INNOVATION IN CONSTRUCTION: A PROJECT LIFECYCLE APPROACH

Beliz Ozorhon
University of Salford, Salford, UK
b.ozorhon@salford.ac.uk

Carl Abbott
University of Salford, Salford, UK
c.abbott@salford.ac.uk

Ghassan Aouad
University of Salford, Salford, UK
g.aouad@salford.ac.uk

Innovation is a multidimensional, dynamic, global, and an open activity that increases competitiveness, generates economic benefits, and improves the quality of living standards through the creation and adoption of new ideas and technologies. The construction industry is widely perceived as being among the less innovative sectors, in part due to its project-based and fragmented nature. However, there is an increasing recognition that to understand and quantify the extent of innovative activity within a sector, metrics appropriate to the particular sector must be developed. The patterns of innovation in construction are different in many ways from those of others, and effective management of innovation is still essential to create value for construction customers and their clients. Therefore, more research is required to analyze the different types of innovative activities as well as the role of project stakeholders in stimulating and implementing construction innovation. The major objective of this study is to set out a methodology to investigate in detail the particular ways in which innovation occurs in a project setting and the dynamics between project and firm level innovation. In this respect, the innovation value chain can be investigated in terms of the parties involved in a construction project. The proposed lifecycle approach will help observe and measure the underlying drivers, enablers and the contextual variables related to the whole process and understand the role of different actors and improve their capability in facilitating innovation.

KEYWORDS: innovation measurement, construction industry, project lifecycle, project stakeholders.

INTRODUCTION

Innovation has become a central issue for all industries and countries due to its contribution to national economic growth, competitiveness, and higher living standards. It is a complex phenomenon with a wide range of inputs and outputs creating diverse impacts on performance at the company, sector and national level. There is not a single and complete definition of innovation; it can be technological as well as non-technological including organisational and marketing aspects. In broad terms, it may be defined as creation and adoption of new knowledge to improve the value of products, processes, and services.

Innovation can be a key source of competitive advantage for construction companies as well, offering the means through which a firm can achieve a client’s objectives in a specific project or its own objectives over a range of projects (Slaughter, 2000). The construction industry
provides an example of a sector within which traditional measures do not reflect the true extent of the innovative activity that is taking place (NESTA, 2006; Barrett et al., 2007). Construction is often categorised as being among the less innovative sectors. However, as the Hidden Innovation report (NESTA, 2007) has shown, this perception is perhaps undeserved. Much of the innovation remains hidden, as it is co-developed at the project level. Being a project-based and fragmented industry, the patterns of innovation in construction are different in many ways from those of others. There has been a considerable amount of research that focuses on investigating the characteristics, significance, and management of innovation in construction. More research is required to analyze different types of innovative activities that are carried out throughout the lifecycle of a construction project.

Management of innovation is complicated by the discontinuous nature of project-based production in which, often, there are broken learning and feedback loops. As Gann and Salter (2000) stated project-based firms need to manage both project and business processes since the resources of the firm are embedded at both the project and the firm level; it is the integration of these two sets of resources that enables the firm to be competitive. In addition, business processes are ongoing and repetitive, whereas project processes have a tendency to be temporary and unique (Gann, 1998; Brusoni et al., 1998), therefore firms should integrate the experiences of projects into their continuous business processes in order to ensure the coherence of the organisation. The same principle is also valid for the success of innovation both at the project and firm-level.

The major objective of this study is to obtain an insight as to how innovation occurs throughout the lifecycle of a construction project including the conceptual phase, planning and design, procurement, construction, and operation and maintenance. In addition, the role of project stakeholders including the clients, designers, contractors, suppliers, and external bodies in stimulating and implementing innovation should be investigated. In this respect, this study proposes a methodology to investigate the ways in which innovation occurs in a project setting and the dynamics between project and firm level innovation thereby enabling the analysis of the innovation value chain in terms of the parties involved in the process. The proposed methods include the production of case studies, interviews, workshops and a seminar. The proposed research will increase awareness on the hidden innovation at the project-level and in doing so aid project stakeholders to better understand and improve their innovation processes and activities, thereby increasing firm level competitiveness and value creation at the project level.

