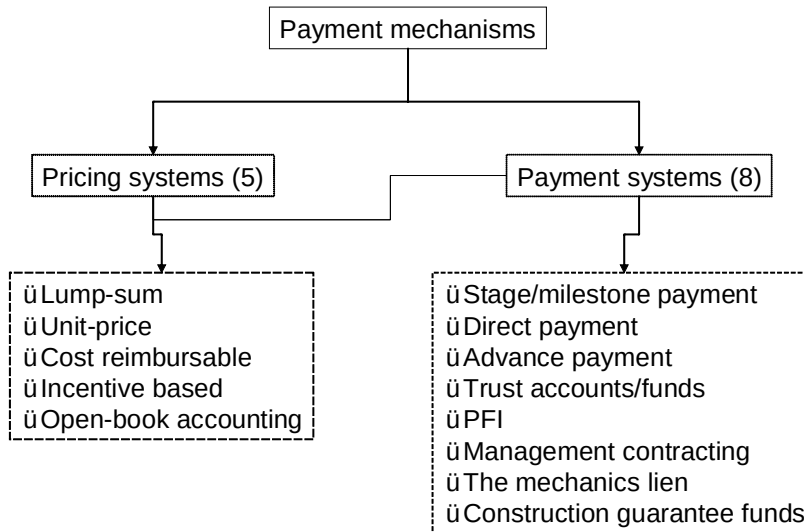


Figure 1 - payment mechanisms identified from the literature

Table 1 - the most common building contracts with their associated payment systems

Building contracts	Lump-sum	Unit-price	Cost-plus-percentage-of cost	Guaranteed maximum cost	Novel payment systems
JCT 98 Standard Forms					
Private or Local Authority					√
1 with quantities		√			√
2 without quantities	√				√
3 with appro. quantities		√			√
4 with contractor's design	√			√	√
5 IFC 98 Intermediate Form	√	√			√
6 MTC 98 Measured term		√			√
7 MC 98 Man. contract				√	√
8 CM 02 Construction Man.					√
9 PCC 98 Prime Cost	√				√
10 GCWks1 Edition 3		√			√
11 NEC	√	√	√	√	√

3. The interview survey

The first phase of the research project started with a comprehensive review of the relevant literature on issues concerning the payment systems in use in the building industry in the UK as well as elsewhere. This was followed by data collection through direct interaction with practitioners so as to explore current practice on the ground. This contact was iterative in its nature and structured interviews with six questions were carried out with eight practitioners whose businesses were located in both Scotland and England. The professional backgrounds of the interviewees were: consultant quantity surveyors-5 number, architect-1 number, building services subcontractor-1 number and PFI project company-1 number. A short

description of each of the eight companies interviewed is made as follows: Pilot Company, and Companies V, Y and Z are leading consultancy firms operating worldwide providing cost and risk advice; Company T is a project company that was set up to work exclusively on PFI projects; Company U is a regional consultancy firm providing cost and risk advice; Company W is a building services subcontractor; and Company X is a regional consultancy firm providing architectural and design advice for predominantly housing association work. The sample of firms for the interviews was primarily provided by members of the project steering group. The intention was to provide a good mix of practitioners in both Scotland and England. The sample is however, not necessarily a structured, representative sample of the UK building industry. Only two of the six questions are considered in this paper.

3.1 Pricing and payment systems in use

Table 2 shows that the traditional pricing and payment systems of the unit-price and lump-sum remain the most frequently used systems by six out of the eight companies interviewed. The two other systems that are the first choice to these companies are the stage payment and the PFI payment mechanism. Others, such as direct payment, mobilisation advance payment, cost-reimbursables and trust accounts/funds are used, in that order, as alternatives with trust accounts/funds also as the system most said to be not in use. Whilst the incentives, management contracting payment mechanism, construction guarantee funds and the mechanic's lien are not used at all.

Table 2 - the pricing and payment systems in use

Item ref.	Company	Most Used	Others Used	Not Used
1	Pilot Company	b	a, c, f and j	d, e and h
2	Company Z	d	many incl. f, a and b	g
3	Company Y	b	a, c, d, g, and h	-
4	Company X	b	a	c, g and h
5	Company W	a	b	c, d and h
6	Company V	a	d, b, f and h	c and g
7	Company U	b	f, a and h	g and k
8	Company T	j	f and h	d and g

Key:

- a. Payment requests for lump-sum contracts**
- b. Payment requests for unit-price contracts**
- c. Payment requests for cost-reimbursable contracts**
- d. Stage payment (also the pre-agreed cash flow, s-curve or drawdown schedule)**
- e. Incentive contracts**
- f. Direct payment**
- g. Payments from trust accounts/funds**
- h. 'Client financed construction' procedure/mobilisation advance payment**

- i. Construction guarantee funds
- j. Private Finance Initiative (PFI)/Public Private Partnership (PPP)
- k. The mechanic's lien
- l. Management contracting

3.2 Factors for choosing payment systems

The eight companies interviewed consider nineteen factors when choosing payment systems with eight of these factors being considered by at least two companies. These eight factors are procurement (Companies U, V, Z and Pilot); risk (Companies V, W, Y and Z); project characteristics/circumstances (Companies U, V and Y); project duration (Companies V and Pilot); project complexity (Companies W and Pilot); project stakeholders (Companies Y and Z); client's requirements (Companies U and Y); and client's experience (Companies V and Z). The eight factors are put in three clusters (see Figure 2) i.e. procurement and risk as the most considered - that is by four companies. Followed by Project characteristics/circumstances which is considered by three companies. And then the remaining five factors which are considered by two companies.

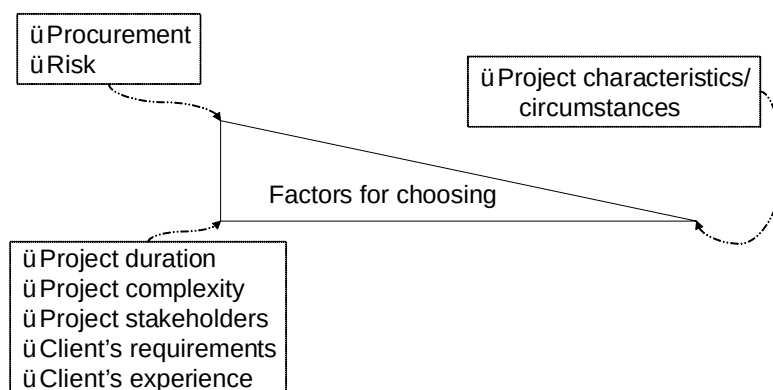


Figure 2 – the common factors for choosing a payment system

4. Discussions

4.1 Pricing and payment systems in use

The companies interviewed demonstrate different perceptions of pricing and payment systems. For instance, Pilot Company appears to regard any payment method that does not allow monthly payment as inappropriate and paying monthly in arrears as a payment method. Paying monthly should, however, be seen as a feature of a payment system to indicate the payment interval or period. Company Y seems to regard the traditional pricing and payment method as any method base on valuation of actual work done. This to them only includes the unit price and lump sum methods and excludes payments base on monthly pre-agreed cash flow, s-curve. Company V also seems to misunderstand issues concerning payment systems by focussing mainly on the payment period.

The companies who are fully engaged in decisions on payment systems get involved at the strategic end of the project when clients are making decisions on procurement and contracting issues. The majority of the eight companies interviewed simply use the payment terms and systems within the client's chosen contract and/or procurement strategy. Perhaps the use in the UK of the traditional procurement method (i.e. the lump sum), as shown in a survey by the RICS Construction Faculty (2003) [5], suggests why the traditional payment methods are also still the first choice.

Some of the companies have showed resistance to using alternatives to traditional payment methods such as stage payments. This suggests that adherence to routine is seen as a way of avoiding another risk that is to be managed. This is a human/social issue rather than a technical issue. The lack of use of alternatives also suggests that the durability of professional roles is preventing experimentation with payment systems. Another interesting observation is that the authority of partners is critical in the choice of payment system to use. Decisions and preferences on payment terms and systems used seem to depend on the partner-in-charge. As is the case with Companies Y and Z and also with Pilot Company and Company V, partners in the same organisation are using different payment systems. This suggests that such organisations are ready to be flexible and are not acting as champions for any particular payment system.

4.2 Factors for choosing payment systems

Construction contracts normally stipulate that the client makes part payments of the contract sum to the main contractor as the work progresses. As indicated by Harvey & Ashworth (1993) [6], it is unusual, except possibly with the smallest of projects, for the whole work to be completed before any payment is made. The procedure followed depends very much on the position of the client and the type of construction

involved. The eight companies interviewed consider several factors when choosing payment systems the most common of which are discussed below.

4.2.1 Procurement

It is vital to accomplishing project success to ensure that at an early stage special care is taken in selecting the most suitable organisation for the design and construction process. This organisational concept is referred to by Masterman (2002) [7] as the “procurement system” defined as the organisational structure adopted by the client for the implementation, and at times eventual operation, of a project. Procurement is an approach used by an industry to organise itself to execute projects. Building procurement is about the practical manner clients who want to build proceed to obtain that building. Most potential clients of the construction industry have to cope with a variety of complex skills and resources that are necessary to produce the building to accomplish their needs. It is only the simplest of buildings that do not demand the management, design, assembly and commissioning of large quantities of raw materials and the use of significant labour resources over a long period of time. The completed building is the end product of the integration of the diverse skills of the entire members of the professional and physical construction project team including the client. All those involve collaborate closely to deliver the required result to the specified quality and value for money.

Company V cites as example, the choice of a procurement route, such as construction management by major repeat airport clients who have the set up to handle large sums of money a month and the volume of certification and paper processing that go with it. This is not the case for the smaller provincial airport client who has limited number of personnel. So the overriding factor to Company V is not to design a payment system but to choose a route which is more applicable or manageable to a client.

4.2.2 Risk

As reiterated by Flanagan & Norman (1993) [8], the construction industry is exposed to more risk and uncertainty than perhaps any other industry. The construction industry is different from other industries in many ways such as: its traditional processes of delivering projects, temporary project teams, adversarial attitudes, bespoke products, unique site and ground conditions, and complex contractual arrangements. It is these differences which make up the distinguishing characteristics of the construction industry and why it is regarded by many as unique.

There are all sorts of risks arising from both the internal and external environment of a project or organisation and affecting the project performance in terms of successful delivery of project success factors such as completion of time, within budget and of the specified

performance. There are contractual implications that emanate from these consequences. It is thus vital that the client and project teams possibly led by a professional project manager consider the risk factors adequately and early enough to avoid their occurrence which could have damaging effects on the project and its performance. The client's approach to risk management is important, for example, as noted by Company T, to eliminate the risk of it overpaying the contractor such that it will be able to step in to complete the works if the contractor was to go burst. Also, the selection and use of an advance payment method to carry out work (which is basically a client financing approach to provide funds to the contractor before they are due) is quite risky, and therefore it is necessary to find ways and means of mitigating such risks (Abeysekera, 2002) [9]. The importance of risk management is further emphasised by Pilot Company who recognises that the chosen procurement route depends on how much risk is shared in the project and how much risk is allocated to the contractor.

4.2.3 Project characteristics/circumstances

There are many variables that make up a project's characteristics such as building type, building size, project complexity, project duration, one-off nature and the composition of the supply chain including specialists work's subcontractors. All these will have significant impact on the procurement and contractual options including their pricing and payment terms. As clients become ever more sophisticated, knowledgeable and demanding and projects become ever more complex and difficult, there is greater pressure on the client's professional advisers to choose the most appropriate options to ensure success in project delivery. As such, Company Y, for example, would design a payment system that assists the contractor if it is a large project that requires a large amount of plant to be brought to site before any site activity starts. However, they only provide assistance, such as advance payments, where the contractor needs it. Also, in some types of construction, such as housing, specified payments are made at the completion of particular stages of the project or at defined points of progress, such as at completion of excavation and foundation, at completion of framing to enclose the structure, at installation of mechanical and electrical rough-in, at completion of the interior finish, and at full completion. A payment system should be unique to the project circumstances.

4.2.4 Project duration

Although a variable of project characteristics, project duration has been found important enough to be treated separately. It is one of those client's requirements whose achievement indicates project success (Chinyio *et al.*, 1998 [10], Cornick & Mather, 1999 [11] and Winch, 2002 [12]). It would also affect the choice of payment system. If the client regards time of completion as of great essence, the contract can include provisions for the contractor to receive, on top of the base fee, a fixed amount of money for each day of useful occupancy gained by the client prior to the originally agreed-on completion date. This provision can be extended such that the contractor's fee can be reduced by the same sum for each day

completion is delayed. There are a number of incentivisation and disincentivisation provisions used in the construction industry as identified by Bubshait (2003) [13] and Arditi & Yasamis (1998) [14].

4.2.5 Project complexity

Although a variable of project characteristics, project complexity, like project duration, has been found important enough to be treated separately. Decision makers should factor it in their decision-making process. For example, the lump-sum type of contract, according to Clough & Sears (1994) [15], is popular with clients for the obvious reason that the total cost of the project is known in advance. Nonetheless, its use is limited, of necessity, to construction projects that can be accurately and fully described at the tender or negotiation stage. As a result, they are generally used for residential and building construction. If it is not possible to accurately determine the nature and quantity of the work prior to the start of site activities, then the lump-sum type of contract with its inherent payment terms is not suitable.

4.2.6 Project stakeholders

The influences of the project stakeholders along with uncertainty are two factors, in particular, maintained by Kolltveit & Grønhaug (2004) [16] to affect project performance. Several stakeholders can be involved in a major and complex project. The internal stakeholders, such as the project client, project sponsor, project manager and other members of the supply chain, are individuals and/or organisations involved in the project activities. The external stakeholders, such as the community in which the project is being built and pressure groups, for example, environmentalists, are individuals and/or organisations who may be affected by the project activities. The external stakeholders, and maybe even some members of the internal stakeholders, have their own expectations which may not be compatible to the corporate project objectives. It is thus vital to recognise the influence each of these stakeholders are exerting, or trying to exert, on the project so as to sensitise them adequately and to benefit from the payment system that is selected.

4.2.7 Client's requirements

As put by Company Z, the client's objectives - delivering what the client actually needs - is the main and most important driver in anything. For example, if the client requires that he does not pay for QS fees for the valuation exercise, Company Y would set up a system where the contractor bills the client and then point out to the client the risk of doing this for the client to find a balance. Also, although Company U tends to pay at monthly intervals, it also considers the client's need to adjust the payment intervals to suit the client and then incorporate it in the tender/contract documents. It maybe that the client's requirements and the circumstances of the project, for example, are that the client has to spend a sum of money by a certain time, say at the end of the financial year. This may then influence the

procurement route chosen, for example, to use two-stage tendering to speed up the process of getting the contractor to site so that the client can make payment to meet the deadline and release the money at a certain date. Every project should be looked on its own merit.

4.2.8 Client's experience

The bigger and more experienced clients, unlike the one-off clients, have their own preferred protocols which involves specific project pricing and payment options. The client may have preferred payment terms, for example, not to have a retention system on partnering projects because of the trust and long standing relationship over a period of a framework between the contracting parties. The experienced clients like the United Kingdom Ministry of Defence can invest in developing payment processes that are efficient enough to be applied across their projects. The choice of payment system would therefore depend on the client's experience in managing projects.

5. Conclusions

The unit-price and lump sum (traditional) payment systems are still mostly used and are said to be satisfactory. There is resistance to using alternatives to traditional payment methods such as stage payments, incentives, direct and advance payments which suggests routines as a way of avoiding another risk that is to be managed. This is a human/social issue rather than a technical issue. The lack of use of alternatives also suggests that the durability of conventional professional roles is preventing experimentation with payment systems. This was the case with procurement systems sometime ago - so change will take sometime to implement. Another interesting observation is that the authority of partners is critical in the choice of payment system to use. Decisions and preferences on payment terms and systems used seem to depend on the partner-in-charge. Partners in the same organisation are using different payment systems. This suggests that such organisations are ready to be flexible and are not acting as champions for any particular payment system.

The common factors that are considered when choosing payment systems are grouped in this order: procurement and risk; project characteristics/circumstances; and project duration, project complexity, project stakeholders, client's requirements and client's experience. A closer look at these eight factors suggests that at least some of these companies are deciding on payment systems that are project focused. For instance, decisions are made based on the desired objectives to be achieved and separate considerations are made depending on whether it is for stage payments or for different procurement routes such as PFI and partnering. Nonetheless, although, the companies identified these eight factors, they have also made it clear that when it comes to making the actual decision it is the client's requirement and what is contained in the chosen contract that matters. They base their decisions on payment terms and systems on what is contained in the chosen standard form of contract or what suits the preferred procurement system or client protocol i.e. what a particular client normally uses or prescribes. The systems (contracting, procurement and payment) that the clients and

consultants are using are the ones they are comfortable and happy with. Clients are not asking for advice on payment systems and decide on payment terms and systems prior to appointment of professional consultants who only adopt systems prescribed by clients and tend not to offer any advice.

Despite some of the companies seeming to have some form of strategy in place for deciding on payment terms/systems, on the whole, due to lack of any consistency, it is not clear whether these companies have a systematic process in place when they are considering payment issues. It could thus be implied that these companies seem to do everything ad hoc and follow their instincts and/or have no methodology.

The research project is currently conducting case studies on building projects which are using innovative forms of payment systems and have been through a partnering process and from live projects from the retail, commercial and social housing sub-markets. Ideally, all the key members of the supply chain should participate in the conference type discussions. The next phase of the project will result in the development of the computer-based simulator that will be used to analyse and assess alternative payment systems, so as to act as an aid to design or “fine-tune” payment systems to individual projects characteristics and needs, and also be used by projects’ stakeholders to forecast and plan their cash flow once a payment system is defined.

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Benchmarking Construction Firm Performance

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Abstract

Existing construction benchmarking models have four basic limitations if they are to be used for firm analysis on a company-wide basis. The first limitation is that the existing benchmarking models are project-specific. Second, as a consequence of being project-specific, they do not allow the measuring of the impact of certain technological and managerial attributes on overall firm performance. Third, current benchmarking models do not take note of trade-offs between the different metrics of performance. Fourth, the relationship between how much was expended on the metrics and the performance of those metrics (a return on investment of sorts) is absent.

This paper critiques existing construction benchmarking models and proposes a new construction benchmarking model that provides a performance metric for measuring firm performance on a company-wide basis and supports trade-off analysis among several performance metrics. Additionally, the proposed model relates the effort expended on the metrics of performance to the level of performance of those metrics and aids in the identification of management practices that lead to superior performance.

Key Words: IT utilization, construction, industry, contractor, performance, research, managerial attributes

1. Introduction

In recent years, the construction industry has recognized benchmarking as a possible catalyst for aiding the performance of the industry and improving its competitive edge in the global market. Benchmarking aims at comparing the performance of firms relative to each other, allowing these firms to recognize their weaknesses and strengths compared to the industry. It aids in the identification of industry leaders who exhibit superior performance as a result of using best industry practices. Since the time when the construction industry recognized benchmarking in this way, there have been several benchmarking models proposed. El-Mashaleh [1] critiques

these benchmarking models and argues that, if the goal is to measure company-wide performance, they all fall short in four respects.

First, the existing benchmarking models are project-specific. This limited view communicates a single metric performance on a single project and by no means translates to the overall performance of the firm. Second, as a consequence of being project-specific, the existing benchmarking models do not allow the measurement of the impact of certain technological and managerial attributes on overall firm performance. Third, the current benchmarking models do not support an understanding of the trade-offs among the different metrics of performance. Fourth, the relationship between how much was expended on the metrics and the performance of those metrics (basically a return on investment) is absent.

In a highly competitive environment, the long-term success of construction firms depends on improving performance by continually acquiring and applying new knowledge. Existing models have limitations in their ability to guide the industry into both benchmarking and identifying practices of superior performance.

This paper proposes a new construction benchmarking model that provides an overall performance measure for the firm and supports trade-off analysis among the several performance metrics. Additionally, the proposed model relates the effort expended on the metrics of performance to the level of performance of those metrics and aids in the identification of management practices that lead to superior performance. The proposed benchmarking model is deployed using data that was collected from 74 construction firms.

2. Previous Benchmarking Models

Camp [2] defines benchmarking as “the continuous process of measuring products, services, and practices against the toughest competitors or those companies recognized as industry leaders.” CII adopts the following definition of benchmarking: “a systematic process of measuring one’s performance against results from recognized leaders for the purpose of determining best practices that lead to superior performance when adapted and implemented.” [3] The following discussion presents three construction benchmarking models:

- Fisher et al. [4]
- Hudson [3] and CII [5]
- CBPP [6]

2.1 Fisher et al. Benchmarking Model

The Fisher et al. [4] benchmarking model was probably the first notable benchmarking effort in the history of the construction industry. Houston Business Roundtable (HBR) assembled a group of owners and contractors to solicit ideas and compile initial benchmark data for use by the construction industry. Data were collected from 17 companies for 567 projects regarding actual versus authorized cost, actual versus target schedule, actual versus estimated construction labor, and change orders versus original authorized cost (scope changes). Fisher et al. [4] summarized the results in the literature and these results should be studied by all who wish to learn about how well companies and owners do at predicting cost and schedule of projects and related topics.

2.2 Hudson and CII Benchmarking Model

Hudson [3] performed his benchmarking study under the guidance of the Benchmarking and Metrics Committee (BM&M) of CII. The database of this report consists of 901 projects from 37 owner and 30 contractor companies. The report supplies these norms depending on type of construction, project size, project nature, and project location.

2.3 Construction Best Practice Program Benchmarking Model

The Construction Best Practice Program (CBPP) benchmarking model is also known as the Key Performance Indicators (KPIs) model. The CBPP [6] indicates that the purpose of the KPIs, developed and implemented in the UK construction industry, is to benchmark a project or a company against the range of performance currently being achieved across the industry. It provides a framework to check how a construction business compares with the rest of the industry and helps firms to focus on their main priority areas of improvement.

The CBPP [6] argues that clients of the construction industry want their projects delivered on time, under budget, safely, efficiently, free from defects, and by profitable companies. The ten KPIs reflect the aforementioned criteria, as seven of the indicators relate to project performance, while the rest relate to company performance.

3. Critique of Existing Models

The reasons that existing models fall short of measuring company-wide performance were analyzed. The reasons can be categorized into the four areas discussed in the Introduction.

3.1 Measuring Project-level Industry Norms of Some Performance Metrics

The results of measuring project-level industry norms on a few, even well-chosen, metrics by no means translates to the overall performance of the firm. There are no answers to the question: where does a certain firm stand compared to other firms when considering overall performance (i.e., all metrics simultaneously)? An overall performance report card for the firm is sought. Overall performance takes on a particular importance to guard against improvement in one metric while losing on other metrics. Towill [7] stresses that “it is important to emphasize that improvement in one business performance metric (say cost) must not be sought at the expense of another (say quality or safety)”

3.2 No Measurement of the Impact of Technological and Managerial Attributes on Firm Performance

As a consequence of being project-specific, the existing benchmarking models do not allow measuring the impact of certain technological and managerial attributes on overall firm performance. The current models account for such measurement but on a single metric performance (i.e., impact of team building on schedule performance on a certain project). This limitation makes it difficult to identify practices that lead to superior company-wide performance. For example, advances in technology have been widely regarded as major sources of improvement in the competitive position of firms and industries, but, using existing models, overall firm performance cannot be tied to the level of technology adoption or utilization.

3.3 Tradeoffs Among Different Metrics of Performance

The current benchmarking models do not support an understanding of the trade-offs among the different metrics of performance. For example, if the firm’s cost performance has improved, but schedule performance has declined, how can one determine whether this trade-off is favorable or not favorable? That is, whether the overall performance of the firm is better or worse? McKim et al. [8] mention this trade-off among the different metrics of performance when they state that “as various techniques are available to control the cost, schedule, and quality individually, these three indicators of performance are highly interrelated and effect one another...these indicators are highly interrelated and require some balance and trade-off among them to achieve efficient overall control over project performance.”

3.4 Cost / Performance Relationships

The relationship between how much was expended on the metrics and the performance of those metrics is absent in existing models. Two firms that arrive at the same performance are considered to be similarly efficient. This is clearly not the case if one firm is expending more resources (i.e., money, personnel, etc.) than the other firm. It makes more sense to consider the firm that commits fewer resources to arrive at a certain performance as a better performer than the firm that is spending more resources to arrive at the same performance.

4. Benchmarking Model Development

4.1 Development of Metrics of Performance

Camp [2] and Spendolini [9] argue that identifying what is to be benchmarked, or the benchmarking metrics, is often one of the most difficult steps in the benchmarking process. Hudson [3] indicates that the BM&M committee adopts the following definition for a metric: “a quantifiable, simple, and understandable measure which can be used to optimize performance.” Hudson [3] also indicates that the BM&M committee adheres to the following principles for metrics used in the CII benchmarking system:

- A metric must provide a value to its stakeholders.
- A metric must focus on continuous improvement and establish an objective target.
- A metric can be influenced by adoption of better practices.

Additionally, Hudson [3] recommends utilizing “The Metrics Handbook” for devising metrics. “The Metrics Handbook” is published by the United States Air Force [10]; it characterizes a good metric as one that conforms to the following attributes:

- It is meaningful in terms of customer requirements.
- It tells how well organizational goals and objectives are being met through processes and tasks.
- It is simple, understandable, logical, and repeatable.
- It shows a trend, i.e. measures over time.
- It is unambiguously defined.
- Its data are economical to collect.
- It is timely.

Camp [2] states that benchmarking metrics are determined from the basic mission of the organization or business unit. How important are these benchmarking outputs or metrics in satisfying end users or customer needs? Ultimately a process exists for this purpose only and whether it should be benchmarked depends on the answer to this question. Benchmarking is the mechanism to ensure that customer needs are satisfied by industry practices. Spendolini [9] supports Camp's statement by linking what is to be benchmarked to the Critical Success Factors (CSF) of a business, which are the factors that have the greatest impact on the performance of the organization. Watson [11] defines CSF as "the limited number of areas in which results, if they are satisfactory, will ensure successful competitive performance for the organization. They are the few key areas where 'things must go right' for the business to flourish. If results are not adequate, the organization's efforts for the period will be less than desired. CSF are measured in basic business terms and are selected as measures of business effectiveness (quality), efficiency (cycle time), or economy (cost)."

To guide the selection of the benchmarking metrics, Camp [2] and Spendolini [9] recommend posing Xerox's ten questions:

- What is the most critical factor to business success (e.g., customer satisfaction, expense to revenue ratio, return on asset performance)?
- What factors are causing the most trouble (e.g., not performing to expectations)?
- What products or services are provided to customers?
- What factors account for customer satisfaction?
- What specific problems (operational) have been identified in the organization?
- Where are the competitive pressures being felt in the organization?
- What are the major costs (or cost "drivers") in the organization?
- Which functions represent the highest percentage of cost?
- Which functions have the greatest room for improvement?
- Which functions have the greatest effect (or potential) for differentiating the organization from competitors in the market place?

For the most part, the literature bases performance upon schedule adherence, cost performance, customer satisfaction, safety performance, and profit. Therefore, this research considers company-wide performance based on these five metrics. These metrics along with the associated method of measurement and calculation are shown in Table 1, which also shows that schedule performance is measured in terms of how often projects are delivered on/ahead of schedule. Similarly, cost performance is measured in terms of how often projects are delivered on/under budget. For both metrics, schedule and cost, the measurement is limited to projects closed in the last two fiscal years.

Customer satisfaction is measured in terms of the percentage of repeat business customers. Net profit after tax as a percentage of total sales for the last fiscal year is used to measure profitability of the firm. Safety performance is based on two indicators: Experience Modification Rating (EMR) and OSHA recordable incidence rate.

Table 1: Metrics of Performance Along With Their Measurement Method

Metric	Measurement/Calculation
Schedule performance	Percentage of the time projects are delivered on/ahead of schedule in the last 2 fiscal years (i.e., how often are projects delivered on/ahead of schedule?) Calculation (for projects closed in the last 2 fiscal years): Percentage = [(Number of projects delivered on/ahead of schedule) / (Total number of projects)] * 100%
Cost performance	Percentage of the time projects are delivered on/under budget in the last 2 fiscal years (i.e., how often are projects delivered on/under budget?) Calculation (for projects closed in the last 2 fiscal years): Percentage = [(Number of projects delivered on/under budget) / (Total number of projects)] * 100%
Safety performance	OSHA recordable incidence rate Calculation: Obtain last reported OSHA recordable incidence rate
	Experience Modification Rating (EMR) Calculation: Obtain last reported EMR
Customer satisfaction	Percentage of repeat business customers Calculation: In general, percentage of customers that come back for a repeat business with the firm
Profit	Net profit after tax as a percentage of total sales for the last fiscal year Calculation (for the last fiscal year): [Net profit after tax / Total sales] * 100%

4.1.1 Data Envelopment Analysis

DEA is concerned with evaluation of performance and it is especially concerned with evaluating the activities of organizations such as business firms, hospitals, government agencies, etc. In DEA, the organization under study is called a DMU (Decision Making Unit). A DMU is regarded as the entity responsible for converting inputs (i.e., resources, personnel, money, etc.) into outputs (i.e., sales, profits, customer satisfaction, metrics of performance, etc.). It is their performance that is to be evaluated. DEA utilizes mathematical linear programming to determine which of the DMUs under study form an envelopment surface. This envelopment

surface is referred to as the efficient frontier. DEA provides a comprehensive analysis of relative efficiency for multiple input-multiple output situations by evaluating each DMU and measuring its performance relative to this envelopment surface. Units that lie on (determine) the surface are deemed efficient in DEA terminology. Units that do not lie on the surface are termed inefficient and the analysis provides a measure of their relative efficiency.

The following example illustrates the basic idea behind DEA. Figure 1 plots the firms Input x1/Output y and Input x2/Output y as axes. From the efficiency point of view, it is natural to judge firms that use fewer inputs to get one unit of output as more efficient. Therefore, the line connecting C, D, and E is the “efficient frontier.” This frontier should touch at least one point and all points are therefore on or above (in this case) this line. All the data points can be “enveloped” within the region enclosed by the frontier line, the horizontal line passing through C, and the vertical line through E, suggesting the name Data Envelopment Analysis.

The relative efficiency of firms not on the frontier can be measured by referring to the frontier point in the example. Say Firm “A” is inefficient. To measure its inefficiency, let OA, the line from zero to A, cross the frontier line at P. Then, the efficiency of A is to be evaluated by: $OP/OA = 0.8571$.

The analysis can be extended to identify improvements by referring inefficient behaviors to the efficient frontier. The projected values for inefficient firms to become efficient can be calculated. From Figure 1, Firm A for example, can be effectively improved by movement to P with Input x1 = 3.4 and Input x2 = 2.6. The coordinates of P (3.4 , 2.6) are the projected values for A to become efficient. In the same sense, Firm B can be improved by movement to Q with Input x1 = 4.4 and Input x2 = 1.9.

The metrics of performance shown in Table 1 are the outputs to be used in conjunction with the proposed benchmarking model. Two inputs are accounted for in this part of the model: expenses on safety as a percentage of total sales and expenses on project management as a percentage of total sales. By considering these two inputs, the benchmarking model is relating the effort expended on the metrics of performance to the performance in the areas of those metrics. Firms that spend more on project management are expected to have better schedule performance, cost performance, customer satisfaction, and profit. Similarly, firms that spend more on safety are expected to have better safety performance.

Expenditures on safety are annual cost of safety programs and salaries of safety personnel. Expenses on project management are project management personnel salaries, annual costs of project management training, and annual costs of project management software acquisitions and updates. The reciprocal of EMR and OSHA incidence rate are used as the benchmarking model variables in order to convert these unfavorable measures to favorable ones, since the lower the values of EMR and OSHA incidence rate, the better the safety performance.

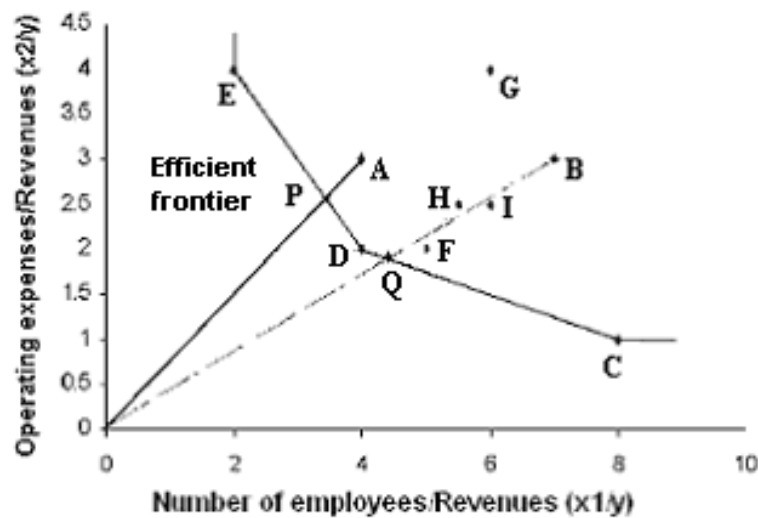


Figure1. Firm Efficiency as shown by DEA

5. Data Collection

The data for this research were collected through a survey questionnaire that collects general information about the person completing the survey, general information about the firm, and the performance of the firm on a company-wide basis. Firms are asked to supply their Schedule Performance, Cost Performance, Safety Performance (OHSA incidence rate and EMR), Customer Satisfaction, Profit, expenses on safety, and expenses on project management. The survey questionnaire was posted on the University of Florida web site and 545 practitioners were contacted by e-mail to fill out the survey. The research team received 88 responses, which accounts for a 16.15% response rate. The 88 respondents represent 74 firms.

6. Results and Analysis

This section benchmarks firms based on their performance against five metrics of performance: schedule adherence, cost performance, customer satisfaction, 1/EMR, and profit. The benchmarking analysis identifies efficient and inefficient firms and supplies inefficient firms with projected values for the metrics of performance. These projected values serve as a road map for inefficient firms to improve their performance and become efficient.

6.1 General Information

Fifty-two percent of respondents were upper management, 28 percent were middle management, and 13 percent were lower management. Forty-three percent of the firms that the respondents worked for were general contractors (GC), 29% were companies that could

function as a GC or construction managers (CM), 10% were CM firms, and the rest were some combination of design-build, GC, CM, subcontractors, or specialty contractors. Thirty-one percent of the firms work solely in the commercial construction area, 23% do commercial or industrial construction, 12% do commercial, residential, or industrial construction, and the rest were made up of heavy/highway contractors or some combination of some or all previously-mentioned areas of construction. Figure 2 shows the sizes of the firms, by revenue. Table 2 provides descriptive statistics for the metrics of performance along with the number of firms. OSHA recordable incidence rate is not reported because only a few firms supplied it.

6.2 Benchmarking Firms' Performance

Several DEA models were developed to benchmark firms' performance. Table 3 shows two of these. Model 1 is named FULL since it includes all metrics of performance and has both inputs. Model 2 is named SCCPE because it includes the following metrics: Schedule Performance, Cost Performance, Customer Satisfaction, Profit, and EMR. Model 2 uses unity (1) as input, just as several examples found in DEA literature [12] , Ozcan and McCue [13]. The reason behind using "1" as input lies in the fact that few firms supplied sufficient details in answering this part (expenses on safety and expenses on project management) of the survey questionnaire.

6.2.1 Model 1: FULL

For the FULL model, scores average 0.88 with a standard deviation of 0.23. The highest score is 1.0 and the lowest score is 0.22. Among the 21 DMUs, 16 are efficient (score = 1.0) and 5 are inefficient (score < 1.0).

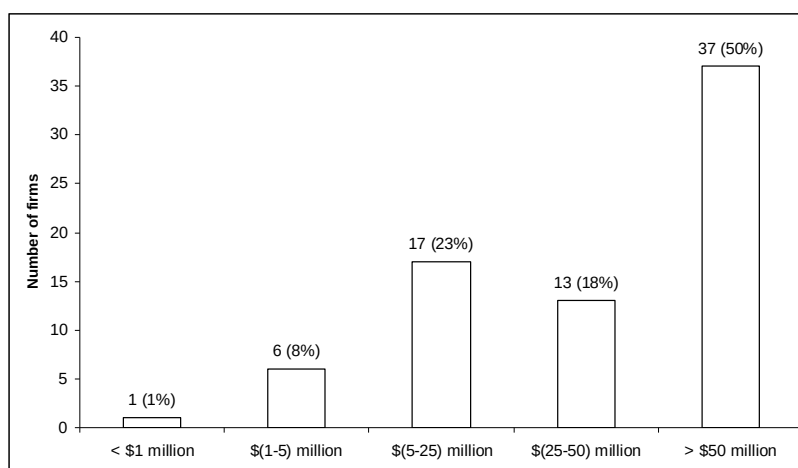


Figure 2. Firms' Revenue

Table 5 supplies the projected values for seven important metrics. The projected values are of particular importance to inefficient DMUs. By arriving at the projected values, inefficient DMUs have the opportunity to become 100% efficient. For example, in order to be considered efficient, Firm AN has to reduce safety expenses and project management expenses by 54% and

Table 2: Metrics of Performance Descriptive Statistics

Metric	Number of firms	Mean	Sd	Min.	Max.	25th Quartile	75th Quartile
Schedule performance (%)	69	80.3	23.12	10	100	75	95
Cost performance (%)	69	81.75	15.22	10	100	75	90
Customer satisfaction (%)	67	60.34	25.25	10	100	40	80
EMR	35	0.702	0.1356	0.45	0.95	0.61	0.8
Profit (%)	23	3.066	2.645	0.14	12	1.5	3.875
Safety expenses (%)	43	0.98	1.344	0.1	5	0.25	1
Project management expenses (%)	40	4.311	3.26	1	12	2	6

48.7% respectively. At the same time, AN has to improve its schedule performance, cost performance, 1/EMR, customer satisfaction, and profit by 5.26%, 7.69%, 4.11%, 26.92%, and 120.73% respectively. By meeting the above criteria (reducing inputs and improving outputs), AN can raise its score to 1.0 and can then be considered 100% efficient.

Table 3: DEA Models to Benchmark Performance

Model #	Model name	Number of firms	Inputs	Outputs
1	FULL	21	– Project management expenses – Safety expenses	– Schedule performance – Cost performance – Customer satisfaction – Profit – 1/EMR
2	SCCPE	28	1	– Schedule performance – Cost performance – Customer satisfaction – Profit – 1/EMR

6.2.2 Model 2: SCCPE

This model includes 28 firms. The outputs are: schedule performance, cost performance, 1/EMR, customer satisfaction, and profit. Table 7 provides descriptive statistics for the results of the SCCPE model. The scores average 0.943 with a standard deviation of 0.0888. Again, the highest score is 1.0 and the lowest score is 0.602. Ten DMUs are efficient, while 18 are inefficient. The information from the SCCPE model can be used in exactly the same way as the information from the FULL model.

Table 5: FULL Model Results

No.	DMU Input/Output	Score Data	Projection	Difference	%
5	AN	0.51			
	Safety expenses (%)	0.25	0.115	-0.135	-54.00%
	PM expenses (%)	1.95	1	-0.95	-48.72%
	Schedule performance (%)	47.5	50	2.5	5.26%
	Cost performance (%)	65	70	5	7.69%
	1/EMR	1.31	1.37	0.05	4.11%
	Customer satisfaction (%)	65	82.5	17.5	26.92%
	Profit (%)	2.05	4.525	2.475	120.73%

7 CONCLUSIONS

This is the first construction benchmarking model introduced to the industry that accurately rates the efficiency of a construction firm on a company-wide basis and identifies the areas that the firm must improve upon in order to be on par with the most efficient firms in the industry. It accomplishes this by measuring a firm against the five metrics identified by a consensus of the literature as the five most important measures of company efficiency.

The model also produces and reports the magnitude of the deficit that a company must overcome in each of the five areas measured in order to become as efficient as the most-efficient firm(s) in the industry.

The data from a diverse set of 74 firms, randomly chosen were analyzed and then two different versions of the model were validated. Each model performed satisfactorily, identifying the efficient firms and instructing the inefficient firms about where to concentrate their efforts and telling them how much improvement is needed in each area measured.

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A comparison of social housing in the Netherlands and England on characteristics and quality

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Abstract

The Netherlands and England both have a large social housing stock. In this article the two countries are compared on sector and stock characteristics, the quality and backlog of the stock, and investment and maintenance expenditure.

Both countries show a declining tendency in the social housing stock. Social management bodies are strongly urged to develop businesslike approaches to housing management. There are differences in the way the management of the property is organized (private or public), independency of operations, regulatory systems and supervision requirements. The housing stock in both countries have many characteristics in common. A significant difference is the age of the stock.

The quality of the stock is measured in both countries periodically by central government (KWR in the Netherlands and HCS in England). Significant improvements in the quality of the stock has been achieved. In both countries the social rented housing stock had the lowest quality backlog of all ownership categories. Although there are differences between local authorities and housing associations, the overall quality of social housing in England is somewhat higher than in the Netherlands. Total investment and maintenance expenditure are on the same level. Within this total expenditure there are differences between the two countries and between social housing management bodies in England. The expenditures are in line with the backlog.

It's interesting that the quality survey in England is based on a quality standard (Decent Home Standard). Decent Home Standard defines the future agenda. All social houses must satisfy the decency criteria in 2010.

Keywords: social housing, characteristics, quality, backlog, maintenance

1. Introduction

Thirtyfive percent (Netherlands) and eighteen percent (England) of the housing stock is managed by social landlords. The proportions in other West European countries are lower. From this perspective it's interesting to compare the Netherlands with England. The main objective is to study the differences and similarities in social housing in the two countries.

We first look at the circumstances and conditions (i.e. the housing stock characteristics, national legislation and housing stock policy) before comparing the quality and backlog of the social housing stock. Both countries periodically survey the quality of the housing stock. Next we will inventorize the investment and maintenance expenditure per dwelling and the underlying maintenance types. For the sake of comparison it is interesting to look at the relationship between the quality and backlog of the stock and the investment and maintenance expenditure.

OTB Research Institute organized an enquiry on strategic stock management and maintenance management among all housing associations in the Netherlands in 2004 [16]. The results have been used in this article. The information on the social housing stock in England was gathered by means of an extensive literature review and contacts with the University of Greenwich in England. The following research questions will be dealt with in this article:

- what are the characteristics of the social housing sector in the Netherlands and England?
- what are the characteristics of the social and other housing stock in both countries?
- what is the quality and backlog of the social housing stock?
- what are the levels of investment and expenditure on maintenance in social housing in both countries?
- is there a relationship between the expenditure or investment and the quality and backlog of the social housing stock in the two countries?

We end the article by presenting our conclusions, along with an outline of developments and relevant recommendations.

2. Social housing in the Netherlands and England

The social rented housing stock in the Netherlands is 2.4 million homes and is almost entirely in the hands of housing associations. The social housing stock accounts for 35% of the total housing stock in the Netherlands. There is also a small private rented sector (12%). A little over half the stock is owner-occupied (table 1). The proportion of social housing is reasonably stable, but is decreasing slightly, partly as a result of housing association sales programmes. In addition, most new building is for owner-occupied housing.

Until recently, the municipalities also managed part of the social housing (municipal housing departments). The housing associations were privatized in the mid 1990s, in which the municipalities had a supervisory role. To avoid problems of being seen to wear 'two hats' (i.e. management and supervision), it was then decided to phase out the municipalities' management role. The property of municipal housing departments was gradually transferred to housing associations. Currently, 540 housing associations manage an average of 4,335 homes [1, 16]. Approximately 10% of the management organizations manage over 10,000 homes.

Table 1: Division of housing stock by tenure in the Netherlands and England

Percentage of total housing stock	Social rented	Private rented	Owner-occupied
Netherlands	35%	12%	53%
England	18%	10%	72%

Source, VROM, 2003 and National Statistics, 2004

England has 3.8 million social rented homes, which amounts to 18% of the total housing stock (21.5 million homes). As in the Netherlands, the private rented sector is small (10%), and more than 70% of the stock is owner-occupied.

Sixty six percent of the social housing in 2003 was in local authority hands (i.e. public housing companies), and the other 32% in the hands of housing associations [9]. Although most of the almost 2,000 housing associations are voluntary not-for-profit organizations, they operate under close government regulation and are registered as social landlords (RSLs), and the majority are affiliated with the Housing Corporation (HC). This umbrella organization was set up by, and is supported financially by, the government. The HC is responsible for public and private investments in the corporation sector and oversee the RSLs.

Table 2: Characteristics of social landlords in the Netherlands and England

Characteristics	Netherlands	England	
	Housing associations	Local authorities	RSLs
Total housing stock	6.7 million	21,5 million	
Social housing stock	2.4 million (35%)	3.8 million (18%)	
Number of homes	2.4 million	2.6 million	1.2 million ¹
Number of landlords	540	241	1,925
Dwellings per landlord (average)	4,335	10,788	623

Source, VROM, 2003 and National Statistics, 2004

Public housing company ownership in England is being scaled down sharply. In 1979, they managed 5.1 million of the 5.5 million social homes [14]. Between 1980 and 1990, the total social housing numbers fell to 4.4 million, most importantly because of the sale of 200,000 homes to tenants. Social housing numbers dropped further in 2003 to 3.8 million. As well as the sales, a feature of recent years has been the transfer of 350,000 homes from local authorities to RSLs [11]. The public housing companies managed 2.6 million homes in 2003 and the RSLs 1.2 million [9].

Public housing companies are large management organizations that handle on average more than 10,000 homes. RSLs are considerably smaller, managing on average as few as 1,000 homes. The vast majority of RSLs are extremely small, with the largest 10 managing on average 23,700

¹ Excluding 645,000 LSVT dwellings

homes. The RSL sector is very diverse. There is “a wide range of quite different organizations, varying from ancient almshouses trusts and Victorian charitable foundations to self-build co-ops and former local authority housing departments” [14]. The transfer of ownership from housing departments to RSLs has caused a rise in the average number of homes in management.