INNOVATION IN CONSTRUCTION

There are differing definitions of innovation, but there is an increasing trend to consider a wider view of innovation that reflects the many ways in which innovation occurs in practice. A suitably wide definition is that innovation is “the adoption of an idea or behaviour, whether a system, policy, program, device, process, product or service, that is new to the adopting organisation” (Damanpour, 1992). It is a complex and multidimensional process having a number of outcomes including the renewal and enlargement of products and services, and their associated market; new methods of production, supply and distribution; and new organisational and work forms and practices (Barrett and Sexton, 1998).

Phillips (1997) distinguishes between technological innovation and non-technological (including organisational and marketing) innovation. Technological innovations comprise implemented technologically new products and processes and significant technological
improvements in products and processes. Organisational innovation in the firm includes significant changes in organisational structures; the implementation of advanced management techniques; and the implementation of new or substantially changed corporate strategic orientations. Marketing innovation, on the other hand, is the implementation of a new marketing method involving significant changes in product, price, and promotion strategy (OECD and Eurostat, 2005).

Slaughter (1998) presented five models of construction innovation categorised as incremental, modular, architectural, system and radical, which can provide a basis upon which companies can select and implement the innovations. These models range from incremental innovation, which is a small change, based upon current knowledge and experience, to radical innovation is a breakthrough in science or technology that often changes the character and nature of an industry.

Many studies on how innovation could be implemented in construction projects have been undertaken (Tatum, 1987; Slaughter, 1998, 2000; Winch, 2003). There have been a number of case studies of how successful firms have been able to make a range of different organisational, managerial or technological innovations to overcome the limits of their environment (Slaughter, 1993; 1998; Veshosky, 1998; Koskela and Vrijhoef, 2001; Sexton and Barrett, 2003). These studies usually focused on how innovation is managed within one firm and there is a lack of focus on specific project stages as well as a lack of specific focus on different construction sectors. Only a small minority of the research articles have considered innovation at a specific stage of the project lifecycle or from the point of view of the project lifecycle in general (Dickinson et al., 2005). Moreover, none of these studies discussed the accurate measurement and proper indicators for construction innovation.

As Blayse and Manley (2004) stated, building and construction is partly manufacturing (materials, components, equipment) and partly services (engineering, design, surveying, consulting, management) industry. The characteristics of innovation in the service industries are different from those in manufacturing industries (OECD and Eurostat, 2005). Therefore, as Barrett et al. (2001) have suggested, specific research into innovation in construction must be undertaken and all generic innovation research be “envisioned, embedded and evaluated in a construction context to form a robust body of construction innovation knowledge in its own right”. Since construction is also a project-based industry, while measuring construction innovation, project-level indicators as well as the firm and sector level ones should be considered.

**ANALYSIS OF CONSTRUCTION INNOVATION**

As a significant economic variable, the measurement of innovation has attracted a lot of attention. However, due to the complexities inherent in the whole process, measuring innovation is not an easy task. Historically, organisations and public bodies have tended to measure innovation in terms of inputs (e.g. R&D expenditure) and outputs (e.g. patent or trademark applications) (Archibugi and Pianta, 1996). Much construction innovation is project-based and unrelated to formal R&D expenditure and many innovations, particularly organisational or process innovations are neither patented nor trademarked (Slaughter, 1993). Construction is a very diverse sector and there is not one single way in which innovation occurs. According to Lansley (1996) the occurrence of innovation within the construction industry is often characterised by the widespread adoption of new practices as a result of advances in technological and business processes. Therefore, traditional indicators poorly
reflect the true level of innovative activity in construction. This gulf between practice and measurement is the real innovation gap (NESTA, 2006).