Table 3: Characteristics of social housing stock in the Netherlands and England

Characteristics	Netherlands	England	
	Housing associations	Local authorities	RSLs
Typology houses versus flats	70-30	67-33	60-40
High-rise flat		8%	2%
Age profile of the stock: <1945 versus >1945	9-91 (49% 1945-1975)	32-68 (42% 1945-1965)	30% after 1985
Number of rooms	2.3	2.5	2.4
Useable floor area houses/flats	90-68 m ²	93-59 m ² (total stock)	

Source, VROM, 2003 and National Statistics, 2004

3. National legislation and strategic housing stock policy

Dutch housing associations are not-for-profit organizations, which are obliged to operate in the interest of housing, in particular by providing decent, affordable housing to lower-income households. This is reflected in the Housing Act and the Social Rented Sector Management Decree (BBSH), which states the rights and obligations of Dutch housing associations [10, 13]. In the 1990s, the national government granted social landlords considerably greater freedom of policy, but also diminished the financial support to social landlords. Furthermore, demand for social housing decreased, partly because of a booming economy and changes in housing preferences towards home ownership. As a consequence, housing associations in the Netherlands began to adopt businesslike approaches in their housing management. They had to operate in a more market-driven and client-driven way. For technical management, only the lower limits have been set. All dwellings have, at any rate, to satisfy the minimum requirements of the Dutch Building Decree.

In England, local authorities and housing associations operate within different statutory, regulatory and funding frameworks. They started independently and developed along different legislative paths. Nevertheless, both parts of the social rented sector have some key similarities. The stock has been provided through public subsidy and is subject to regulation (e.g the Housing Act, the Housing Association Act and the Landlord and Tenant Act). Rents are set below market levels. Like the Netherlands, both local authorities and housing associations are under pressure to develop businesslike approaches towards housing management [14]. From 2001/02, local authorities in England have started to operate under a new financial framework. The associated introduction of business plans is part of the process of encouraging authorities to make better use of their housing assets [2]. These business plans draw on an investment plan informed by condition stock surveys. The recent government agenda for social housing policy was set by the Housing Green Paper [3]. This is a wide agenda that covers many subjects. The agenda for the

future emphasizes a more strategic role for local authorities and the need to prepare housing strategy statements that are tuned to regional and national agendas and objectives.

Local authorities and housing associations are responsible for their own investments and the maintenance of their stock. In contrast to housing associations, local authority investment continues to be eligible for central government support (grants for disabled facilities and, from April 2001 onwards, the Major Repair Allowance). Local authority Housing Investment Programme (HIP) allocations are based on government assessment of requirements for housing investment, informed by local housing strategies and, from 2004, by the priorities set out by Regional Housing Boards.

Housing associations are subject to the Housing Corporation's Regulatory Code, which requires RSLs to operate viable businesses with adequate resources to meet current and future business and financial commitments. All business plans are assessed by a lead regulator of the Housing Corporation to check compliance with regulatory requirements [4]. The inspections (oriented to RSLs with more than 250 homes) cover six housing association duties, including maintenance and investment. RSLs must fund all their maintenance and investment plans from their own resources. RSLs must operate a clear asset management strategy and develop clear plans for bringing the housing stock into compliance with the Decent Home Standard by 2010 (see section 5).

Strategic housing stock policy is generally accepted within large social housing associations in the Netherlands. In a housing stock policy document, a housing association constructs a picture of the composition of the desirable dwelling portfolio and sets up market and complex strategies [15, 16].

4. Quality and backlog social housing stock Netherlands

The physical quality of the Dutch housing stock and living environment is measured periodically (i.e. every five to six years) in a Qualitative Housing Survey (KWR). The last comprehensive investigation was carried out in 2000 [7]. The KWR focuses on the structural state of the building, the functional quality, energy-saving measures, security facilities and the spatial quality of the living environment.

The Dutch housing stock consists of 70% single-family and 30% multi-family homes (Table 3). The local and regional differences are large, and indeed, the proportion in the major cities is exactly the opposite.

The *structural quality* is expressed in the necessary repair costs to remedy overdue maintenance and defects. The average repair costs for the entire Dutch stock fell between 1990 and 2000 by 40%, from € 4,200 to € 2,500 per home. For the total stock, this equates to a fall from € 24.3 to € 16.4 billion. The quality improvement arises largely from an improvement of the prewar stock, which is the group of homes that the urban renewal of the 1980s and 1990s focused on [7]. The Dutch social rented housing stock is in good structural condition. The average repair costs are € 2,200 per home.

Exterior frames, roofs, sheds or garages, external walls and ceilings are the most important repair items, accounting for two-thirds of the repair costs. The other structural and installation elements are responsible for the remaining repair costs.

The repair costs are then corrected in the KWR for the size of the home, which is then expressed as relative repair costs. The relative repair costs are a percentage of the rebuilding costs of the home. Four classes are distinguished (Excellent - less than 1%, Good - 1-10%, Moderate - 10-20% and Poor - >20%)

Approximately 8% of the total stock is in the moderate (6%) to poor (2%) categories. In 1990 this percentage was 27%. Considerable improvements are therefore also apparent in the relative repair costs. The social rented housing stock has the best statistics, with only 4% of stock in the moderate (3.5%) to poor (0.5%) classes.

The KWR also investigated the residents' satisfaction with the state of repair of the home. Not surprisingly, the residents of poor and moderate homes were considerably less satisfied with the structural state than residents of good and excellent homes.

Functional quality is an important indicator of usable area. The average usable area of the Dutch housing stock is 104 m² (single-family home: 118 m² and multi-family home: 72 m²). Social housing is considerably smaller than the average, with a typical single-family home being about 90 m² and a multi-family home 68 m². The level of facilities in the home increased sharply in the 1990-2000 period, and the same applies to internal and external accessibility. For internal accessibility, the living room, kitchen, sanitary facilities and at least one bedroom are situated on one floor. 37% of the total housing stock satisfies this criterion. For the social housing stock, the figure is almost 50%. For external accessibility, the home must be accessible from outside without needing to climb stairs. Three quarters of the Dutch housing stock is completely accessible, which is mainly because of an increase in the number of multi-family homes with a lift. Corporations have installed a relatively large number of lifts in their early postwar stock.

Table 4: Quality of the social housing stock in the Netherlands and England

	Netherlands	England		
	Housing associations	Local authorities	RSLs	Total
Backlog in technical quality (per dwelling)	€ 2,200 (€ 2.500 total stock)	€ 2,416 ² (€ 5,619 per non decent dwelling)	€ 1,497 ³ (€ 5,344 per non decent dwelling)	€ 2,111 (€ 3,519 total stock ⁴)
Backlog in housing quality (functional, energy etc)	Not known			
Central heating	84%	84%	80%	82%
Double glazing	69%	60%	74%	65%
Wall insulation	55%	Unknown	Unknown	Unknown
Floor insulation	30%	Unknown	Unknown	Unknown
Secure windows and doors	Unknown	42%	55%	46%

Source, bewerking KWR, 2003 and ODPM, 2003

The *energy quality* of the housing stock is an important topic. The Netherlands is striving for a 10% CO₂ reduction in the existing stock in 2010 relative to 1990. One of the most important energy-saving measures is insulating the shell of the home. KWR 2000 shows that the necessary progress is being made: The proportion of homes with double glazing rose from 57% to 69%, the proportion of homes with wall insulation from 42% to 50%, the proportion of homes with roof insulation from 51% to 63% and the proportion of homes with floor insulation from 24% to 34%. If we focus on the social housing stock, then it appears that the sector has performed several percentage points better than the average for wall insulation, approximately equal to the average for double glazing, and a few percentage points below average for floor insulation and roof insulation.

Eighty four percent of space heating in the social rented sector is provided by an individual central heating installation. The proportion of local heating has declined steadily. Tap water is heated in 52% of the homes by a combination boiler, but kitchen and bathroom water heaters and storage water heaters are still common. The social housing stock is in line with these average levels. The proportion of solar water heaters in the total housing stock is only 1%.

5. Quality and backlog social housing stock in England

A Public Service Agreement (PSA) was concluded in 2000 between the government and the social rented sector (local authorities and housing associations). The agreement is that all social rented housing will achieve a quality level in 2010 in line with the Decent Home Standard. The Decent Home Standard distinguishes the following four assessment criteria.

² This is the average of all 2,79 million local authority dwellings (2001). 43% of the stock is non-decent. € 5,619 per dwelling (see table 5). Exchange rate £ 1 to € 1.47

³ This is the average of all 1,388 million RSL dwellings (2001). 28% of the stock is non-decent. € 5,344 per dwelling.

⁴ This is the average of all 21,141 million dwellings in England (2001). 33% of the stock is non-decent. € 10,556 per dwelling.

- The minimum fitness standard. The fitness standard states that there must be no serious defects, that the home is structurally safe and healthy, that facilities are present for heating, lighting and ventilation, and that the home has tap water, sewers, a WC and a bath or shower and cooking facilities.
- The repair criterion. Twelve essential and three ordinary building components are distinguished. Building components refer to the constructional, shell and internal building elements. The assessment is made on the basis of the age and the state of a building element. Guidelines have been drawn up for the age and state of each building element. A home is deemed to be non-decent if one or more essential, or two or more other building components are old and in need of replacement or drastic attention with respect to their state of repair.
- The modern facilities criterion. A home is assessed on six facilities (e.g. kitchen, bathroom and sound insulation), primarily on age, area, etc.. If the home does not satisfy three or more of these requirements, it is deemed non-decent.
- The thermal comfort criterion. A home must have both efficient heating and effective insulation. Efficient heating is defined as a programmable central heating or heater. The effective insulation requirement (thickness) depends on the type of heating. In the case of gas and oil-fired heating, there must be an insulation package of at least 50 mm in the external walls and roof. In the case of electrical, LPG and solid fuel heating (e.g. wood), the package must be at least 200 mm thick.

Table 5: Social housing stock failing the Decent Home Standard in England

	Total stock	Social housing		
		Local authorities	RSLs	Total
Total percentage failing DHS	33%	43%	28%	38%
Failing Modernization	2%	6%	2%	5%
Failing fitness	4%	5%	3%	4%
Failing disrepair	9%	9%	5%	8%
Failing thermal comfort	26%	34%	22%	30%

Source, ODPM, 2003

The quality of the UK housing stock is measured in the Housing Condition Surveys. Like the KWR, the measurements are made periodically. The last comprehensive measurement was in 2001, and before that in 1996 [11, 13].

For the total stock, one third of the homes were non-decent in 2001, whereas the figure in 1996 was still 46%. Therefore, as in the Netherlands, there has been a considerable jump in quality. This improvement can partly be explained by the construction of over 800,000 new reasonably high quality homes in the period concerned (the stock expanded between 1996 and 2001 by approximately 4%). However, the 13% jump in quality is several times as high as this expansion.

As table 4 shows, backlog is defined somewhat more broadly in the House Condition Survey than in the Netherlands. In the Netherlands, reliable backlog data is available only on the basis of technical quality, while in the UK the Home Standard also incorporates housing quality in a

broader sense (e.g. functional quality and energy) alongside technical quality. The total backlog for the UK housing stock is € 74 billion, which is equivalent to an average of € 3,419 per home.

Social housing stands out in a positive sense, where the backlog of € 9 billion, or € 2,111 per home, is considerably lower than the average for the total housing stock. In 2001, 38% of social housing was non-decent. The quality improvement in the 1996-2001 period is in line with the national trend. In 1996, more than half (i.e. 52%) of the public sector stock was non-decent.

If we focus on the social landlords, local authority property would appear to be in somewhat poorer condition than that of the housing associations, with 43% being labeled non-decent. Otherwise, the backlog per home for this category is still more than € 1,100 lower than the average UK home (average € 2,416 per home). Local authorities can tackle the non-decent homes themselves, but alternatives are also offered to them:

- setting up an Arms Length Management Organization (ALMO), in which the municipality sets up a sort of private company to manage and repair the homes;
- joining the Private Finance Initiative (PFI), i.e. entering into (30 year) contracts through government-supported Public Private Partnerships, where the municipality continues to own the homes, but the private sector takes responsibility for the administration and management;
- transfers of ownership to a housing association (RSL), which then repairs the property (364,000 in the 1996-2001 period).

There were 138 transfers, 36 ALMOs were founded and 16 PFI contracts were concluded in the 1997-2004 period [5].

The property of the housing associations stands out positively in terms of quality, in that 'only' 28% is non-decent, and the backlog is only € 1,497 per home. The Housing Corporation itself investigates the affiliated housing associations each year. Data from 2003 shows that the quality increased further in the 2001-2003 period to 23% non-decent [5]. The backlog has therefore continued to decline in recent years.

The most common reason for a dwelling being deemed non-decent is failure to provide a reasonable degree of thermal comfort (about 80%). 34% of all local authority dwellings and 22% of the housing associations' stock fail on thermal comfort (i.e. lack of adequate insulation, poor heating, or both). 82% of the social rented housing has central heating; 65% has double glazing in part or all of the home. The RSL homes are less old and therefore also better insulated.

Another important reason for non-decency is disrepair. Housing associations perform better than the average. The key building components on which dwellings most frequently fail the disrepair criterion are chimneys (28% of all failing on disrepair), windows (26%), wall structure (14%) and roof structure (13%).

A small proportion of the social housing stock fails to satisfy either the minimum fitness standard or the modernization standard. Regarding the modernization standard, the most common contributory factors are the age of the kitchen or the bathroom.

The total of the non-decency criteria exceeds 100%. It goes without saying that homes can be assessed as inadequate on more than one criterion. Older homes are generally of lower quality

(i.e. have a higher non-decency rating) than younger homes, and this is particularly true of the fitness and disrepair criteria. Prewar and postwar homes differ little in terms of modernization and thermal comfort.

More than 80% of the tenants are actually satisfied with the housing [9], which means that tenants can still be satisfied with their home in spite of non-decency. In the assessment of the home, matters such as living environment and level of rent naturally also play a role.

6. Investments and maintenance expenditure social housing

The Dutch housing associations spent about € 3 billion in 2002 on maintenance. This is equivalent to € 1,263 per home per year [1]. Besides maintenance, housing associations expended approximately € 2.1 billion per year on investment in existing stock (conversions, renovation). This is equivalent to € 922 per home per year [16].

Table 6 : Investment and maintenance expenditure per year in the existing social housing stock in the Netherlands and England (estimate)

	Netherlands	England		
	Housing associations	Local authorities	RSLs	Total
Total investment in the existing stock (conversions and renovation)	€ 2.1 billion	€ 1.1 billion ⁵	€ 2.2 billion	€ 3.3 billion ⁶
Investment per dwelling	€ 922	€ 423	€ 1,192	€ 742
Total maintenance and repair expenditure	€ 3.0 billion	€ 3.0 billion ⁷	€ 3,0 billion	€ 6.0 billion
Maintenance per home	€ 1,263	€ 1,154	€ 1,636	€ 1,350
Total investment and maintenance	€ 5.1 billion	€ 4.1 billion	€ 5.2 billion	€ 9.3 billion
Total investment and maintenance per home	€ 2,185	€ 1,577	€ 2,818	€ 2,092

Source, Aedes, 2003, Vijverberg, 2005, National Statistics, 2002, Housing Corporation, 2004

The total investment and expenditure on maintenance are almost equal in both countries. In the Netherlands the average level of investments per home is higher and maintenance expenditure lower.

Local authorities in England expended an amount equivalent to € 1.1 billion on conversion and renovation in 2001 [8]. This amount excludes the Private Finance Initiatives (PFI contracts). In addition, local authorities spent € 3 billion on maintenance and repair in 2001. For RSLs the estimate is € 2.2 billion on conversions and renovation and € 3 billion on maintenance in 2003 [6].

⁵ Estimate: £ 720 million. Exchange rate £1 to € 1.47

⁶ Estimate: £ 18 billion was invested in the 1997-2004 period in existing homes: average £2.25 billion a year. Another £7 billion will be invested in the 2004-2007 period.

⁷ £2,046 million

Within social housing in England the housing associations investment and expenditure exceed the local authority expenditure with almost 80%.

Closer analysis of the maintenance expenditure in the Netherlands reveals that routine day-to-day maintenance accounts for about one-third of expenditure (i.e. € 448 per dwelling per year). The remaining € 815 is spent on planned maintenance and major repairs expenditure [1]. For local authority no reliable data was found. For RSLs planned maintenance expenditure is about the same as in the Netherlands. Routine maintenance makes the difference. Expenditure in this maintenance type per home are 82% higher [6].

Table 7: Volume of maintenance business per home according to maintenance type in social housing in the Netherlands and England

	Netherlands		England		
	Housing associations	%	Local authorities	RSLs	%
Routine maintenance	€ 448	35%	Unknown	€ 817	50%
Planned maintenance and major repairs	€ 815	65%	Unknown	€ 819	50%
Total maintenance and repair expenditure	€ 1,263	100%	€ 1,154	€ 1,636	100%

Source, Aedes, 2003, Housing Corporation, 2004

7. Conclusions and recommendations

The Netherlands and England have a large social housing stock. Housing associations have been privatized in the Netherlands, and are responsible for their own financial affairs. Associations are therefore fairly independent in operations. The national and local authorities in the Netherlands retain some influence on the operations through rent policy and admission and supervision requirements.

A substantial proportion of the social housing stock in England is still in public hands. There is more regulation and supervision. There is a division in the social rented housing stock in England, with property falling either under local authorities or housing associations. A similar situation also existed some time ago in the Netherlands. The local authorities in the Netherlands have now transferred the majority of the property to housing associations, with a view to avoiding problems of ‘wearing two hats’ (i.e. management and supervision). There are signs that the same is happening in England. Local authority property is being transferred on a large scale to housing associations. The local authorities still retain the majority of the stock. Another difference with the Netherlands is that the housing associations are small. In order to facilitate professionalization, the property level of the average housing association will probably expand sharply in the coming years. In England too, social management bodies are being strongly urged to develop businesslike approaches to housing management.

Housing associations in both the Netherlands and England are responsible without government support for investments in and maintenance of their stock. It is striking in this regard that housing

associations in England are under the supervision of an umbrella organization (i.e. HC) that was set up and is supported financially by the government.

The social housing stock in the Netherlands and England have many characteristics in common. The distribution between houses and flats, the number of rooms and useable floor area is about the same. A significant difference is the age of the stock. More than 90% of the stock in the Netherlands was built after 1945, whereas the corresponding figure in England is less than 70%.

In both the Netherlands and England, the quality of the housing stock is measured periodically by the government. The Netherlands have the Qualitative Housing Survey (KWR), and in England there is the House Condition Survey (HCS). Most recent investigations have shown significant improvements in the quality of the stock in both countries in recent years, which is attributable partly to building additional new social housing. However, the most important reason appears to be the investment and maintenance programmes. In both countries, the social rented housing stock has the lowest quality backlog of all the ownership categories. The quality backlog of an average public sector home in the Netherlands is € 2,200, and in England the average is € 2,111 per home. However, the measurement of quality backlog in England is not limited to technical quality (as is the case in the Netherlands) but also covers housing quality (e.g. functional and energy aspects) in a broader sense. It therefore has to be concluded that the quality of social housing in England is somewhat higher than in the Netherlands. Otherwise, there is a pronounced difference in quality between local authority and housing association homes in England. The quality backlog of housing local authority property is considerably greater.

The total investment and expenditure on maintenance are almost equal in both countries. In the Netherlands the average level of investments per home is higher and maintenance expenditure lower. Within social housing in England there are big differences between investment and maintenance expenditure of housing associations and local authorities. The figures match with the backlog.

It is interesting that the Decent Home Standard in England is based on the House Condition Survey. The Decent Home Standard distinguishes four criteria on which the quality measurement focuses (i.e. the minimum fitness standard, repair criterion, modernization criterion and thermal comfort). Currently, 38% of the social rented housing stock fails to satisfy one or more criteria. Thermal comfort is the greatest culprit. 80% of the non-decent dwellings are inadequate on this criterion. A Public Service Agreement sets down that all local authority and housing association homes must satisfy the decency criteria in 2010. It would be advisable for the Netherlands to introduce this broad quality measurement approach into the KWR and subsequently to reach performance agreements in national or local covenants between governmental bodies and housing associations.

This research will be continued on links between expenditure, quality and backlog. Is it for instance possible to calculate quality improvement? Therefore we have to get more reliable information on investment and backlog in the social housing stock in England and the Netherlands over a period of time. Another interesting topic for future research is the effectiveness of the combination of condition survey tools and (real-time) quality standards. For that we have to dig deeper into KWR, HCS and quality standards. Maybe it's interesting to

involve other European countries in future research. We are especially interested in North European countries in this perspective (also fairly large social housing stock).

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Information, Technology and Procurement Organization Form

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Abstract

A central theoretical question is how organization makes a difference to economic performance of construction firm. Obviously, technology will have a great bearing on the way a firm performs. The thesis of this paper is that a partner construction firm, by virtue of the fact that it manages the IT function for multiple-discipline construction firms, is privileged to information not available to the focal firm. In this paper I derive the conditions under which privileged information allows the partner construction firm to construct superior incentives for its employees, resulting in superior IT procurement. Further, I detail the circumstances under which outsourcing will not provide additional benefit, and what sorts of partners are likely to provide the greatest benefit. The two main findings are that for low levels of uncertainty, both in-house and relational procurement are equally acceptable. However, as uncertainty increases, the value of relational procurement increases. Conclusions are drawn and extensions are proposed, related to economies of scale and transactions costs.

Keywords: Information Technology, Relational Procurement, Organizational Form

1. Introduction

Although there is good reason to expect that the growth of information work and information technology will significantly affect the trade-offs inherent in different structures for organizing procurement, the theoretical basis for these changes remains poorly understood. Procurement officials and researchers in construction business each suffer from the lack of robust theoretical models that provide sharp, testable predictions.

The ability to manage interorganizational relationships is one of the most valuable capabilities of a firm [1, 4, 12]. Construction firms must not only execute tasks at a frenetic pace, they must also execute a greater number and variety of electronically enabled tasks. This obliges their information technology (IT) infrastructure to be both highly reliable and extremely flexible. As construction firms move away from simply procuring the development of software into multifaceted electronic business infrastructure projects, the nature of the relationship becomes more complex. A rational construction firm would only choose to institute a relationship if it

believed that the partner were more able to perform the IT task. This superior performance could manifest in the form of lower costs, higher quality, greater knowledge or a myriad of other factors. While these performance results are widely described, the causal mechanism remains a mystery. What is the resource that the partner brings to the table that cannot be duplicated by the focal owner? These arguments point to the simple fact that the causal mechanisms of value creation from relational procurement are not at all well understood. There exists a fundamental need for reconciliation between procurement's shining triumphs and its glaring failures in construction business. Moreover, as an academic practice, we require a sound explanation about how a resource can exist, which is inimitable to certain firms (focal owners) and yet readily imitable by other firms (partners). In short, the literature requires a reasonable theory of why IT partners in construction business are more capable of providing infrastructure services than focal owners, and of the boundary conditions that explain when partners are not more capable than focal owners.

As introductory work, in this paper, I focus on the specific domain of archetypical outsourcing in information technology infrastructure procurement. I build on the insights of the incomplete contract approach to clarify the mechanisms by which information technology can be expected to affect the organization of procurement activity in construction business. I consider the incentive effects of various allocations of "information assets" as well as physical assets. This approach is particularly appropriate given the increasing importance of information in the procurement process. While many implications are still unexplored and untested in construction business, building on this approach appears to be a promising avenue for the careful, methodical analysis of human organizations and the impact of new technologies in procurement.

2. Literature Review

By far, the most common way of understanding the decision between in-house and relational procurement for IT functions has been transaction cost economics (TCE). TCE seeks to explain the locust of transactions as an attempt to economize on costs [9, 18, 19]. They propose the electronic markets hypothesis, which suggests that IT will reduce transaction costs, and thereby increase the use of market, rather than hierarchical organization [16]. TCE has been used extensively by Clemons and colleges [5, 6, 7, 8]. The most widely known application is the move to the middle hypothesis, which posits that IT not only reduces market transaction costs, but also reduces the transaction costs of hierarchical organization. As Williamson notes "...economizing takes place with reference to the sum of production costs and transaction costs, whence tradeoffs in this respect must be recognized." [19, p. 22]. Thus far, there is a significant gap in the information system (IS) literature in trying to explain both the transaction and production costs (an important exception is [13]).

I seek to fill the production cost gap by developing a formal model to explain the production cost advantages of partners in construction business. However, rather than use the classical

economics' concept of a firm as a black box, I use TCE's concept that the organization of the firm is important [10, 19]. Thus, I propose a model of production cost advantage based on the internal organization of partners in construction business. In this sense, my work is an extension of [13]. While they develop a description of the interactions between TCE and production costs, I concentrate on the development of a formal, rigorous model of the production costs. My formal model could then be compared to TCE in the same way as Gurbuxani and Whang compared agency predictions to TCE. Separately, my model could be combined with a formal model of transaction costs to develop a more thorough understanding of the procurement interactions in construction business.

The idea that organizational form creates resources is not new. Coase [9] suggested that there was some resource generated simply by organizing as a firm, which provided advantage over a market. Similarly, Williamson [18] expanded on this idea and showed how M-Form organizations might have resource advantages over U-Form organizations, simply by virtue of the form. Maskin, et al. propose that the distribution of shocks can be mitigated by a choice of the appropriate organizational form [17]. Barcena-Ruiz and Espinosa [3] show that the incentive scheme of a firm depends on whether the goods it produces are complements or substitutes. In this model, firms chose between U-form and M-forms of organization specifically to allow them to provide the proper incentives to managers. However, such an assumption does not explain what the scale economies arise from, and such an assumption is often unwarranted as "...most large companies have the critical mass required to achieve economies of scale. [15, p. 169]".

The focus on production cost aspects is particularly salient in the context of archetypical outsourcing. This is true because the relevant question is not whether to organize the IT department within a hierarchy or as an independent entity. Rather, the question is whether to organize the IT department within one hierarchy over another hierarchy. Thus, many of the TCE considerations relative to internal organization will remain constant. For example, of the three categories of transactions costs that limit firm size—bounded rationality, bureaucratic insularity, and atmospheric consequences [18]—only the atmospheric conditions are likely to be systematically different between partner firms and focal owners in construction business. At the same time, all of the TCE considerations based on non-integrated transactions are present. Thus it becomes especially important to explain some production based advantage of IT providers.

3. The Model

A firm is a collection of different units, usually arranged either by objective or by function. Specifically, communication is more efficient within a firm than across firm boundaries. I normalize the ability to communicate externally to zero, so that the only information available to the firm is information about its internal units. In the sense of the model presented here, a firm is an imaginary envelope that traps information. In IT related tasks in construction management this is reasonable assumption.

Each unit in construction business has one employee, who produces the output of the unit. In the case of the IT department the employee is the developer. The goal of the firm is properly to give incentives to this employee to put forth some level of effort, e , that generates output, y . These incentives are not necessarily monetary, but also occur in the form of promotions, awards, or a good word. For the purposes of this paper, motivating the employee is the same as motivating the unit. The problem is that the output of the functional area is only imperfectly correlated with the manager's effort. Thus, the observed output of functional area j in firm k is:

$$y_{jk} = e_{jk} + \varepsilon_{jk}, \quad (1)$$

where ε_{jk} is assumed to be normally distributed with a mean of zero and a variance of σ_{jk}^2 .

Equation (1) suggests that not all of the output of a given unit is directly under the control of the unit employee. Software may be buggy, systems machinery can fail, or users can fail to adopt. Further, IT professionals in construction business are much like knowledge workers than other physical workers and as such, much of the work they do is unobservable [11]. Thus the effort level cannot be directly observed and the incentive can depend only on the observed output, y . This makes sense for IT because much of the manager's effort involves intangibles that are invisible to the end user, but that certainly effect usability. Thus I present a standard agency problem in which the principle cannot observe the agent's effort. To this, I add the additional innovation that output is not a perfect indicator of effort. The problem of the construction firm is to choose an incentive scheme, $i(y_{jk}, y_{lm})$, to best motivate the risk adverse manager to perform. The only difference between a focal owner and its partners is the information available to them in the form of output data. A construction firm can be considered as a set $F = \{y \in y_{jk}\}$, so that a construction firm is a set of outputs, and the construction firm can use those outputs to structure incentive schemes.

The employee must choose the level of effort to maximize his utility subject to the incentive offered by the construction firm and some disutility of effort. This choice can be represented as:

$$\max_{e_{jk}} U(i_{jk}(y_{jk}, y_{lm})) - D(e_{jk}), \quad (2)$$

Thus, the employee's utility is based on his output relative to another employee and the cost is based on actual effort. Cost of effort is assumed to be increasing. The construction firm's problem is to choose a set of incentives to motivate employees to undertake the profit maximizing level of effort. This can be represented, in the two employee case, as

$$\max_{i_{jk}, i_{lm}} \left([y_{jk} - C(i_{jk}(y_{jk}, y_{lm}))] + [y_{lm} - C(i_{lm}(y_{jk}, y_{lm}))] \right), \quad (3)$$

Thus, the construction firm chooses the incentive schemes that induce the employees to produce outputs, which are construction firm's revenues. However, the construction firm must pay the

cost of these incentives.

For parsimony and generalizability assume two functions (IT and Other) and two construction firms (1 and 2) yielding four outputs (y_{IT1} , y_{IT2} , y_{o1} , y_{o2}). Assume that each unit receives its own shock denoted by $\varepsilon_{ObjectiveFunction}$. I define a focal owner as a construction firm that manages multiple different functional areas with the same objective. I define the partner as a construction firm that manages multiple identical functional areas with different objectives. In this case, construction firm 1 is the focal owner. The question then is which organization can structure a better incentive for the IT manager in construction firm 1. If IT is insourced then the incentive for the IT manager is based on the output of the IT manager of construction firm 1 (y_{IT1}) and the output of the other manager in construction firm 1 (y_{o1}). If IT is outsourced, the incentive is based on the output of the IT manager of construction firm 1 (y_{IT1}) and the output of the IT manager of construction firm 2 (y_{IT2}). Thus, the incentive offered by the focal owner to the IT manager is:

$$i_1(y_{IT1}, y_{o1}), \quad (4)$$

and, the incentive offered to IT manager by the partner firm is

$$i_{IT}(y_{IT1}, y_{IT2}). \quad (5)$$

It can be shown that if employee *o1* of the focal owner exerts a level of effort e^* , then an incentive scheme can be designed by the partner firm such that if employee *IT2* of the partner firm exerts a level of effort e^* , then $i_{IT}(y_{IT1}, y_{IT2})$ is equivalent to $i_1(y_{IT1}, y_{o1})$, in that $i_{IT}(y_{IT1}, y_{IT2})$ motivates the developer to exert at least as much effort as $i_1(y_{IT1}, y_{o1})$. However, this result rest on the assumption that

$$\text{Var}(\varepsilon_{IT1} | \varepsilon_{IT2}) < \text{Var}(\varepsilon_{IT1} | \varepsilon_{o1}). \quad (6)$$

The assumption in (4) implies that if the measurement error of an IT manager's effort is less given the measurement error of other IT managers in different construction firm, than given the measurement errors of other functional areas in the same construction firm, then the partner can provide incentives at least as good as the focal owner, and thus operate the IT department at least as efficiently. Outsourcing will be a good solution when the variance among construction firms is less than the variance among functional areas. This means that the IT function in a construction firm is more similar to the IT function in other construction firms than it is to non-IT functions within the same construction firm. If variance among functional units is taken as fixed this leads to the following Proposition:

Proposition 1: If $\text{Var}(\varepsilon_{IT1} | \varepsilon_{IT2}) < \text{Var}(\varepsilon_{IT1} | \varepsilon_{o1})$ then for any incentive scheme $i_1(y_{IT1}, y_{o1})$, based on the output of the focal construction owner's IT unit and the other unit of the focal owner, resulting in effort level e_{IT} on behalf of the developer; the partner construction firm can find an

equivalent scheme $i_{IT}(y_{IT1}, y_{IT2})$ based on the output of the focal owner's IT unit and the output of the partner's other IT unit, that would result in the same effort level e_{IT} on behalf of the developer.

What the Proposition indicates is that the partner construction firm can encourage at least the same level of effort in its employees as the focal construction owner. This is the case, no matter how complex the focal owners' incentive schemes may be. This powerful result hinges on the conditional variances, so the reverse case (that the focal owner can duplicate the partner firms' incentives) does not hold. The idea that partner construction firms focusing on specific functions rather than overall objectives can offer better incentives to employees is supported in the literature. Lacity and Hirshheim [14] provide a number of case studies in which managers indicate that they expect IT personnel to have better opportunities when transferred to a partner firm. The actions of the employees seem to support this, because they typically transfer to the infrastructure partner rather than seek employment in another manufacturing type firm.

Proposition 1A: If $\text{Var}(\varepsilon_{IT1} | \varepsilon_{IT2}) < \text{Var}(\varepsilon_{IT1} | \varepsilon_{o1})$ then it is not necessarily true that the partner construction firm can find an equivalent scheme based on the output of the same function in other objectives that results in the same effort level e_{IT} on behalf of the IT manager.

Proposition 1A is a restatement of Theorem 1 that provides important insight into the understanding of interorganizational partnerships. Proposition 1A states the boundary conditions under which the focal construction owner may not expect a relationship to be advantageous. If a partner construction firm cannot bring additional information with which to gauge the productivity of functional employees then it is not able to provide superior incentives to those employees.

It is important to consider the conditions that would cause $\text{Var}(\varepsilon_{IT1} | \varepsilon_{IT2}) < \text{Var}(\varepsilon_{IT1} | \varepsilon_{o1})$ so that the partner construction firm would have superior evaluative information than the focal construction owner. An obvious candidate condition is that the partner construction firm performs substantially similar activities across a number of similar objectives. This is the typical concept of firm specialization. The innovation offered in this case is simply to explain the source of the value of specialization. Rather than appealing to the idea that some construction firms are simply better than others, I propose that it is because of the information inherent in the construction firms' organizational structure.

Another possibility is that there are functional and objective shocks. Functional shocks would be those shocks that occur to all units in a specific function, while objective shocks would occur to all units with a similar objective. A perfect example of a functional shock would be a change in legal reporting requirements that required rework of financial software. Thus, the financial reporting function would be impacted across multiple objectives. An example of an objective shock would be cyclical variation in the objective area, like Christmas. Given these types of shocks, the observed output of a manager would be

$$y_{j,k} = e_{j,k} + o_k + f_j. \quad (7)$$

This characterization shows that the observable output of a unit manager is a function of his effort plus the shock to the objective plus the shock to the function. The focal construction owner would know the o_k while the partner construction firm would know the f_j . The conditional variance of the unit manager from the focal construction owner's point of view would be the variance of the f_i 's and the conditional variance from the point of view of the partner construction firm would be the variance of the o_k 's. Thus, the variance condition for Proposition 1 becomes $\text{Var}(o) < \text{Var}(f)$. Thus, when shocks to IT infrastructure are larger than shocks to business objectives of construction firm, it makes more sense to form partnerships with the partners in order to control the variance. Another useful case to look at is the limiting case where output is observable without error. It is obvious that

$$\text{Proposition 2: } \lim_{\text{Var}(\varepsilon_{IT,1}) \rightarrow 0} \text{Var}(\varepsilon_{IT,1} | \varepsilon_{IT,2}) = \lim_{\text{Var}(\varepsilon_{IT,1}) \rightarrow 0} \text{Var}(\varepsilon_{IT,1} | \varepsilon_{o,1}) = 0.$$

Simply stated as the output of a certain unit in construction firm becomes more accurately observable, the value of using relationships over internal management decreases to zero. This implies that partnerships provide no special value for highly standardized, easily observable tasks in construction business. This seems a contradiction to the standard wisdom, which suggests that firms should outsource the mundane, commodity like tasks and keep in-house the unique tasks. However, the result above is symmetrical in the sense that it suggests that keeping tasks in-house provides no special advantage, too. Thus, other considerations must be used to make the decision. If there are significant economies of scale, for example, construction firms may very well want to offload a mundane task to a partner. On the other hand, if there are significant transactions costs, a construction firm may choose to keep such a task in-house. The point is that if two construction firms are otherwise equal, then it does not really matter where a mundane task is handled. This intuition makes more sense than the typical prescription that firms should always outsource these types of tasks.

4. Specific Example

Basing an employee's compensation on the output of another employee boils down to a situation wherein, whoever works the hardest gets a reward. There can be variation in the actual mechanism in construction. For example, handicapping might be used, so that one employee would have to work some amount harder than the other. However, the basic premise is well represented by a model in which whoever works harder gets the bonus. Thus, I illustrate the model with that example. Assume that the only incentive scheme available to each construction firm is offering a lump sum reward with a value of one, and that reward is offered to the employee with the greatest output. This could represent a promotion, a bonus, a corner office, or any other reward. Mathematically this is expressed as

$$i_{jk}(y_{jk}, y_{lm}) = \begin{cases} 1 & \text{if } y_{jk} > y_{lm} \\ 0 & \text{if } y_{jk} \leq y_{lm} \end{cases} \quad (8)$$

Further, assume that the utility of this reward is also one, and the utility of no reward is zero. The developer takes the other employee's effort as given, so he sees the expected utility of a given level of effort as the normal cumulative distribution function (CDF). The employee's decision then reduces to choosing the level of effort where the marginal increase in expected utility as a result of effort is equal to the marginal cost of effort. When the developer works for the focal construction owner the CDF from which he derives his benefit has a greater variance than the CDF from which he would draw his value if he worked in the provider firm. This is illustrated in Figure 1.

As Figure 1 illustrates, the provider firm is able to offer better incentives to the developer, so that the developer exerts more effort. Incentive costs and benefits are held constant, and yet the developer working for the provider firm put forth effort equal to P, while the same developer, if working for the focal construction owner, would put forth effort level F, which is less than P.

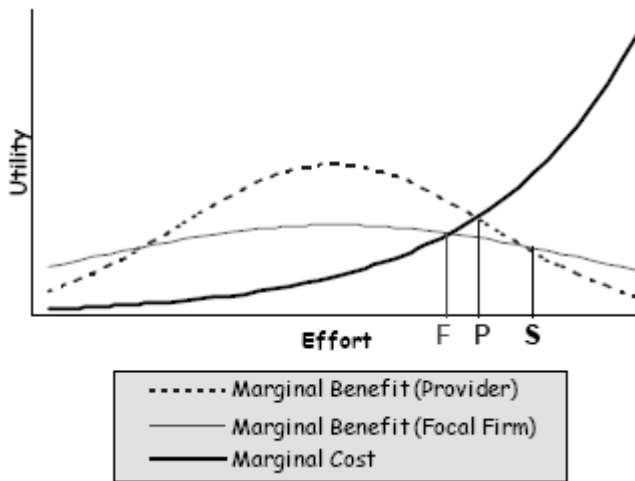


Figure 1: Employee's Effort Choice

The more interesting insight offered by Figure 1, is that beyond effort level S the effort level induced by the focal construction owner's higher variance incentive actually induces greater effort. The intuition here is that as effort becomes more observable, the harder worker is more certain of winning the reward. Thus, engaging in extra effort to insure winning becomes less valuable. At the limit, with complete observability of effort, the developer would only work until he had surpassed the other employee. This seems like a contradiction to the Propositions developed earlier, but it is not. The important factor to understand is that the provider firm can introduce variance into its observations, so that beyond point S it mimics the CDF of the focal construction owner. This means that the provider firm purposefully chooses to ignore some of the output information, and by doing so actually encourages greater effort. The important, and

pleasing, take-away is that more information is not necessarily better. This is a well known view in the IS literature [2], but goes against the grain of many economic models.

5. Conclusions

Interorganizational relationships focused on IT are an ongoing concern of most construction firms, and an important research question to academics. However, neither academics nor practitioners have satisfactorily explained the fundamental premise of procurement—that the partner construction firm is better than the focal construction owner at providing IT services. Not only must a partner construction firm be better, but also it must be superior enough to justify the very real expenses associated with IT outsourcing. Armed with a better understanding of the circumstances under which the partner construction firm is, in fact, superior, focal construction owner will be better able to make the initial step in deciding whether outsourcing is even a viable option.

I have presented a model that proposes why an outsourcing partner construction firm might perform better than a focal construction owner might. The model contains several innovations. First, the source of the advantage (the resource) was not exogenously assumed, but rather derived as a property of the organization structure of the partner construction firm. This allows for a richer description of the resource, including the boundary conditions where the resource might not be present. The second innovation is in the richness of the analytical model. Whereas standard agency theory models focus on a very small range of incentives—usually commission verses salary—my model focuses on the ability to generate any incentive. This is certainly more realistic in the case of IT professionals who are frequently paid in stock options, which are computationally much more complex than a simple commission usually provided by many construction firms.

A third advance of the model was to hold constant both economies of scale and IT managerial talent, and explain how a purely organizational explanation of procurement advantage could arise from differences in the type of information available to construction firms. A fourth contribution of this work is to offer an introductory attempt to join classical economics to transaction cost economics, recognizing not only the costs of transacting, but also the relative production cost advantages of different construction firms. To this end a model is developed that uses the same level of analysis for production as TCE work traditionally uses. Specifically, the internal production costs of a firm are assumed to depend on characteristics of the construction firm, rather than to be the traditional black box. Only by formulating models of transaction costs and production costs at the same level of detail, can researchers hope to reconcile these two viewpoints.

By focusing on the information/knowledge assets available to a partner construction firm I develop an analytical model that shows how information which reduces the variance of observed

output allows a construction firm to structure better incentives. The basic intuition is that partner construction firms have access to the output of other functional areas, which are doing the same job. The ability to observe a matched sample gives the partner construction firms an edge in designing incentives. Further, because much of this information is tacit, the partner construction firm cannot simply sell the information to the focal construction owner.

The basic result then is that because the partner construction firm has access to information about similar departments, it can more accurately estimate the IT department's effort and reward accordingly. This result is tempered by the caution that if the other IT departments/projects are dissimilar to what the partner construction firm is able to observe, then that partner construction firm provides no additional benefit. Thus, if either the construction firm itself or the project is unusual there is no benefit to outsourcing in procurement. In addition, if the project is ordinary but very different from what the partner construction firm usually does, outsourcing provides no particular benefits.

Until now, the study of outsourcing has largely put the cart before the horse, going in to great detail about how to manage an owner-partner relationship, without ever asking when a relationship is even appropriate. By establishing these boundary conditions, this paper makes way for a better understanding of procurement success and failure in construction business. This will allow managers in construction business to decide which projects are the best candidates for procurement and which partners are the best candidates for a specific project, before they begin the difficult undertaking of outsourcing a contract to manage the procurement relation.

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Section VI

Industrialization in Construction

Successful Industrialisation, innovation and prefabrication in construction

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Abstract

The construction industry is commonly characterized as one that is labour intensive, with a low level of innovation, of technology diffusion, of technological advancement of on-site construction and thus a low level of industrialization compared to manufacturing. The importance of the construction industry to the national economies is no subject for debate in contrast to its performance -in terms of efficiency as well as quality of output- in many cases. More than often the example of the manufacturing industry is taken to point at opportunities of industrialisation in construction, by application of innovation and prefabrication. The number of rather successful attempts on large scale in construction however is limited. The question mark that comes up refers to the factors that can be considered determining for successful industrialisation processes particularly in the construction industry. The objective of this paper is to end up in a methodology to assess industrialisation in construction based upon which strategies can be formulated to implement innovation, prefabrication and industrialisation in construction. This paper draws on contemporary theoretic views regarding the factors impeding or stimulating industrialisation, innovation and prefabrication in general. It further will discuss the application of these views in the construction industry.

Keywords Industrialisation, Innovation, Prefabrication, Construction Industry

1. Introduction

The importance of the construction industry to the national economies is no subject for debate. Its contribution to GDP, fixed capital formation, government revenue and employment is significant. In terms of production output the construction industry proves to be one of the

largest industries. On the other hand construction industry is often blamed for being inefficient, labour intensive, with a low level of innovation, technology diffusion and a low level of technological advancement of on-site construction. More than often the example of the manufacturing industry is taken to point at opportunities of industrialisation to improve the performance in construction, by application of innovation and prefabrication. It is stating the obvious to mention that the construction industry differs in many respects from the manufacturing industries also in the case of industrialisation and innovation in construction. In the following first contemporary theoretic views regarding the factors impeding or stimulating industrialisation in manufacturing will be reviewed. After that we will discuss the application of these views in the construction industry.

2. Industrialisation and innovation

Industrialisation is a rather complex concept. The process of industrialisation in West-European countries involved extensive changes of production systems which resulted in a shift from home-based manual production to large-scale factory production. Industrialisation and socio-economic changes are closely intertwined with technological innovation, particularly the development of large-scale energy production and developments in the field of new materials such as metallurgy, plastics, and polymers [2] "Industry" is hereby equated with the manufacturing sector which comprises establishments primarily engaged in the mechanical, physical or chemical transformation of materials, substances or components into new products. The production systems in manufacturing changed through mechanization, systematization, standardization, automization and flexibilization of the production processes in a sequence of era. In response to the customer's demand for more variability of the production output the production processes became more flexible with a movement towards reaching a higher quality of output and the production of finished products of different kinds.

The conclusion is that in manufacturing sectors industrialisation could have taken place thanks to *innovation*. Innovation is not only the *invention* -i.e. the development of new technologies (products and production processes) and knowledge-, but also the *diffusion* (acceptation, adoption) and *application* of these in manufacturing sectors that enhanced the changing production characteristics over time. [16].

A key question that should be raised now is: What were the major factors that enhanced the invention and diffusion of new technologies and knowledge which made manufacturing sectors industrialise?