Based on the review of construction innovation literature by Dickinson et al. (2005), studies on construction innovation so far lack a specific focus on the level of analysis, stage of lifecycle, and sector. According to Barrett et al. (2007) innovation can be observed at three different levels namely the sector, business and project level. Among these, sector-level is the most visible type of innovation and project level is the most hidden. The firm level has received most attention in the analysed literature; this might be because the principal drivers for innovation are often created at the firm level (Seaden and Manseau, 2001).

**Innovation value chain at the project level**

The innovation value chain view that is developed by Hansen and Birkinshaw (2007) presents innovation as a sequential, three-phase process that involves idea generation, idea development, and the diffusion of developed concepts that includes six critical tasks namely, internal sourcing, cross-unit sourcing, external sourcing, selection, development, and companywide spread of the idea. Table 1 shows the links of value chain and key questions and key performance indicators to measure each link.

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<tr>
<th>IDEA GENERATION</th>
<th>CONVERSION</th>
<th>DIFFUSION</th>
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<tbody>
<tr>
<td>Creation within a unit</td>
<td>Collaboration with parties outside the firm</td>
<td>Movement from idea to first result</td>
</tr>
<tr>
<td>Do people in our unit create good ideas on their own?</td>
<td>Do we source enough good ideas from outside the firm?</td>
<td>Are we good at screening and funding new ideas?</td>
</tr>
<tr>
<td>Number of high-quality ideas generated within a unit.</td>
<td>Number of high-quality ideas generated from outside the firm.</td>
<td>Percentage of all ideas generated that end up being selected and funded.</td>
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The first phase is to generate ideas that can happen inside a unit, across units in a company, or outside the firm; the second phase is to convert or select ideas for funding and developing them into products or practices; and the third is to diffuse those products and practices. The innovation value chain offers a tailored and systematic approach to assessing firm-level innovation performance (Hansen and Birkinshaw, 2007).

Although the innovation value chain stages are sequential the actual process is a “recursive process through which firms source the knowledge they need to undertake innovation, transform this knowledge into new products and processes and then exploit their innovations to generate added value” (Roper et al., 2006). Adopting a similar view, this study proposes the investigation of innovation value chain of different actors in the construction process at the project-level.
Roles of different actors within the innovation process

The construction sector is viewed as a system involving clients, contractors, sub-contractors, suppliers, consultants, and designers. Technological (product and process) innovation is driven mainly by the suppliers (manufacturers), whereas contractors tend to introduce service and organisational innovations (Carassus, 2004).

In this view, clients can act as a catalyst to foster innovation by exerting pressure on the supply chain partners to improve overall performance and by helping them to devise strategies to cope with unforeseen changes (Gann and Salter, 2000), by demanding high standards of work (Barlow, 2000), and by identifying specific novel requirements for a project (Seaden and Manseau, 2001). Knowledge and financial provision, effective leadership, and dissemination of innovations are among the key roles which clients could play (Egbu, 2008).

Contractors on the other hand play a mediator role in the interface between the institutions that develop many of the new products and processes (materials and components suppliers, specialist consultants and trade contractors) and those which adopt these innovations (clients, regulators and professional institutions) (Winch, 1998). They introduce different types of innovations depending on their specialty areas. It is therefore suggested that companies operating in building, infrastructure, housing, industrial construction should be investigated as well as the subsectors of construction including architecture, urban planning, surveying, consultancy, asset/facilities management, and project management that could be better way of understanding and measuring innovation in different phases including the production, construction, and marketing.

Manufacturing firms are also key sources for construction innovation; they invest far more in R&D than contractors or consultants, and are subsequently more likely to develop product and process innovations (Gann, 1997) and thus they are recognized as key drivers of technical innovation in the construction industry.