3. Theoretical approaches towards industrialisation and innovation

The answers to the question above have been a subject for research by many scholars already since a long time. The role of innovation in improvement of production performance and competitiveness has developed considerably over the past decade in economic literature. In neoclassical economic theories the basic assumption is that a motivated *profit-maximizing, cost minimizing and output maximizing* entrepreneur has to make choices among various production technologies in a perfect competition environment. [18] The neoclassical theories however could not offer a clear insight on the content and process of innovative activity or on the existence of persistent differences in the volume, scope and quality of innovations across firms, sectors or countries. [17] In these views the ultimate incentives are economic in nature; but economic incentives to reduce cost always exist in business operations and precisely because such incentives are so diffuse and general, they do not explain much in terms of the particular sequence and timing of innovative activity. Incentives thus constitute only a necessary condition for innovation. The traditional theories in the field of economics have traditionally had difficulties in addressing issues surrounding technological change. This is also due to the special nature of technology. Technology and knowledge are seen as a system of interrelated know-how, skills and knowledge (know-why, when, where and by whom) regarding production processes and products. Technology and knowledge that is general and widespread to the industry and is partially un-codified is seen as public good. Firm-specific technology and knowledge that is often patented, protected, or secret is seen as private good is not freely available. [19] In recent years, both extensions of the neoclassical theory (e.g., new growth theory), as well as alternative approaches to this dominant paradigm have emerged, including the broad field of evolutionary economics. The core concept in these theories is the innovation within technological paradigms. The theoretical approach often draws on Thomas Kuhn's seminal thesis (1962) in which the word *paradigm* is introduced. [10] This relates to. social constructs -a pattern- made of knowledge, rules, conventions, consensual expectations, assumptions, or thinking which characterize professional practice. A *paradigm shift* is a significant, profound and irreversible change from one fundamental view to another, a different model of behaviour or perception. It can be either evolutionary (i.e., a slow pace of change) or revolutionary-dramatic, short-term, and immediate high impact. Innovations -technological and knowledge developments- can thus bring about a paradigm shift. However innovation processes do not take place in isolation. [3]. Nelson & Winter's (1982) stated that sectoral asymmetries in industrial dynamics and innovativeness can be interpreted on the grounds of technological regimes [14] A technological regime defines the particular knowledge environment where innovation (problem-solving activities by firms) take place [23]. In this sense technological regimes (a set of rules that guide the design and further the development of a particular technology) sets the boundaries and form a constraint to what can be achieved in innovative activities associated with a given set of production activities, and the directions (natural trajectories) along which solutions are likely to be found [12] Malerba & Orsenigo (1996),

Breschi *et al.* (2000) define technological regimes as a particular combination of four factors - technological opportunity, appropriability of innovations, cumulateness of technological advances, and properties of the knowledge base- as being common to specific activities of innovation and production and shared by the population of firms undertaking those activities.[11]; [1] *Technological opportunities* indicate the likelihood of innovating for any given amount of money invested in search. High opportunities are to be found in an economic environment that is not functionally constrained by scarcity. This situation provides powerful incentives to the undertaking of innovative activities, thus potential innovators may come up with frequent and important technological innovations. There also is a policy and regulatory environment that might form either an opportunity or a constraint to innovation. *Appropriability of innovations* indicates the possibilities of protecting innovations from imitation and of reaping profits from innovative activities. High appropriability reflects the potential to successfully protect innovation from imitation by means of patents, secrecy, lead times, costs and time required for duplication, learning curve effects, superior sales efforts, and differential technical efficiency due to scale economies. *Cumulateness of technical advances* reflects the existence of a technology and knowledge base that forms the building blocks for future innovations. Based on existing technologies and knowledge a stream of subsequent innovations can be generated that are incremental changes of the original one, or it may create new knowledge that is used for other innovations in related areas. Economic environments characterized by continuities in innovative activities and increasing returns are considered to have high levels of cumulateness. The last is also related to the cognitive nature of the learning process (e.g., learning by doing). The *property of the knowledge base* relates to the *nature* of the technology and knowledge that is available to support innovative activities. Technology and knowledge can be classified in various ways: generic versus specific; public vs. private; degree of complexity, tacitness etc. Previous literature mainly focuses on specificity, i.e. specialized and targeted to specific applications. [1] The level of specificity reflects that knowledge can be universal and widely applicable, or more specific to particular ways of doing things. The knowledge base is to be found in a network of more or less interrelated enterprises institutions and organisations that all together form the industrial *innovation system*. The opportunities to innovate depend on the extent to which an industry can draw from the knowledge base, the technological advances of its suppliers and customers, and major scientific advances in universities and R&D institutes.

Conclusion Industrialisation in manufacturing thus could have taken place thanks to a sequence of innovations. Innovativeness of industries highly depends on technological regimes and the characteristics of the innovation system.



Figure 1: Factors influencing Industrialisation and innovation

4. Construction industry

In line with the definition for manufacturing one could state that construction is the transformation of materials, substances or components into buildings and infrastructural works. A building construction process can be seen as a complex multi stage production system. Each of the stages involves a production process in which intimately related interactions take place between various parties:

- (a) Product development stage; planning, design, engineering, specification;
- (b) Process development and production stage, which includes determination of the construction system, construction planning, work breakdown, work packaging, the schedule and layout of the construction site, organisation structure, cost estimation, tendering, preparation, transformation and assembly of materials, components for physical realisation of a building. cost and quality control;
- (c) Production process stage of the building materials, elements and components. [4]

In traditional building construction processes in the past, but also still in developing countries at present, the production process of building materials, elements and components takes place on the building site and thus is integrated in the stage of actual realization of the planned building. The lack of alignment between the parties working side by side on construction projects translates into dysfunctional teams, poor levels of cooperation and lost opportunities for the optimum use of resources, innovation and industrialisation.

5. Industrialisation, innovation and prefabrication in the Construction Industry

The construction industry is commonly characterized as one that is labour intensive, with a low level of innovation, of technology diffusion, of technological advancement of on-site construction and thus a low level of industrialization compared to manufacturing. Industrialisation is expected to reduce costs through faster construction, to increase construction quality, to eliminate dependence on weather conditions at the construction site, and to improve coordination of planning and construction. Viewing building construction as a total production system, sub-divided in a number of individual production processes, implies that each of these processes has a potential to be industrialised. This means that innovations can be applied in (a) the process of design, engineering and specification of the construction; (b) the process of project execution, i.e. the actual building process; (c) the process of building materials, elements and systems production as well as integrated in the total construction process. CIB W24 (International Council for Research and Innovation in Building and Construction, Work group 24) defined Industrialised Building as "a building technology where modern systematised methods of design, production planning and control as well as mechanised and automated manufacture are applied". Industrialised building, following the views applied to industrialised

manufacturing, should relate to the application of accumulated knowledge and technologies in construction processes that become increasingly mechanized, rationalized, systematized, standardized, automatized and flexible. Industrialised building does not necessarily equate with mass production. Mechanization in parts of the construction process on site and prefabrication of building materials and elements were the first phenomena of industrialisation in the construction industry with the purpose to reduce costs of manpower and time-consuming activities. What actually has happened in the construction industry in the course of time is that combinations of innovative solutions based on accumulated technological and knowledge advances were adopted in attempts to move from largely craft-based construction to a systematic construction process where resources are utilised efficiently. In fact a *convergence of technologies and knowledge* from different areas and disciplines has taken place. By drawing parallels between industrialisation in manufacturing and construction like Girmscheid and Hofmann (2000) did, the sequence of accumulated knowledge and technology advances as well as their impact on the construction process characteristics can be noticed as outlined in table 1.

Table 1 Innovation and changing construction process characteristics

Sources: based on Dicken (2000) and Girmscheid & Hofmann (2000)

Era	construction process characteristics	Cumulative technology & knowledge advances
craft based construction	- location-bound - labour + division of tasks - building materials and constr. system determined by availability of natural resources	Materials Product engineering
Mechanization	- Labour substituted by machines - New materials - Prefabrication of building materials & elements	Materials Product engineering Energy Transport
Rationalization Systematization Standardization	- New materials and composites - Standard bld elements & engineering solutions (e.g. components, methods, processes or dimensional standardisation and modularisation) - Pre-assembly (materials, prefabricated components and/or equipment are joined together for subsequent installation); - Modular and dimensional coordination - Work process organization further division of tasks - More control and supervision	Materials Product engineering (based on applied mechanics & building physics; new mathem. tools) Energy Transport Production management
Specialization Automization	- New and engineered materials, (e.g. high strength concrete, fibre reinforced materials, glass, ceramics) - Assembly line production processes of standard bld elements with flexibility in design - More control on pace of production - Mass production: large volumes of standardized products - Large span and tall buildings - Building systems (a product system with an organised entity consisting of components with defined relationships, including design rules) - Construction management - Optimization of procurement & logistics - Lean construction - Concentration on market segments	Materials Product engineering Transport Energy Production management Process engineering
Flexibilization Integration	- Utilisation of programmable machines (e.g. robots-performing tasks; computerised tools for planning, design and operation; computer added management) - Flexibility in standardized elements and bld systems - Intelligent buildings - Interaction of design, engineering, planning, production, construction and marketing - Integration of planning, construction, manufacturing and marketing - Response to dynamic market demand: (mass customization) >relation/communication suppliers-producer-user-	Materials Product engineering Transport Energy Enterprise management Process engineering ICT

Innovation in the construction industry refers to the process of development, distribution and application of technologies -a new or improved product, process or service- and knowledge with

the purpose to improve productivity and to suit the customer's requirements. Construction industry innovations are mostly incremental and thrive on accumulated technological and knowledge advances and took place in various areas: materials, engineering, transport and equipment, ICT, computers, robotics and management. As construction evolves into an industrialized process, new construction methods and building systems are also being developed to assemble prefabricated components. "Prefabrication" existed already in the ancient world; in Egypt, Greece, and Italy, where famous buildings were erected with prefabricated components made of stone [22]. The past decennia have seen the popularity of prefabrication rise and fall. At present it still gets a mixed acceptance. Despite this it is widely applied in modern construction and became almost normal practice. The benefits of prefabrication, or off-site fabrication, as making a significant contribution to construction performance, are increasingly recognised by the construction industry. The advantages of prefabrication include a reduction of (time-consuming) on-site activities and an elimination of some of the construction peculiarities such as suboptimal (climatological, locational) site conditions. On the other hand the introduction of prefabrication in the construction process tends to make the total process more complex. Prefabrication means investing in preparation, so that things proceed smoothly. Planning and organization must be intensified, of interaction, cooperation and co-ordination in a multi-trades context has to be optimized. [9]. This also implies a need to have a quality control system for all activities during the whole process since the requirements on dimensional tolerances are more severe. The degree of industrial prefabrication has an impact on competitive prizes. A higher degree of prefabrication on the other hand, requires more work on the part of planners, which means that more time must be invested in planning processes. There is a necessity of making precise commitments in certain instances in the planning process. According to Warszawski [22], the main problem of prefabrication today is the lack of a system approach to its employment among the diverse parties involved.

Industrialised building did not automatically imply increased productivity, reduction of man-hours, or economic growth. To provide high performance buildings to the consumer, profit maximization, cost minimization and output maximization to builders, production theories and management tools were used in order to know how to manage their operations in all phases. Koskela and Vrijhoef [8] note that direct application of radical managerial innovations such as mass production or lean production from manufacturing, to construction has been limited due to different context in construction in correspondence to manufacturing. The question is whether the evolutionary theoretic approach will offer a better understanding of the major factors that are impeding or stimulating industrialisation, innovation and prefabrication in the construction industry and thereby a better insight in the strategies to be followed to industrialise.

6. Innovation system, technological regime and paradigm shifts in construction industry

The next paragraph tries to describe innovation and industrialisation in the construction industry following the lines of thought of the theories that were discussed in the foregoing. The assumption is that the innovation system comprises incentives for innovation and paradigm shifts provided (or constraints formed) by the technological regime, i.e. the economic and regulatory environment, the internal capacity of firms to seize market and technological opportunities; cumulativeness and nature of technological and knowledge advances; accessibility of critical inputs and the way new technologies and knowledge is protected for imitation. *The innovation system of the construction industry* includes a variety of actors. It is the network of more or less interrelated enterprises, organisations and institutes which jointly and individually contribute to innovation, i.e. to the development, diffusion, application and use of new technologies. *Longterm linkages* between the various actors are critical for innovativeness and for the efficiency in terms of speed and costs at which projects and technological inventions in these are realised, handed over and used by and among the actors. It counts also for the efficacy at which clients requirements are met with the project. Linkages in the construction industry however are mostly project bound and of temporary nature. It is not only the linkage that counts it is also the *size and nature of the knowledge base* within the distinct institutes, organisations and firms that is considered determining for innovation and industrialisation. The construction industry is characterized by a high percentage of small and medium sized firms. Much of the technology and knowledge – at least in the contractor business- is tacit, not codified and project experiences are often not documented, which makes diffusion more problematic. Building product and material manufacturers have been the major sector of the construction industry to actively develop or look for new technology to improve their products, given the fact that they can profit from scale economies, which forms an *technological opportunity*. Another industrialisation *stimulating factor* concerns the aging and shrinking construction labour force in many Western countries as progressively fewer young people enter the industry. If demand for labour remains the same and the supply decreases, costs will increase. This pressure will lead builders to innovate and apply industrialized construction, which requires fewer specialized trades and people. *Impeding factor* is the tendency to conservatism making that diffusion of technological developments - a new or improved material, building element, process component or procurement method - generally faces quite some constraints within the construction industry. The array of regulations and standards -often unduly conservative and prescriptive- as well as the variety of contractual agreements and the separation of responsibilities among those involved in a construction process can be blamed for this. [13], [15]. The reluctance to change is enhanced by risks of unforeseen failure and damage during the project execution and a marginality of profits. Acceptance, application and implementation of technological developments, inventions and improvements in the construction industry therefore slowly come to pass. An important role for Governments is to improve the efficiency of innovation systems and facilitate their formation. Innovation

stimulating is the fact that people become more educated and know more about for instance energy conservation, lighting, indoor air quality, and other health and comfort related issues, consumers (homebuyers and commercial property owners). These customers put pressure on firms to deliver better quality goods and services. The uniqueness of each construction project provides an impetus for innovation. Moreover *appropriability in construction is low*; construction operations are rather transparent, easy to copy and have the opportunities for job-site training; the industry has an extensive scope for diffusion of inventions and technological improvements from other projects and industries. [7], [20]. Although there are incentives to innovate and industrialise, there are factors impeding innovation and industrialisation which in majority appear to be the deficits in the innovation system such as cooperation between planning and construction as well as characteristics of the technological regime such as the reluctance to accept and adopt new technologies.

7. Conclusion and discussion

In this paper the theories that could underpin our understanding of industrialised manufacturing have been discussed as well as how these can be utilized to improve our understanding of what happens regarding industrialisation in the construction industry. The innovation system approach as developed by economists (Malherba, Nelson and Winter) seems to offer an interesting opportunity to get a grip on the processes of industrialisation in the construction industry. The basic assumption that is adopted here is that the technological regime of the construction industry sets the boundaries for innovations, which applied in this industry stimulates or are an constraint for industrialization processes. The construction industry has continuously developed during the years. Innovations could develop by accumulation and convergence of technologies and knowledge from various areas and different parties in the construction industry in the course of time. Despite this the technological regime and the innovation system seems to adversely affect innovation and industrialisation. More transparent forms of planning cooperation could be a way forward as well as innovative forms of communication and/or exchange between planners and builders. The development of integrated production management in the construction industry - of which development prefabrication is a part- supported by ICT development and application, is expected to lead to industrialised building and at the same time will bring about radical changes for the involved firms. It still is point for discussion what exact type of paradigm shifts is needed for real successful industrialised construction.

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Industrialization in Building Construction – Production Technology or Management Concept?

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Abstract

So-called “Industrialization in Construction” is always presented as the ideal solution when the problems facing the construction industry take on survival-threatening proportions.

Hope centres on solving these problems by using state of the art on- and off-site production technologies and standardized products, elements, and modules, but this approach ignores the fact that the problems facing the construction industry are caused by fundamental structural economical deficits, which cannot be overcome simply by implementing measures such as these. Past experience has shown that attempts to “industrialize” the construction process have failed time and again, since such efforts always focus on the production aspect. The following paper attempts to demonstrate the real consequences of rigorously industrializing the construction processes, whereby production-related measures, such as automation or standardization, are not, on their own, the deciding success factors. Success depends on the ability to combine these measures, both with a product-oriented and customer-oriented approach, and the industrialized organization of all production and planning processes.

Keywords: industrial construction, project delivery model, system provider

1. Introduction

1.1 Status quo

A survey of cost structures in building construction [4] shows that the total construction costs account for only approx. 50 % of the total investment costs of a residential building (Table 1). Depending on local land prices, however, this share may differ to the high or to the low side. In the light of industrialization, however, the construction industry can influence the construction costs. However, Table 1 shows that the costs caused by the production process costs (wages, use of equipment, construction methods) amount to approx. 50 % of the construction costs, and can be influenced by industrialization of the production processes.

Table 1: Distribution of Construction and Investment Costs to the Cost Groups [9]

Cost Groups	Total Construction Costs			Investment Costs
	Share of Manpower / Equipment	Share of Material	Construction Costs	
	%	%	%	%
Land				25 %
Planning / Management			~ 10 %	5 %
Development	70 %	30 %	14 %	
Structure	50 %	50 %	36 %	
HVAC	40 %	60 %	30 %	
Finishings		40 %	20 %	
Construction Costs	~ 50 %	~ 50 %	100 %	53 %
Outdoor Facilities				7 %
Financing				5 %
Marketing				5 %
Total				100 %

The potentials of economies and efficiency respectively, which are immanent to the construction cost group, can be classified as follows:

- Increase of the efficiency of the production processes and methods
- Elimination / reduction of working hours lost due to inclement weather
- Elimination / reduction of weather-related fluctuations in performance
- Increase of efficiency by clear work flow processes
- Elimination / reduction of searching for material
- Elimination / reduction of rearranging material
- Reduction of loss of material

This would increase the value-adding activities during production and, to a large extent, eliminate the non value-adding activities (Figure 1).

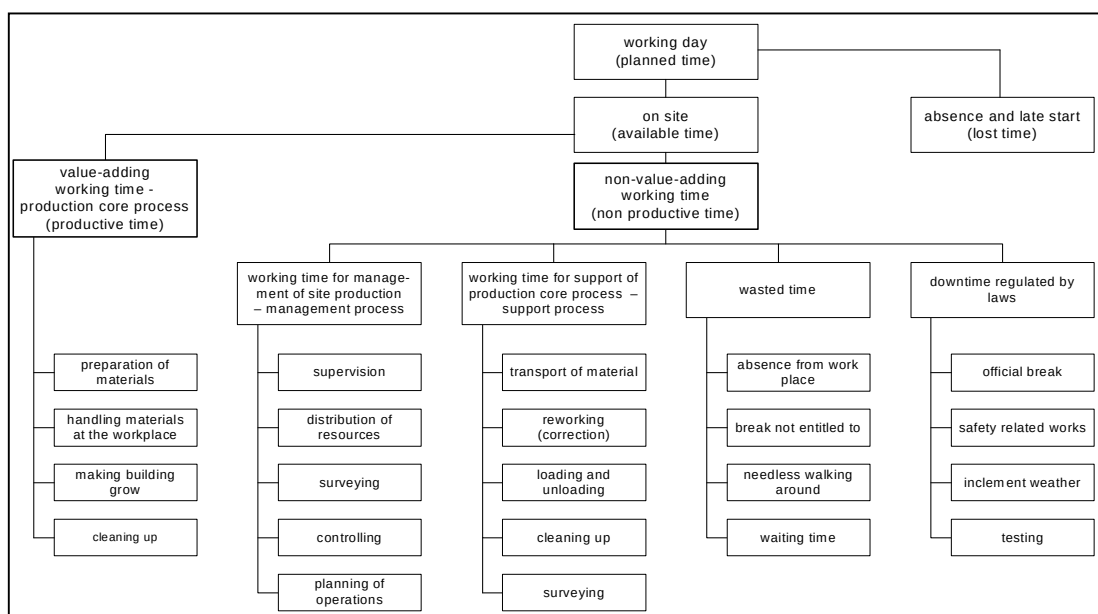


Figure 1: Systematization of working time on a construction site [14]

Boenert and Bloemeke[[2] show in a survey of building construction sites with largely parallelised structure, technical installation and finishings activities that approx. 33 % of the hours are used for non value-adding work as searching for, and rearranging of, material, which shows potential for an increase in efficiency. Potential for increasing efficiency on traditional construction sites has also been identified by Winch [14].

Not only the pure service provision process but also the support processes (Figure 2) in an enterprise can be organised in a more value-adding way by industrialisation. Potentials in the support processes arise, among others, from procurement [5] and knowledge management [3], [12] as well as from the production planning. At the time being, however, it can be ascertained in some economically important countries of the EU that the traditional, largely manual, individual on-site production is, to a large extent, undamped due to cheap labour from the new member states of the EU and Portugal. However, an adjustment of the wages is to be expected relatively fast. The industrialisation of the construction processes will then gain high momentum to systematically exploit the efficiency potential.

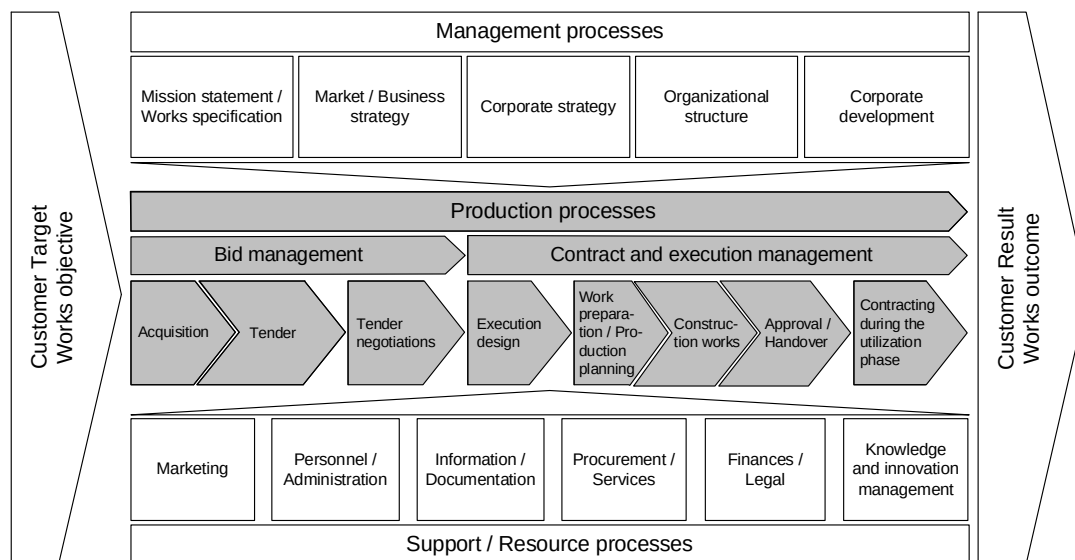


Figure 2: The processes in a construction company

On- and off-site industrialisation of the construction industry will irresistibly make its way, especially in building construction. By developing the tunnel driving machine, the processes in tunnelling have already been industrialised by:

- Mechanization of the work processes
- Logistic systems for supply and disposal in the back-up area
- Automation of the control systems of the tunnel driving machine and the logistic back-up system
- Functional separation of parallelized work processes

As the stationary industry - and not only mass production but also unicum production (e.g. turbines) - has mechanized, computer-aided, and automated its production and service provision processes as stationary in line production and integrated the support processes, a comparison with regard to transferability to construction is indispensable.

1.2 Demands on industrialized construction

A closer analysis of “conventional” industrial production reveals a similarity of the specific characteristics. Taking the particular constraints of construction into consideration, they could, for example, be applied to define the demands on industrialized construction as outlined in Table 2.

Table 2: Characteristics of industrial production and parallels to construction production

Characteristics of industrial production	Demands on industrialized construction
Centralized production	Pre-fabrication of components at the factory
Mass production / increasingly variable production	Development of variable basic types
Production based in standardized solutions and manufacture of variations	Standardization of components but still maintaining flexibility of design
Specialization	Focus in specific market segments
Integration of planning, production and marketing	Interaction of building design, production planning, production / construction
Optimized processes and organization	Optimization of the planning and production processes in terms of automation and mechanization

This refutes the frequently sweeping claim that industrial production is not possible in the construction industry on the grounds of its typical situation that cannot be compared with the conditions prevailing in other industries.

Previous attempts to industrialize construction primarily focused on the objectives of replacing manual labour with machinery and automating permanently recurring processes. To be successful, however, any approach aimed at creating industrial structures in the construction industry must extend far beyond these processes, and must lead to process reengineering, or even the establishment of system provision.

Industrialisation of production can be reached by:

- process oriented work preparation and production cycles
- optimized (mechanical / automated) machinery and plant for on-site as well as for off-site production

For implementation in the construction industry, business and cooperation models are required. Industrialisation of construction is a generic process with

- Standardization
- Systematization
- Flexibilization
- Rationalization

Industrialisation has different paradigms (Table 3). Realisation of the different paradigms or their combinations requires collaboration with designers and construction companies of different trades. Further, new project delivery models are required if more standardisation and off-site production is anticipated.

Table 3: Industrialization Paradigms

Paradigms	Process orientation	Design to build	On-site production	Off-site production	product orientation	sustainable product orientation
Measurements	for off- and on-site production: • using work planning and controlling tools to reduce the non-value-adding activities • production flow • logistics	• collaboration / cooperation in design between designer and contractor • standardisation of elements, details, connection • unifying similar elements and details • digital transfer to production equipment and controlling	• work planning • supply planning • work progress control • using mechanical plant • planning off-site logistics • controlling	in factory: • clear sequences of work • independent of climatic conditions • clear work-preparation • work planning • supply planning • using mechanical and automated plant	develop, produce and sell: • clients groups • process oriented production • pamper clients or cost leader • marketing	product is life cycle value oriented: • optimise product in regard to cost- and value efficiency of the life cycle • collaboration / partnering • cooperation • marketing
Marketing strategy / target	cost efficiency	cost efficiency	cost efficiency	cost efficiency	cost efficiency and / or differentiation	cost efficiency and differentiation

In case of product orientation, collaboration and cooperation are required with key designers and trade contractors with core competencies for the product in either case of investment oriented or life cycle oriented construction products. The focus on industrialisation should be in a staged manner, to improve the performance and productivity, and to create continuous improvement for small, medium, and large enterprises. Therefore, the focus is staged in

- improving and rationalizing the work preparation and execution on-site
- incorporating prefabricated products
- producing industrialized on- and off-site structures
- offering to selected client segments off- and on-site construction products

1.3 State of practice in construction production

In order to give the importance of construction production its due, a brief analysis of the state of practice follows, which focuses primarily on the processes found in building construction [9].

When industrialization in construction is mentioned nowadays it is generally linked, above all, to the deployment of computer-aided or computer-controlled equipment. Such equipment is, however, so far only common in partial areas of on- and off-site construction production. Although all levels of industrialised in line production with mechanization and automation, ranging from pure manual production right up to highly automated production plants, are found in pre-fabrication, building site production is still dominated by manual construction using different, mostly non-automated mechanized equipment.

1.3.1 On-site production

The majority of works on building sites are still performed manually to this day. So far neither mechanization concepts, nor and particularly automation concepts, have achieved any widespread acceptance. In the field of masonry construction alone there are first signs of mechanical cogging equipment being used to supplement manual labour, whereas in concrete construction the last major streamlining surge was triggered about 20-25 years ago by formwork systems. Whilst progress in the field of material technology has been ongoing, with a trend towards high-performance materials becoming recognizable, the field of material processing has more or less stagnated.

The development and continuing reduction in size of high-performance and robust DV systems, declining prices for electronic and hydraulic components and the development of service robots, for example, in space, nuclear and underwater technology are providing impetus to continue efforts aimed at automating building site processes. In extreme working conditions, easily programmable and controllable equipment has achieved very high levels of reliability and accuracy, which look promisingly like it could be transferred to building site production.

The real challenge facing on-site production therefore lies in ensuring a working environment and processes that are suited to automation.

1.3.2 Pre-fabrication / Off-site production

During the course of the first wave of industrial automation, which took place back in the 1980s, the first pre-fabricated concrete and masonry elements and modules were also developed for production. Based on in line fabrication processes with a relatively simple structure for the production of concrete pipes, concepts were developed for automated stationary off-site production that were also transferred to the fabrication of elements and modules for residential building construction over time. As such, it would theoretically be possible nowadays to use for the in line production CIM technology to construct a variably designed building completely from elements and modules that had been produced by in line production by computer-aided manipulators and equipment which acts stationary. This would allow a wide range of variability in the architectural design by simultaneously standardizing joints and connectors, reinforcement, wall sections, and, to a certain extent, the material used. The prefabricated elements and modules would then only have to be assembled on the building site with a minimum of effort. Some manufacturers even venture one step further and already offer partially or fully finished building

modules like e.g. bathrooms. It is hereby of secondary importance whether the elements and modules are concrete or masonry. Correspondingly automated production machinery is available for both materials, both for use on building sites and for the fabrication of finished elements and modules. Highly-developed production planning and control support for the planning and control of the entire range of fabrication processes are, however, crucial but available in other economical sectors and need to be adapted.

The off-site fabrication of elements and modules in production and assembling lines enables not only the fabrication of simple structural elements but also fully integrated elements and modules with insulation pipes, cables and basic finishing. For the on-site assembling, special joints and connectors are required for the structure and the technical installations. In this case, the prefabricated elements and modules include all the technical and finishing works. The degree of individuality also increases with the resulting decline in the size of the series of the elements and modules (Figure 3).

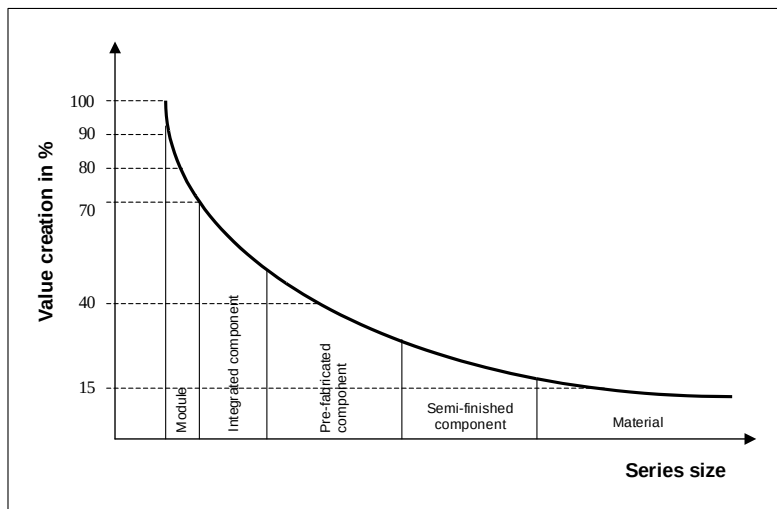


Figure 3: Value creation and series size

1.3.3 Transferring technologies and procedures from other branches of industry

A generalized analysis reveals that the work steps in construction production are very similar to those in other areas of industrial production [10]. The primary categories of work involved are the handling and transport of materials, the fabrication of elements or modules, fittings and connections, the positioning and fixing in the corresponding place, and the prior and subsequent processing steps using special tools. Equipment is already available to handle many of these work steps, and these could be adapted for on- and off-site construction production. One of the characteristics of construction production is the frequent need to work with large and heavy components, elements or modules, which places particular demands on the transport capacity and mobility of placing equipment. Nevertheless, a “peek over the fence” looks promising, given the comparability of the fundamental processes.

2. Consequences for processes and organization

2.1 Means of escaping price competition

The fragmentation of products and services in the construction industry has led to pure price competition which is one of the primary factors that has resulted in the problems facing the construction industry today. Suppliers and products/services have become virtually interchangeable and replaceable since specific quality attributes are not developed in the manufacturer-neutral planning process. The “classic” structure of a construction contract comprises planning works performed outside the sphere of influence of the construction or prefabrication company with the property developer or owner employing a planner, a construction company, technical installation and finishing companies, whereby the companies have to implement the design in line with technical specifications without being able to accept or analyze the feasibility and optimize the same. All that is important is that the works are offered at a lower price than the competitors and performed within a timeframe stipulated by the client. Any strategy aimed at industrializing construction must therefore include approaches to overcome the fragmentation of planning and construction works, which has resulted in the current situation on the construction market.

2.2 Interactive works and production planning

A strategy aimed at making construction profitable for contractors again must also start at precisely this point. The contractor must use other differentiation characteristics in the market, and not just price, to prove his suitability for performing the works. These include, above all, offering the client total services tailored to his specific needs as a basis for the construction works, and rendering these same services quickly and with a high level of quality. Sufficient run-up time for integrated, interactive works and production planning is crucial to allow the contractor enough time to plan the working drawings and the construction production processes in detail and accurately. Potential areas of planning optimization are to be found in the integration of all requisite works into a production planning process that takes all the technical, schedule and commercial aspects into consideration.

2.3 Information flow

One of the major problems currently facing project delivery is securing a coordinated, reliable and ongoing flow of information. The coordination work involved is considerable, given the fragmented approach to delivering projects caused by numerous independent parties involved in the project who all use different computer and information systems. One means of improving construction processes, both in the planning and delivery phases, is to use a consistent database which all the parties involved in the project can access to reduce interfaces (Figure 4).

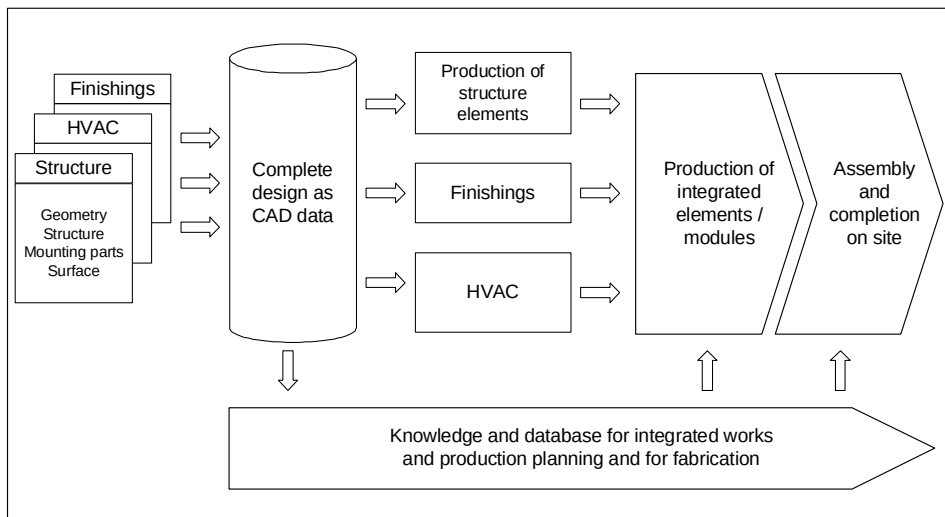


Figure 4: Structure of the planning and construction phases

These newly structured information processes require 3-D-CAD systems with linked data, and the creation of an intrasectoral standard for exchanging information. The currently common exchange of graphics does not meet these requirements at all. On the contrary, what is needed is communication among the various parties involved in the different project process phases, based on object-oriented information.

2.4 Systematic development

Aligning the planning processes to the production needs is a further step towards offering an integrated service from one source. This does not, however, mean that the production should dominate the design of a building. On the contrary, the so-called freedom of design should not necessarily be restricted, especially not in terms of architectural design. However, an analysis of the design alternatives quickly reveals that this freedom primarily exists in varying components, shapes and dimensions of the elements and modules to be produced for the building, and in choosing the fundamental layout and type of building. The technical details and schemes, such as wall or ceiling construction based on pre-defined dimensions, or sound and heat insulation requirements, as well as technical installations, offer broad scope for standardizing components.

2.5 Prefabrication, standardization, serial production

This standardization is also the basis for industrial production processes, which require a certain number of identical parts and / or elements and modules to be economically efficient. But identical elements or modules do not need to be of identical dimensions, they need to be identical in terms of the materials, the build-up of the construction from various materials, or the static impact. The material for serial production of elements or modules that is used recurrently in the same way is either kept available in storage or produced just-in-time; this can contribute to a considerable reduction in construction time since only those elements or modules that need to be

manufactured individually have to be built once the contract has been awarded. To limit and standardize the material reduces storage and the bound capital.

2.6 Construction services as a product

If this approach were to be rigorously adhered to, a building could ultimately be compiled from a basic design and a choice of the various components and finishing elements. Various types or series could be compiled and then individualized by altering the parameters, as is standard practice in the automobile industry. This would result in a transition from individual structures, unique buildings that are newly developed each time, to an industrially planned and designed product. This is one of the approaches to genuinely industrializing construction, i.e. not always re-inventing each building, but the industrialized development of a product from an existing, largely standardized portfolio of components, whereby the product can be given an individual design by changing certain parameters in line with customers' preferences.

2.7 The shift from price to performance competition

The current situation in the construction industry does not allow cost benefits to be generated merely by improving methods. Each and every competitive advantage is equalled out by the competition within the shortest period of time, either by imitating the methods or by using subcontractors and, again, applying price pressure to them. The beneficiaries of this situation are the clients who only need to avoid awarding contracts under time pressure to allow them to take advantage of this cost spiral caused by the suppliers undercutting each other's bids. The consequence for the contractor is that he must avoid a comparability of his bid merely in terms of pricing and costs. Then, and only then, can his bid be assessed independently of a purely cost aspect, and in terms of its aggregate attributes and alignment to the client's requirements. In order to achieve this, the contractor may not just respond passively to tenders by submitting prices, but must sell a solution to a problem, in the widest sense, rather than just offering to perform works.

2.8 Incorporating marketing aspects

As a consequence of this approach to organizing a construction project, the opportunity arises of shifting the acquisition of contracts away from reacting to technical specifications towards active marketing and sales of customer-oriented buildings. These activities, unaccustomed for construction companies, allow them to differentiate themselves from the competitors in terms of actual performance, the range of products and services, and quality attributes [13].

A systematically developed variable building product which meets individual customer requirements with the right marketing mix can offer clients considerable benefits, since the composition of the same is known and understandable, and clients receive a precisely defined level of quality, which is not the case with today's traditional, fragmented, individually rendered

services where the building with all its standard details is re-invented. In residential building construction, especially, design plays an important role. As long as a supplier is able to create a typical design with a high level of recognition, certain standardized quality attributes will be permanently and unconsciously linked to precisely this design.

3. Expanding the portfolio of products and services to become a system provider

3.1 Plan, finance, build, operate

The industrialization requires expansion of the design scope but also of the scope of responsibility of the “product” (the building) in one hand. Industrialization offers opportunities to tie in other activities that extend far beyond the actual construction. Initially it was turnkey construction and general services contracting that led to an expansion of the portfolio of products and services offered; these were followed by project development including financing and marketing services. Nowadays an integrated solution that meets the specific needs of a client is required in many areas, which can include operation and all manner of life cycle services. Irrespective of whether the building is destined for the client’s own use, as a production facility or an investment, the construction industry faces the opportunity and the challenge of meeting all these needs and, in doing so, gaining access to client groups that were previously inaccessible [7].

As such, the provision of processing works is being replaced by a broad portfolio of products and services, whereby each of the areas of planning, construction, financing and operation – either on their own or combined – can open up new potential markets.

3.2 System competency, system providers

The need to develop such competency arises for anyone wanting to engage in industrial construction [7]. Companies need to be more and more flexible and able to offer integrated products and services along the value chain if clients so wish.

Industrialized system providers with specific products, services and customer segments interpreting system business as an integrated approach that affords equal importance to all the stages and components of this service, ranging from planning to construction to services, such as financing and operation, will open a window for new customer segments and for innovation. A purely construction management approach in industrialization is the wrong route to take, particularly for large corporations, because the integrated synergies and continuous improvements can not really be controlled. However, industrialization requires the integration of different key components of the value chain. The system provider needs to have the key competence in-house, but needs not necessarily to provide all performance and services by his own. The modern architecture of system providers in the industry concentrates on core

competencies and a set-up of cooperation partners in a network. The future of industrialized system providers in the construction industry requires a paradigm change from stand-alone service providers with interchangeable subcontractors selected each time only on price criteria to strategic alliances with key designers, producers, and on- and off-site trades for the product and service offered [8].

The successful establishment of system competency depends on maintaining core business in-house, whilst buying in all the other expertise and components.

4. Outlook

4.1 Continuous development of construction methods

Experience from other industries has shown that the development of automated processes and robot technology, in particular, cannot be stopped once initially triggered. This surge in development requires the implementation of the requisite workflow, logistics, cost and/or quality advantages compared with conventional production and, in terms of equipment, units that can be deployed as independently as possible, and which are easy to operate and program. In the long term, the generally recognizable trend towards miniaturization in machine technology, i.e. developing smaller, lighter and simplified equipment with the same performance characteristics, but with ever more complex steering and control mechanisms, will, moreover, result in far more efficient solutions in process technology. Particular focus must be given to interoperability of different construction methods and equipments which, in general, operate in sequential but parallel workflow. Not the optimized single equipment or construction and finishing method leads to an industrialized, efficient, cost-optimal solution - to the contrary: the workflow, construction and finishing methods as well as the equipment must, in off-site and, in particular, in specific on-site construction operations, fit well together to reach an undisturbed high value creating over all processes.

4.2 Continuous development of information technology

As already outlined, the information flow will be the central element that will be used to control and link all the planning and construction areas affected by industrialization. Starting with high-performance data transfer concepts, and the integration of all parties involved in the project using EDM and internet solutions right up to the simulation of construction processes to provide prior information on efficiency, possible conflicts in the sequence of work, timeframes and costs, information technology will form the central nerve system of any industrialization.

In terms of industrial fabrication, the use of these methods and technologies requires a certain level of standardization and logistic planning to allow either the serial production and storage of frequently needed material, elements and components or the just-in-time manufacture of the same.

This offers considerable potential to reduce the construction time since only the really individual components for a specific building need to be manufactured once the contract has been awarded, whilst standard elements can be used to a major degree.

4.3 New contract and cooperation models

As a construction company's product increasingly shifts from providing processing capacities to an integrated system concept designed in line with client needs, the conventional contract models also reach their limits. New forms of cooperation are needed that are also demonstrated by new contract and compensation models. Switzerland has taken first steps in this direction with its "Smart building" [11] concept, a contract model that integrates the companies performing the works during the project definition phase already, and results in the structure being completed by work groups, where several trades are combined and offered to the property developer and performed as a "service package" by a group of companies, with the contractors who are involved being responsible for coordination within this package (Figure 5).

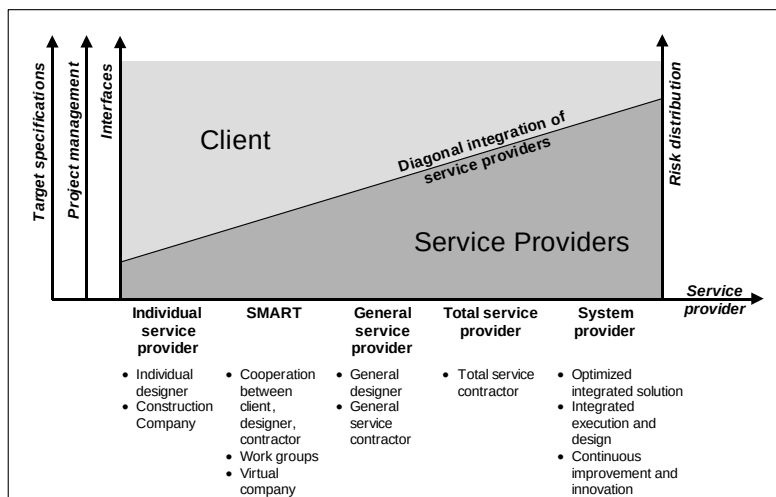


Figure 5: Project delivery models

In Europe, the growing practice of using GMP (guaranteed maximum price) with value engineering in total provision contracts (CM) [1], a contract model derived from American contract law, is a means of responding to the changed cooperation structures. With this form of contract, the client, planners and operators cooperate during the planning and execution phases openly and with the same mutual target to develop an optimized service within a fixed cost framework. This type of contracts could support the industrialization in construction industry to transfer early responsibility for the project to the contractor to allow the integration of building design in the production planning.

5. CONCLUSION

A construction company's orientation to client requirements that can extend far beyond the pure construction works forms the basis for developing industrialized system services and system competency [6]. Considerable earnings potential for construction companies can be found, especially, in providing supplementary services, since this area cannot be captured using standardized detailed specifications, but rather the contractor can use his creativity to set himself apart from the competition in terms of industrialized performance, by developing cooperative, innovative services comprising planning, construction, financing and operation, which are tailored to the individual requirements of each client.

The SysBau system services model developed by the Institute for Construction Engineering and Management at SFIT Zurich clearly illustrates this approach, thus forming a basis for integrated services within the framework of industrialized construction.

The systematic industrialization of manufacturing processes has already been implemented in all of those sectors of industry where top-quality, complex products are manufactured for a relatively clearly defined circle of customers, such as the automotive, airline or plant engineering sectors. Customers are offered all-in-one products, which demonstrate manufacturer-specific quality attributes, use cutting-edge technologies, are manufactured using state of the art fabrication methods and technologies, and, moreover, also include financing and other services incorporated in a cooperative supply chain.

The construction industry is also in the process of adopting this approach to industrialization. The future success of a company will depend primarily on its ability to identify the relevant potential areas of success and to take advantage of them, without fear of accepting new developments.

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Flexible Industrialization in Construction By Humanoid Construction Robots?

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Abstract

Robots were originally introduced in the production of industrialized building components and modular housing. Later mobile robots were developed for special on-site construction tasks. Automated construction sites use robotics for logistics and assembly. Recently humanoid robots have been developed and tested.

Keywords: Robotics , industrialization, prefabrication, customized production, construction

1. Overview

In the 1970s, many companies producing building materials on an industrial basis were founded by companies not otherwise engaged in construction. Ideas from automobile manufacturing, ship building and the chemicals industry were adopted by the construction industry. The 1980s saw the introduction of robots on building sites where they carried out specialized tasks such as spraying, smoothing concrete, distributing materials, fitting equipment to ceilings, assembling form-work, installing facades, painting and many more. In the 1990s, integrated systems for high-rise building were developed. These automated construction sites used robots for logistics and assembly. For around six years, humanoid robots have also been used for various applications on site, such as fitting interior walls, helping to carry slabs and driving forklift trucks and diggers.

2. Industrialized Prefabrication: Robot use in stationary building production

The Toyota Motor Corporation is known for its automobiles. However, it also has a factory for prefabricated houses in which it has successfully transferred manufacturing technology from the automobile sector to the construction industry. Toyota Homes produces from 4.5 to 7 houses per person per year. A Toyota house is assembled from room cells in up to 12 different sizes in four to six hours. In the factory, a room cell is prefabricated every 2.5 minutes.

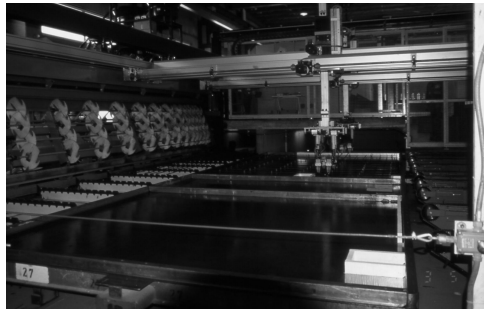


Figure 1: Flexible CAD/CAM gantry type production unit for PC floor, wall and roof elements

Customers can put together their dream home from over 350,000 single parts. Computer-aided design and computer-aided manufacturing systems produce approximately 2,000 components from around 25,000 parts, which in turn make up approximately 300 functional modules. Despite such a huge variety of parts, no manufacturing defects arise.



Figure 2 shows a robot for customized masonry prefabrication

So that customers do not become confused by the huge amount of choice, they can use virtual reality to walk through their dream home and can change anything they do not like before they sign the contract. If they approve of the simulation of the house and agree with the price and the financing terms, the CAD/CAM system starts the manufacture of the components and room cells, from which hardly any waste results. The quality of the robot-aided manufacture at Sekisui and Toyota Homes is so high that the company guarantees its prefabricated houses for between ten and twenty years. They are high-value products, manufactured with industrial expertise. The Sekisui suppliers work on a four-day cycle, planning one day for processing the order and preparation, two days for manufacture and one day for shipping.



Figure 3 shows a robot for customized wooden panel production

In a country where wages are high, a high-investment business will only thrive if it can operate continuously with help from the marketing department. Like the Toyota Motor Corporation, Toyota Homes is managed on a marketing-oriented basis. Marketing controls the robotized production systems at Toyota Home in the same way as the Andon and Kanban systems at Toyota Motors. Customer orientation comes first, which builds up a good reputation with satisfied customers. This service is rewarded with increasing sales of prefabricated houses in Japan where the building industry is otherwise in decline.

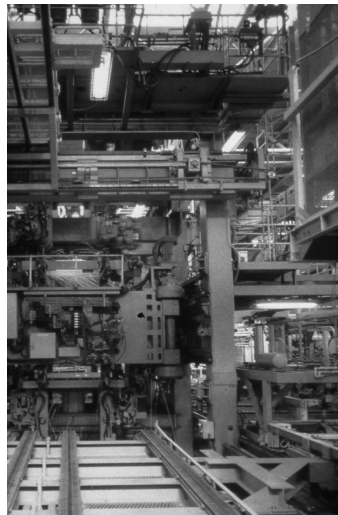


Figure 4 shows a robot for customized steel frame based box unit production

3. Mobile construction robots

Big Japanese construction companies have been researching and developing robotized construction processes since the beginning of the 1980s. Initially, individual robots and remote-controlled manipulators were developed for specific processes on building sites. This included robots for delivering concrete, handling concrete, applying fireproofing to steel constructions, handling and positioning large components and, as a final example, facade robots for plastering and painting. Over 400 different prototypes were developed and tested on building sites.

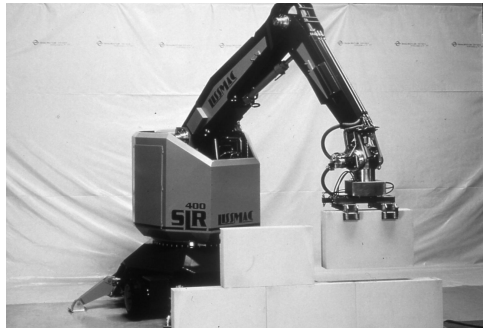


Figure 5 shows a mobile brick laying robot

They all had in common that they were intended for use on specifically defined tasks under building site conditions and were not supposed to have an adverse affect on the work carried out by the construction workers. It became clear that only a few robots were economic to use under these conditions. The restrictions on the workers, the safety regulations and the unforeseeable and unplannable events that affect building sites strictly limited the use of individual robots in parallel with normal work. There are only a few currently in economical use or offered for sale on the market. Examples are the concrete smoothing robots from Kajima and Tokimec. This development revealed that it is difficult and, in particular, not economic to transfer production conditions from the factory floor to the building site. This might seem to be a mundane and predictable result, but it must be acknowledged that these developments were only seen as a first step on the way to automating construction processes and that economy was not the primary objective.

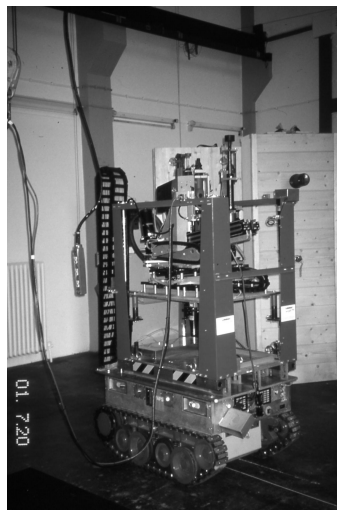


Figure 6 shows an interior finishing robot

There are two other crucial results of significance to the future of the Japanese construction industry. The first is the knowledge and skills acquired in the area of automation and robotics, and the preparation of workers for innovation in the construction industry. The second is the groundwork for the real objective - to automate the final assembly of a building on a building site under factory-like conditions and in bringing to bear the laws familiar from serial production.

4. Automated high-rise construction sites

The first prototypes for automated high-rise construction sites were put into operation in 1990 and 1991 after five years in development and a financial outlay of almost 16 million euros. Since then, 20 automated high-rise sites have been operated by different companies.

An automated high-rise construction site is understood as the semi- and fully automated storage, transport and assembly equipment and/or robots used to erect a building almost completely automatically. It is the attempt to improve the sequencing of construction processes and construction site management by using real-time computerized control systems. This includes an unbroken flow of information from planning and designing the building through programming the robots with this data to using computers to control and monitor building operations on site.



Figure 7 shows an automated construction site in September 2003

After the foundations have been laid, the production equipment, on which the steel construction has been installed with assembly and transport robots is covered completely with a roof of plastic film. Depending on the system, this takes from three to six weeks. Then the robots go into action. Two steel and ten concrete plants supply parts in ten-minute cycles on a just-in-time basis. This approach to supplying is not necessarily part of the system, but is due more to the lack of space around building sites in large Japanese cities. The prefabricated parts are checked and then placed in specific depots at the foot of the building or in the building itself to be available to the robots. This is where the automated construction process actually starts. Up to 22 robots equipped with automatic crane winches deliver the pillars, supports, floor, ceiling, wall and other elements to the floor of the steel skeleton under construction. They are also, in the main, positioned and fixed into place automatically. The steel pillars and supports are joined together by welding robots after they have been positioned. The position and quality of the welding seam are monitored with lasers.

Once a story has been finished, the whole support structure which rests on four columns is pushed upwards by 12 hydraulic presses to the next story. Three 132 t presses in each pillar are required to achieve this in 1.5 hours. Fully extended, the support structure is 25 meters high; retracted it measures 4.5 meters. Once everything has been moved up, work starts on the next story.

By fitting out the topmost story of the high-rise as the roof at the beginning of the building process, the site is closed off in all directions, considerably reducing the effect of the weather and any damage it might cause.



Figure 8 shows the same site in March 2004

This system reduces labor requirements by around 30%. Future projects are expected to achieve a labor saving of around 50%.

The building consists of a remarkably high proportion of prefabricated parts. Once the foundations have been laid, the remaining construction procedure can be described as a matter of configuring transport and geometry. All the elements are prefabricated; only some of the fitting, joint insulation and other minor works need to be carried out by hand. Problems with the construction arise less from the timing of deliveries of materials or from the choice of processes and/or machines but more from the need for accurate planning, from programming the robots or from the just-in-time supply of parts.

5.Servicing robot systems

In Japan the first facade and roof robots were developed and put into operation at the beginning of the 1980s. It should be noted that these devices were almost all without exception developed by the technical departments of large building companies or by their construction machinery suppliers and not by service providers or cleaning equipment manufacturers. This was due to the closely defined area of application of the equipment which, as a rule, was used only on one large building erected by the company in question. There are many varied applications. First of all there were heavy, rail-guided robots such as the exterior wall-painting robot from TAISEI, which was developed to apply paint to the 100,000 m² facade on the 220 meter high Shinjuku Center Building in Tokyo.



Picture 9 shows a watchdog service robot

6. Latest development: Humanoid construction robots

Humanoid robots for construction work have been developed and tested for six years. The robots can carry a joinery bench together with a construction worker, fit an interior wall, and drive forklifts or diggers. They can move over gradients of around five degrees and compensate for up to two centimeters on uneven surfaces. They can right themselves when they fall over.



Figure 10 shows a humanoid robot carrying a construction board with his human colleague

When carrying a component with a human, they use an adaptive and flexible arm system. An image processing system with a mobile portable control system has been developed to allow location detection. When it moves over uneven surfaces, a force sensor in the sole of the foot and a balance sensor in the body register the difference and the gradient allowing the robotic control system to adapt the sole of the foot to the surface.



Figure 11 shows a humanoid robot riding an excavator

7. Conclusions

The research, development and application of industrialization to construction during the last 3 decades shows that by using robotic technologies in prefabrication, on site construction and services, we will be able to achieve customized building products at affordable construction costs and constant quality.

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Systematic Optimization of the Construction Process by Implementation of PRSM (Process-oriented Risk-based Selection Method for innovative construction techniques)

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Abstract

Today's fierce price competition demands that contractors find the optimal solution in the construction process, as inefficiency can no longer be accepted. A reconsideration of the present approaches to decision-making shows the need for an integrated decision-making tool. PRSM is a knowledge-based decision-making model that uses pre-structured processes to allow the interferences that occur between parallel and/or sequential elementary processes when constructing buildings and cyclically repetitive tasks to be taken into account when choosing systems (formwork, equipment, concepts, etc.). The application of this method makes it possible to clearly demonstrate the impacts of system decisions on the overall system. This tool will lead to high performance on site as well as to a reduction of non-value added process activities. The project specific and process oriented choice of construction techniques is a core competency of construction companies and does have a very important impact on the efficiency and effectiveness of the work and the costs involved. Since systematic decision-making tools are missing and the time for work preparation is short, construction techniques are mainly selected on the basis of experience and subjective calculation of the project even for major complex projects. Single sequential construction processes are optimized separately regardless of their interactions and their dependency.

Keywords: selection method, process-oriented, risk-based, PRSM

1. Introduction

1.1 Status quo

An analysis of various buildings with a similar layout and number of floors reveals that the construction methods chosen to build the structure varied significantly in parts. The fact remains,

however, that the completion of all projects was technically faultless. As such, the decision to opt for this or that construction method cannot have been based on objective principles, but rather on subjective criteria, such as predisposition or preference on the part of the project manager.

The choice of project-specific and process-oriented system solutions represents one of the core competencies of a construction company and can influence the efficiency and productivity of the company to a major degree. An analysis of the current profit margins of German construction companies - which barely exceed 1% [1] and are reflected at the same levels by most other Central European countries - reveals that all means of optimization need to be exploited. Moreover, analysis reveals that construction contracts are generally awarded on the basis of pure price competition [2], which is why a systematized and, above all, risk-based decision-making process is of such enormous significance, particularly in the case of such contracts.

Attempts made in the past to support and optimize the planning and construction processes using computer aids nearly always produced aids for monitoring schedules and controlling costs [3][4]. As such, however, the construction process is only receiving support at a relatively late point in time, by which time the strategically important and, as such, cost-relevant decisions in terms of methods and procedures have already been made. The aim of this research project is, therefore, to develop a decision-making model that allows system decisions based on objective fundamental data to be made early on, whilst the planning and work preparation phases are still ongoing. The construction process is being analyzed as a whole, including the various interactions between the partial processes, with clearly trackable performance data being obtained that can subsequently be used for cost comparison purposes.

1.2 Approach

The choice of the optimal project-specific system solutions represents a complex task since all the interactions between the various partial processes that can impact performance need to be taken into consideration. The aim of this research project is to provide pre-structured process models that enable the decision-maker to base his choice of system on knowledge of the individual impacts on the entire system, whereby focus is not on selecting the optimal system for a work area taken on its own, but on choosing the systems in such a way as to ensure an overall optimum for the project.

Up until now, decision-makers in the bidding and work preparation departments processed each and every one of these points manually. It would be unrealistic to assume that, in doing so, every single interaction, constraint and economic impact of the possible individual combinations of systems could be taken into account. As such, the process model developed at the Institute for Construction Engineering and Management at SFIT Zurich aims to offer such decision-makers an effective and utilizable decision-making aid.

The possible uses of PRSM cover all structures demonstrating a recurrence of similar work cycles in a horizontal or vertical direction, such as tunnels, roads or high-rise buildings.

The development of PRSM is divided fundamentally into two principal tasks. The one focuses on modeling the structures, with the aim being to collate the geometric constraints into a form (building model) that can be processed systematically. The second challenge comprises a definition of the interactions and interdependencies among and between the individual partial processes. The only means of ensuring with a high degree of probability that the partial processes and their interferences have been correctly defined and, in consequence, can be correctly incorporated into the process model, is by involving experienced practical experts.

2. Development of PRSM

2.1 Procedure

A survey among respected construction companies in Switzerland and its German-speaking neighbors supported the assumption that there were fundamental weaknesses inherent in the decision-making process used to select systems. The interviewed members of management and employees in the calculation and work preparation departments confirmed this assumption and indicated the following principal failings of the system selection process:

- Unsystematic selection process
- Selection is based on limited knowledge of process interactions
- Decisions are made on the basis of limited information know-how
- Decisions are made purely deterministically, without taking any disruptive factors into consideration

The subsequent in-depth study of literature that was aimed at discovering references to automated decision-making models only revealed a very few usable results. Fundamentally methodical approaches were identified in works by Girmscheid [5], Mawdesley [6] and Motzco [7]. These works only indicate fundamental principles, however, without claiming to provide an integrated analysis. The required renunciation of the common practice to date of analyzing individual partial processes more or less in isolation from each other, due to the lack of appropriate tools, in favor of a total interconnection of all processes and, in consequence, the overall analysis of the technical and commercial impacts of individual system decisions necessitates the development of a knowledge-based decision-making model, PRSM.

So far, the development of this model has reached a stage where it can simulate the influence exerted by system decisions during the construction process of a high-rise building. A risk analysis is needed in order to be able to incorporate the disruptive factors that are constantly occurring during practical construction works into the model; this will be incorporated into the already existing model in the next phase of development.

2.2 Scientific methodology

Constructivism is the primary research method being used to develop this decision-making model since it designs systems based on an intended input-output effect.

The theory-based structure of the model is derived from a constructive approach based, firstly, on scientific mathematical methods, such as workload, cycle and cost calculation, and, secondly, on the simulation of fuzzy variables with regard to the calculation process.

Triangulation is being used to ensure validity and reliability using the theory-based scientific structure, on the one hand, and the realizability test being performed on construction projects of the companies involved in the research project, on the other hand.

2.3 Method of resolution

2.3.1 Modeling of building structures

The ability to present a complex building structure as a model requires high levels of experience and knowledge of the structure. If this knowledge is lacking, then material details might be neglected or incorrectly reproduced in order to simplify the model, resulting in the ensuing interactions not being able to be incorporated into the subsequent workflow. The modeling process therefore needs to be conducted carefully and by specialists.

Basically, modeling aims to transform building structures, where the designer has defined the dimensions, into a geometric model in order to allow the standardized further processing – i.e. using a program – of the same. The degree of detail and other demands on the model depend to a major extent on the type of building structure and method of further processing. A model of the components as slabs or rods with their relevant internal forces might suffice for a static analysis, whereas more complex models would be needed to simulate the manufacturing processes.

After examining various alternatives for an approach to modeling a multi-story building with a reinforced concrete frame construction, the use of modules proved to be the most effective, with standardized partial modules of individual floors containing ceiling sections, columns and even the core in places, being used to model an entire building structure. The modules in question are typical, recurring layout shapes that can be combined to map virtually any building structure with virtually any layout design.

Examples of a core module and edge module are illustrated in Figure 1 and Figure 2, respectively.

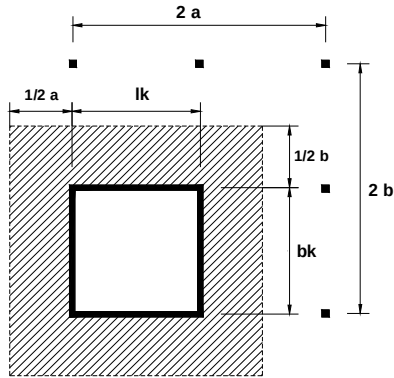


Figure 1: Core module

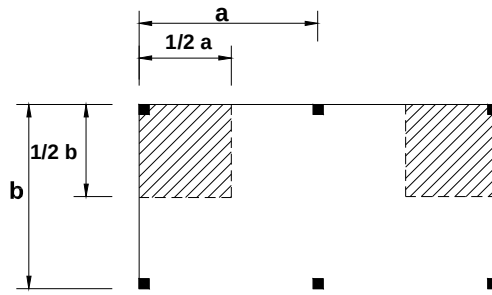


Figure 2: Edge module

2.3.2 Choice of system

Using a multi-story building with a reinforced concrete frame construction as an example, we will demonstrate that the strategically critical choice of system primarily relates to the individual formwork systems for the principal construction elements of ceiling, core (walls), columns, girders and staircases. To enable further processing, the individual formwork systems are listed with all their relevant advantages and disadvantages, and the problems that are already identifiable where other formwork systems interconnect are indicated.

A matrix was drawn up to define all the theoretically possible system combinations and subsequently subjected to a plausibility test, together with practical experts. The approach was as follows: Following the selection of random individual systems for ceiling, columns and core, any potential problems in execution or even reasons for exclusion were revealed. On the basis of this matrix the technically possible and practically relevant system combinations thus identified were linked. This combination scheme as outlined in Figure 3 provides the framework for all ensuing considerations with regard to possible areas of conflict at system crossover points.

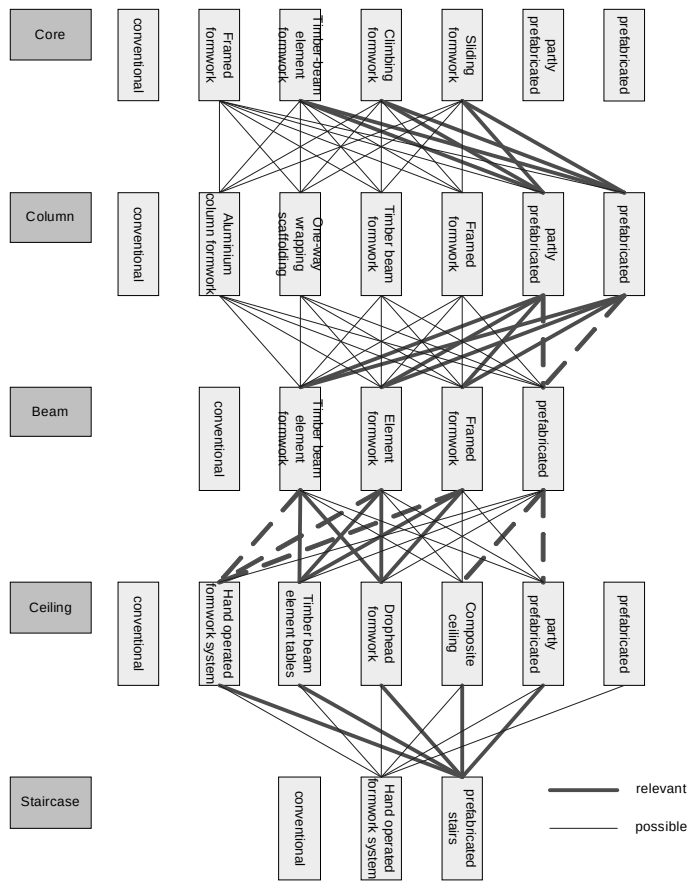


Figure 3: System combinations

The following process steps need to be defined in order to analyze the cost efficiency with an end to simulating the total process flow.

2.3.3 Analysis of the elementary processes

In order to enable the comparability and illustration of the interdependencies respectively the interactions among the individual construction elements, all the construction processes within the individual modules were split into their so-called elementary processes. This breakdown is performed within the modules for each and every possible combination of construction elements and systems. Subsequently the relevant demands on work area or building site infrastructure (crane, hoist, concrete pump, etc.) are defined for each elementary process.

The elementary processes defined using this approach are evaluated in terms of time and costs, with the cost bandwidths contained in this evaluation and associated risks being assessed using the qualitative empirical method developed by Mayring [13] and Yin [14]. The results were processed using the interpretivistic research approach (developed by Weber [8] and Girmscheid [9]), the risk model is being developed using the constructivist research approach (developed by Piaget [10], von Glasersfeld [11] and Girmscheid [9]).

2.3.4 Analysis of interactions

An analysis of the interactions depends to a large degree on the planned construction workflow of the high-rise building being examined, with the fundamental issue being whether the core is being constructed precursory or the structure is being built floor by floor. Nowadays, staircases are generally delivered to the building site as pre-fabricated components – and are positioned at some random point in time, the only condition being that the surrounding walls have already been built and the stairwells are accessible.

In addition to these possible variations for core and stairs, the practically relevant system combinations illustrated in Figure 3 can be further subdivided relative to their construction sequence, where – depending on the structure – it might be beneficial to manufacture the components separately and directly after each other, or, at times, to produce them together.

The interdependencies are evaluated in line with four criteria:

- constructive interaction:
formwork and construction link between the construction elements
- geometric interaction:
reciprocal obstruction of formwork, reciprocal obstruction of columns and supports for the formwork systems, saving concrete platforms by simultaneously manufacturing individual construction elements, available space (core, edge, corner)
- temporal interaction:
integratability into the cycle, saving time by performing simultaneous formwork works / concreting individual construction elements, losing time by separately manufacturing individual construction elements
- logistical interaction:
crane deployment, workforce separation, formwork “idle time”, material deployment

The interactions are evaluated on the basis of the basic construction sequence Walls → Columns → Beams → Ceilings → Staircases, i.e. the columns are interacting with the walls, the beams with the columns and walls, etc. The qualitative and quantitative evaluation of the individual interactions must be performed together in close collaboration with specialists with practical expertise and must later be tried and tested in practice on several construction projects, and adapted where necessary.

2.3.5 Analysis of the cost-efficiency of the system combinations

The time-relevant and, as such, cost-relevant impacts of these interdependencies are analyzed within the framework of a cost-efficiency analysis of the individual system combinations, which is divided into three parts:

- Performance calculation
- Cost calculation
- Risk analysis (uncertainties surrounding deadlines and costs)

2.3.5.1 Performance calculation

Determining the performance of the overall process is based on the performances calculated separately for each module or even for each construction element within the individual modules. The partial work processes are calculated using the method developed by Girmscheid [12]. To incorporate the interactions and the ensuing time differences (in both a positive and negative sense) the surcharge values obtained from building site practice are added to the workload figures. The total time is the aggregate of the partial times of each individual module.

2.3.5.2 Cost calculation

In the model developed here, the costs are calculated automatically based on the performance calculation, with the program accessing databases containing the relevant basic data for the detailed calculation of the wage, material and equipment costs. These figures can be replaced or supplemented by each and every construction company incorporating its own calculation methods. The method of calculation is largely aligned to the recommendations made by Girmscheid [12] and complies with the guidelines issued by the Swiss Association of Construction Entrepreneurs (Schweizer Baumeisterverband, SBV).

2.3.5.3 Risk analysis

The cost bandwidths ascertained back in 2.3.3. and the relevant density allocations of the individual elementary processes are incorporated into the program in the next phase of development. Inputting the essential parameters in the form of expected values together with their upper and lower limits would be conceivable.

The individual probability distributions cannot simply be aggregated to reach the probability distribution of the total costs, but rather they need to be linked in line with the law of probability as the value calculated would otherwise be much higher than the actual value.

If there were only two probabilities, this could still be achieved purely analytically, but with multiple density allocation functions for the cost groups, such as is the case here, a simulation model has to be used instead of an analytical model.

Instead of individual figures, this process produces bandwidths for the calculated costs combined with the probability distribution for the aggregate anticipated costs, thus providing the decision-makers in the calculation and work preparation departments with a sensible decision-making aid on which they can base a thorough and justified choice of a certain system combination. Figure 4 provides an overview of the PRSM approach.

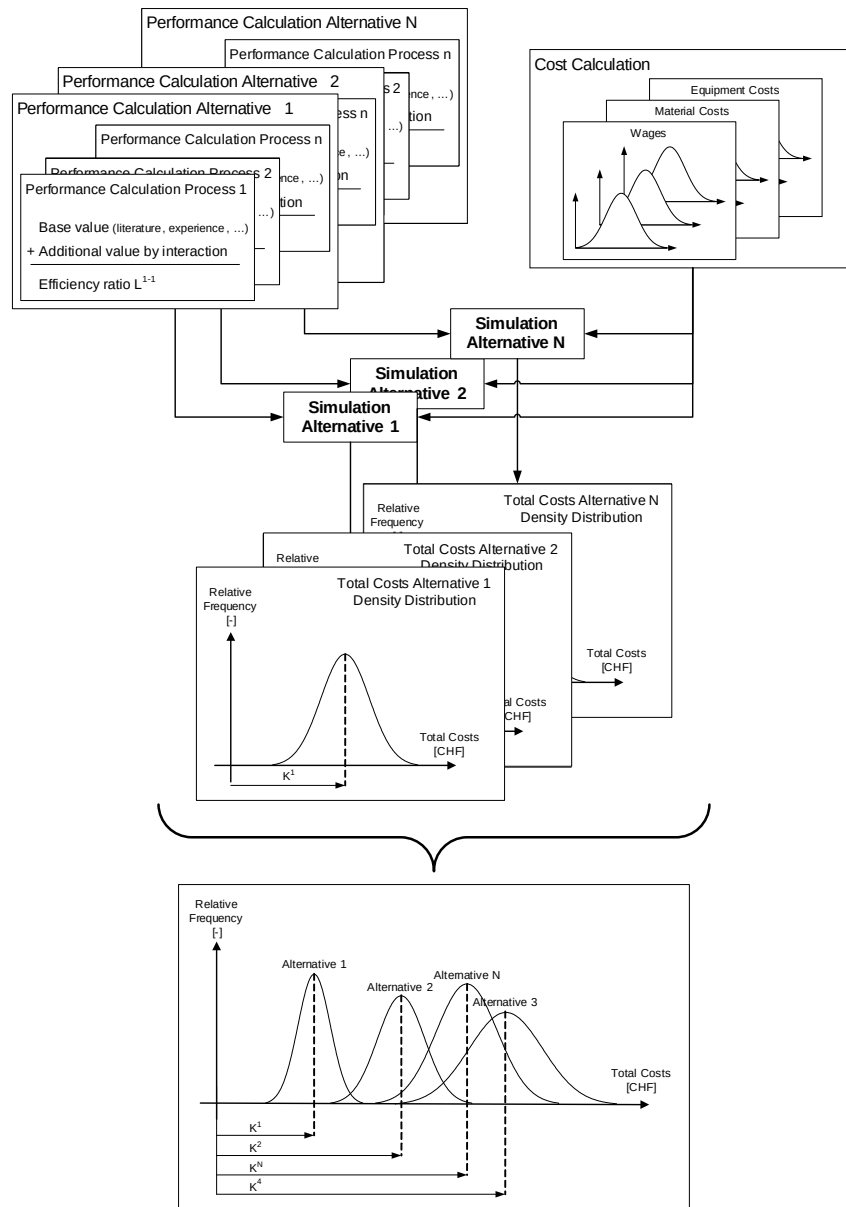


Figure 4: Fundamental methodology of PRSM

2.4 Results

The following findings emerge from this research project:

- List of all the interactions arising from the system combinations, qualitative and quantitative
- Information on the impacts of system decisions on the construction process, available at short notice

The impacts of individual system combinations on the overall system in terms of construction time, work cycles and the associated overall performance can be systematically analyzed using PRSM. The model enables the illustration of the cycles for constructing both an individual standard floor and the entire building.

- Information on the impacts of system decisions on the costs of the building structure, available at short notice

The choice of a system combination has direct impacts on the wage, material and equipment costs. The automated cost calculation makes it possible to evaluate the costs of various system combinations at an early stage and, as such, to select a cost-optimized and cost-stable system.

- Information on the impacts of system decisions on the stability of the construction timeframe, available at short notice

The risk analysis makes it possible to evaluate various execution alternatives / different system combinations using the relevant bandwidth for the duration of construction works and the associated density allocation.

- Information on the impacts of system decisions on the stability of the construction costs, available at short notice

The risk analysis makes it possible to evaluate various execution alternatives / different system combinations using the relevant bandwidth for the costs of executing the construction works and the associated density allocation.

3. Conclusion

3.1 Reasons for developing PRSM

When past reference was made to optimizing construction processes, efforts generally focused on optimizing individual partial processes, virtually in isolation of each other. The interactions and interdependencies between and among the individual partial processes were ignored for the most part. When analyzing the overall process, however, it is, indeed, possible that a suboptimal process sequence of a partial process (e.g. within a construction element) turns out to be an optimal sequence in the overall process (e.g. module). For this reason, an optimization of the overall process is not equivalent to the aggregate of all optimal partial processes.

As literary research further demonstrates, there are approaches that are heading in the right direction, but to date no integrated concept that encompasses the entire complex process of erecting a building structure has been identified.

The commercial potential offered by PRSM can be clearly demonstrated by taking into consideration that the proportion of unproductive hours due primarily to obstructions caused by non-compatible system decisions and insufficient coordination of the work processes is estimated to be approximately 30% on average. Using PRSM would allow a marked reduction in this percentage and, as such, an increase in productivity.

Moreover, new developments can be easily incorporated into the model to ensure that information know-how is available with the right information in the right place. All of the primary system selection failings indicated in 2.1 can be eliminated using PRSM.

3.2 Outlook

The principle of PSRM is not just limited to use on shells of multi-story buildings with reinforced concrete frame constructions. On the contrary, this is just an example to demonstrate the optimization potential offered by the deployment of systematized, process-oriented and risk-based decision-making models.

Other conceivable applications, for which the model would need to be adapted, include, primarily, building sites with cyclically recurring work steps, i.e. line construction sites, such as tunnel, road or bridge construction.

The tense economic situation within the construction industry makes it imperative to exploit all possible means of optimization, not just during the actual construction process. In order to make full use of this potential, we must refrain from studying individual partial processes virtually in isolation of each other and start focusing on the complete link-up of all processes and, as such, arrive at an integrated analysis of the technical and commercial impacts of individual system decisions. The process-oriented and risk-based model PRSM supports decision-makers and enables superior performance on the building site by reducing unproductive works.

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How Industrialisation Serves a Client Focused Industry and How Clients Appreciate the Approach

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Abstract

There is a tendency in the housing market to give future tenants more influence in the design of their houses. Designers and project developers experiment with a variety of new ways to involve the future tenants. Around the turn of the century the industry of building components and the big contracting companies understood that here was a chance to gain market share. They launched new products and new processes to better meet client's needs. New products were designed to deliver flexibility in use. New processes were developed to allow more client specific variation and client's choice in a later stage of the process. One recent Dutch project went to the extreme. Tenants of an apartment building under design were allowed to bring their personal architects to the project team and have even their part of the facades personalised. The reasons why this and some other client focused process were finally not a success, while other strategies for client focussed actions turned out to be good selling, were investigated. The new developments were monitored to asses the effectiveness and appreciation of the new strategies of the industry.

Keywords: Industrialisation, Mass Customisation, Open Building, Personal Housing.

1. Some recent developments in the market

1.1 Growing demand

For many years the housing market was a sellers market. In most western countries there was a shortage of houses. So new houses were easily sold or rented out. The quality of design and construction were not very decisive factors in the marketing of the product. The long lasting shortage had nothing to do with low production. On the contrary the production capacity grew over the years. The shortage was mainly caused by the fact that the average number of inhabitants per house decreased steadily. The most common family size came down to about 4 persons. Two parents and two children. But also the increasing number of divorces was a reason

for the growing demand for houses. In Western Europe the average occupancy of a house is now down to 2.5 and there is a tendency to an even lower figure. Also the flow of refugees from all over the world, mainly to Europe and America, was a reason for a growing demand and consequently a structural under supply. The figures for the Netherlands demonstrate this development. Between 1998 and 2002 the population grew with 2,88%. In the same period the number of households grew by 4,28%. [2]

1.2 Decreasing supply

Recently it appeared that houses are not any longer that easily sold. The reason is not found in a decreased demand, or in an over production. Though the birth rate is stabilising and the number of immigrants in Western countries is falling back. These factors are not yet strong enough to cause an effect on the demand side. The reason for a stagnating market is found in rising prices and an economy in recession. The economies of most developed countries are in a recession that started in 2000. As a consequence many employees lost there jobs. The recession came together with a collapse of the stock exchanges. The Dutch stock exchange index was reduced to less than half its highest value. So retired people and businesses lost capital and purchasing power. This resulted in a significant decrease in the effective demand for housing. While the market lost purchasing power the construction industry could not lower its prices. On the contrary the prices of new built houses and offices continued to rise at a rate above inflation. Even a dramatically decreased production could not prevent an oversupply of houses and office space. The number of houses completed in The Netherlands decreased over the years 1998 till 2002 from 90.500 to 66.700 units. The prices of single family houses increased with 62%. [2]

1.3 Customer focus

In the late nineties the supply side of the market became aware of the fact that a high demand and an under supply had made selling of houses too easy. There was no driver to meet the requirements on the demand side of the market. This resulted in a misfit between supply and demand. Many clients were not satisfied with the quality of the products, nor were they satisfied with the attitude of the suppliers in case of complaints. Investigations into the market showed that tenants wanted more variety and more influence to personalise their homes. Real estate funds required more flexibility to meet future needs. And all owners wanted a better quality at completion. In particular they complained about the ever occurring remedial work to be performed after hand over. It was clear that a more customer focussed market approach was needed. The awareness of a need for more customer focus came before the collapse of the market. But decreased demand caused a sense of urgency. It forced the industry to introduce the new client focussed strategy immediately.

2. The supply-side response: industrialisation

2.1 Industrialisation

The supply-side of the housing market reacted to the new demand with a move to what is generally described as industrialisation. To understand this move a definition of industrialisation should be given first. Industrialisation is a word with a wide scope. The word is often used, but an exact definition is difficult to give. Industrialisation in Building is generally understood as the development towards a building process that is

- Better under control,
- Benefiting from the effect of repetitive processes,
- Benefiting from the effect of mass production,
- Benefiting from the support of mechanised and automated tools,
- Organised as a permanent process rather than incidental.

This list could be completed with more characteristics. It is just a rough sketch to get an idea of what we are speaking about. In construction we see two basically different approaches to industrialisation. Some parties concentrate their efforts on changing the processes on-site. Others expect more from moving the production to an off-site facility. Another distinction between approaches is between product industrialisation and process industrialisation. [6]

2.2 The strategies

Most parties in the construction industry understood that a new client is emerging. A client that was seeking for a more personal approach. Architects, developers, contractors and investment funds, they all had to reconsider their processes and products. They all had to ask themselves how to meet the changing requirements of the market. How to deal with a demand driven industry. Each party sought his own reply to the arising demand for a more client focussed production. The strategies can be divided in four categories.

1. Mass customisation. Developers and contractors were used to offer a standard product with little choice for variation. These parties choose mass customisation to better meet client's needs. They developed a more flexible process, allowing for more alternatives and for decision making later in the process. It can be categorised as on-site process industrialisation.

2. Prefabrication of components. Suppliers of components developed new products especially designed to enable tenants to change their homes later. This is categorised as off-site product industrialisation
3. Prefabrication of elements. The suppliers of catalogue homes and prefabricated units who always had build single houses to client's specification, had no reason for a strategic change. Their processes had always been very client focussed. This is off-site product and process industrialisation
4. Prefabrication of unit. Some manufacturers of voluminous units for temporary facilities but also an off-shore construction plant studied the possibility to radically change the industry by moving production of buildings completely to factories. Not just components or elements but full sections of buildings, installed and finished, ready for use. This concerns also off-site product and process industrialisation

2.3 Mass customisation

In the Dutch market almost every mayor construction company developed a new concept for housing. Commercially attractive names were given to the new products, such as “Wenswonen” (Desire Housing) by Heijmans Contractors, “Smart House” by BAM Contractors, “Persoonlijk Wonen” (Personal Housing) by Bouwfonds Development, “Multiple Choice Homes” by Koopmans Bouw, and many other beautiful brand names. All these concepts advertised that within certain limits clients were enabled to make a personal choice from a variety of alternatives. The alternatives included additional rooms, position on the plot, location of kitchens and bathrooms, façade materials etc.



Figure 1: Smart House, a product of mass customisation.

The most extreme step to better meet client's expectation was the 7 Heavens project in Rotterdam, The Netherlands. Here a project developer allowed prospective buyers to select their own architect and design their own apartments within the frame work of a steel load bearing system completed with staircases, lifts and riser ducts. Even the facades were to be design by the private architects. Some hurdles had to be taken. The building permit for a building without a design for the facades was in principle not possible. The city of Rotterdam supported the innovative process, made an exception and awarded a building permit. The Ministry of Economic Affairs was prepared to give a financial support. And also the project developer was prepared to invest extra budget in this innovative process. [3] [5]



Figure 3: the 7 Heaven project, facades according to clients design

One may say that in this approach the influence of the client has so much impact on the process that it can not be considered as real mass customization. The progress of construction is too much dependant on the process of decision making by the client. In real mass customization the manufacturer or contractor should keep full control over the planning.

2.4 Prefabrication of components

A strategy typical for the suppliers of the construction industry was the development of new components suitable for postponed decision making and for future modifications to houses. In particular suppliers of flooring systems came with new flexible systems. In the Dutch market prefab concrete has a long standing tradition. For floors there is a wide variety of systems available such as hollow core floor slabs, wide-slab floors and Bubble Deck floors. All these systems are designed for cabling and ducting cast into the floors. It forces designers to early decision making on the services and does not allow tenant to any modification later on. The manufacturers of these floors understood that a market for flexibility was arising, driven by client's demand. New products to meet these new requirements were developed. The hollow core floors are now available with a lower zone to put cabling in. Wide-slab floors are produced with a lower zone covering up to 50% of the slab. In stead of the old products with cast-in piping and

cabling the new floor slabs provide now openable ducts where cabling and piping can be installed in a later stage of the building process. This services also may be replaced to meet future needs better. [10]

Also openable floor systems based on steel beams and removable toppings were introduced on the market. The A+ systems should be mentioned here as one of the most successful systems. It is based on steel beams, cast with the lower flange into a concrete slab. The beams are perforated to allow the passing of cables and ducts. The upper flange supports a removable flooring system. The space between upper and lower flange is accessible for tenant when they want to modify their services systems. [7]

2.5 Prefabrication of elements

Another market response were new developments of prefabricated homes. Factories for prefab houses existed already for decades. The market share did not rise above 2 percent of the Dutch housing market. A push came from the Dutch ministry of housing. The minister proclaimed a new policy aiming at a target production of 30% housing by private initiatives. The target may be far from realistic in a country where land for such private clients is scarce, but a substantial rise in the market share of prefabricated houses can certainly be achieved. Several small and medium sized contractors redesigned their business and joined the industry for catalogue homes and offices. They range from wood framed houses to prefab concrete systems. Transportability over public roads is the main constraint to these systems. For that reason most suppliers of prefabricated houses produce systems based on the pillar-slab concept or the slabs-only concept where the frame is incorporated in the elements. [8]

For the 7 Heavens project it was proposed to make façade elements, with standardised connections, but client specific appearances. The initiators considered a concept with mass manufacturing of standardised façade elements, with a take-back service and a second hand market. For the time being the concept is not yet expected to be feasible.

2.6 Prefabrication of units

One step further in this development is the manufacturing of houses and offices based on voluminous units. In particular suppliers of site offices and temporary housing facilities have chosen this strategy. They developed houses consisting of a number of units. Each unit is approximately 3 meters wide and 3 meters high. These dimensions are just acceptable in normal traffic. On site a number of these units is build together to a complete house. The concept existed already in other countries. In particular Japan is known for this approach. In the Dutch market the phenomena is still rather unique but gaining market share. [9]

Some manufacturers produce floating prefab houses. Not an unsuccessful approach in a country with much water and scarcity of land for construction. The construction of a factory for the

continuous production of floating houses was announced in early 2004, but production has not yet started. Still a small industry for floating houses is emerging. Unlike the traditional house boats these buildings look good. Quality is comparable to traditional housing.



Figure2: A factory made prefabricated house.

Another industrial strategy to meet client's needs better is found in the production of units for one specific use like bathrooms and kitchens. This strategy also uses prefabrication of units as its starting point. But these units are considerably smaller than the units mentioned before. Transportation is not a problem. Exterior appearance is not a problem either. These units are incorporated in a building and in many cases hidden behind partition walls. The prefabrication of sanitary units occurred already for some decades, but on a project bases. A more continuous production is expected when client focussed building really breaks through.

The ideal of producing also bigger buildings under factory conditions is still a dream for many, but one client got an office like that. A 10-storey high office building was fully assembled in a factory. After completion it was shipped to its foundation over a distance of 25 kilometres. The circumstances were ideal. The building was to be erected only 100 metres from a big waterway. A workshop for off-shore construction was found prepared to build the office building. And the client was the world leader in big transports. This client shipped the building himself to its foundation. The costs of transportation were never disclosed. It is likely that the client was prepared to make a show with his new offices. A demonstration of what his company could. But nevertheless here is a proof of what is possible in the field of off-site production. In countries with less water ways this example may be not relevant. There for another option for big transports may be mentioned here also. In Germany a new airship has been developed based on the principles of the Zeppelin concept. This airship will be marketed under the brand name of Cargo-lifter. It will be designed to carry a pay load of up till 160 tons. Enough to transport homes and small offices. We should not too easily conclude that off-site production is limited by the possibility to transport units over public roads.



Figure2: A fully factory made office on its way to the foundation.

3. The clients response

The question to be answered is now: Did the supply-side of the market understand what their clients really wanted? Did the industry respond adequately? Were the new processes and products proposed to the market really an effective action?

3.1 Response to mass customisation

To meet the definition of mass customisation it is required that the continuity, which is a characteristic for industrial production, goes together with the ability to produce in accordance with the personal specification of the client. Of course there must be a balance between the two aspects that at first sight seem incompatible. The automotive industry proofed in past decades that mass customisation is not impossible. At building sites the ideal of mass customisation is still far from achieved. Where contractors offered a list of alternative many of these alternatives were only available for early buyers. Clients had to make choices while the contractor was still in the foundation stage. In a traditional process decisions on the location of pipes and outlets are already made when load bearing walls and concrete floors are cast. Some contractors and developers offered alternatives without really changing their process. They just expected their site-officers to deal more flexible with late requests for modifications. It only caused tension in project teams and an interrupted process. When the construction process is not basically changed to allow decision making in a late stage, the offer of alternatives to the client's choice is not a real way to client focussed construction. But clients highly appreciate the idea. Alternatives within the framework of mass production on site are a good strategy for client focussed construction.

The Smart House concept is an example of a completely new process. Though the decision making by clients is optimized here the marketing appeared difficult. Reasons found are the fact

that the concept is rather luxurious. All in prices of over 700 thousand Euros per house were expected to be acceptable for a certain part of the housing market. It turned out to be too expensive for the quality offered. Apart from that the marketing focussed on clients for a high tech image. The market for such an appearance did not appear big enough. It can be concluded that client focussed concepts are appreciated, but not at any price.

The 7 heavens project, mentioned above, met also marketing problems. In a research project focused on this project [5] was found that tenants were reluctant to take responsibility for the coaching of their own architect. Unlike private builders they do not plan to live in an apartment for the rest of their life. They look only a few years ahead and expect to move to a single family house or elderly home after that period.

A problem for clients for mass customisation is their lack of experience to imagine how the rooms, shown in 2-dimensional drawing will look in real life. Introduction of 3 dimensional virtual reality presentations will facilitate the decision making process for clients. What we see is that many project development companies with private clients are introducing now 3-D technology into their marketing. On the Internet clients are invited to experiment with the available alternatives. For mass customisation with 3-D supported decision making a great future is expected.

3.2 Response to prefabricated elements

The market reacted very positive to the new floor systems. A great deal of the market for concrete slabs is now supplied with these newly developed products. It allows contractors to postpone the moment where no alternative cabling routes can be chosen any more. Clients of course appreciate the postponed deadline. If they also will use the possibility to change cabling later, after some years of occupancy, is something the future will learn us. A recent survey by the University of Aachen concluded that many tenants prefer to consider moving to another house rather than rearrangement of partition walls and cabling while the investment in this flexibility is considerable. [4]

The so called “computer floors” are already a well known feature in the market for office buildings. In housing the concept was up till now seldom applied. The costs were considered too high for that market. The recently introduced new products based on steel beams and removable lids appear to fit well within the budget of housing clients. A growing number of projects is applying such systems.

In respect of facades tenants appeared not interested to invest in the facades of their own apartment. The exterior appearance of an apartment building should be dealt with as a whole, not per floor. Investing in a section of the façade of an apartment building does not increase the value of related apartment. So owners prefer an investment in the interior of their apartment rather than in the exterior.

3.3 Response to prefabricated components and units

The market for prefabricated houses, either build with pillar slab systems or with voluminous units does not yet grow. The market share in The Netherlands for these types of houses remains at approximately 2%. Encouragement by the government is not enough to boost demand. Lack of land for housing and lack of enthusiasm to take the responsibility are constraints. And most important, the prices of prefabricated houses are not substantial lower than the prices of traditionally produced houses. If the manufacturers of these prefabricated houses could produce higher volumes prices could certainly go down tens of percents. Here a breakthrough could be enforced with some public support

4. Conclusions

Clients are not satisfied by the actual supply of standard solutions to their demand for housing. Clients want better quality, flexibility and a choice from a variety of alternatives even when the project is already close to completion. But most clients are reluctant to take responsibility for the design process themselves. If they really are prepared to take the lead themselves then are best served by small contractors and local architects. Also suppliers of prefabricated houses are an option for these clients. But a vast majority is not ready to take the lead in their own housing project and favours the products of mass customisation. They want a standardised product, with a wide range of options to personalise their homes. Flexible systems are appreciated, but clients cannot afford to pay much extra for such a concept.

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