Relationships and knowledge-flows are important for innovation at all levels of economic activity, including internationally, nationally, inter-sectorally, sectorally, inter-firm, intra-firm, inter-project and intra-project (Manley, 2008). In a complex systems industry such as construction, firms must rely on the capabilities of other firms to produce innovations and this is achieved by the cooperation between those concerned with the development of products, processes and designs (Blayse and Manley, 2004). More research is needed as the relationships between designers, contractors and suppliers need better explanation (Gann, 2000).

Project lifecycle approach for analysing construction innovation

Analysis of innovation at the project level is often ignored in the literature mostly due to the difficulties in monitoring different activities carried out by different parties in each stage of the project. Management of innovation is complicated by the discontinuous nature of project-based production in which, often, there are broken learning and feedback loops. Project-based firms need to manage technological innovation and uncertainty across organisational boundaries, within networks of interdependent suppliers, customers and regulatory bodies (Gann and Salter, 2000). However, project-based firms are always innovating; their work is always unique, always delivered to bespoke designs, always achieving something new (Keegan and Turner, 2002). Study by Gann and Salter (2000) points out the need for a better...
conceptual understanding and new management practices to link project and business processes. Although some strategies are proposed in these studies, they do not address how to track innovative activities during the lifecycle of a construction project.

It is increasingly accepted that construction innovation encompasses a wide range of participants within a ‘product system’ (e.g. Marceau et al., 1999). This broad view incorporates the participants including governments, building materials suppliers, designers, general contractors, specialist contractors, the labour workforce, owners, professional associations, private capital providers, end users of public infrastructure, vendors and distributors, testing services companies, educational institutions, certification bodies, and others (Blayse and Manley, 2004).

Figure 1 shows the innovation value chain in a construction project. The link between firm level processes and innovation at the project level should be explored to observe how different firms contribute to innovation process by developing/implementing strategies, assigning resources to create ideas and diffuse them.

Figure 1: Innovation Value Chain in a Construction Project

Gann (2001) suggests that project-based construction firms often struggle to learn between projects, and often have weak internal business processes. Measurement of the dimensions and elements of construction innovation at the project level is key to improving the innovation performance of companies. Therefore, specific metrics should be developed to assess the inputs, implementation (processes/activities), contextual factors (related to the external environment), and outputs of innovation and different indicators should apply to different actors of construction industry for an accurate analysis. Possible indicators to measure the inputs include the necessary resources such as human, capital, IT, etc.; contextual factors relate to organisation, industry and country-level issues that enable/hinder innovation such as organisational culture, competitiveness, and economic conditions, respectively; implementation phase comprises of the tools, techniques, and strategies such as business process reengineering and building information modelling; and outputs include metrics such as improvement in the product/service and efficiency of the operations.
DISCUSSION AND FURTHER WORK

In construction, much of the innovation remains hidden, as it is co-developed at the project level. A deeper understanding and analysis of the different types of innovative activities that are carried out throughout the lifecycle of a construction project is therefore essential to enable its effective management and so create value for construction companies and clients. Besides construction firms, suppliers, designers, and service organisations play a large part in innovation. To carry out such a wider study of innovation, a comprehensive approach of the construction industry is necessary, specifying the different kinds of firms involved in the construction and the built environment processes.

Within the context of this study, it is suggested that innovation should be analysed throughout the project lifecycle and roles of different participants should be explored. Project-based analysis can be expanded to sector and national-levels as well. Analysis of distinct project stages and development of proper indicators will allow effectively measuring the different types of innovative activities. Innovation process in each stage will be identified considering the inputs, outputs and outcomes of those activities as well as the function of the parties involved in the project.

The innovation process and the roles of different actors throughout the lifecycle of a construction project can be analysed by adopting a set of research strategies. Through the use of a framework approach, the details of how, why and when innovation is developed and measured by individual stakeholders throughout the project lifecycle could be investigated by:

- The production of case studies documenting innovation within construction projects;
- Semi-structured interviews with key individuals within the above case studies;
- Individual reports on these cases and cross-case analysis;
- Project level workshops bringing together entire supply chains to consider how innovation occurred and was measured at the project and at the discipline level; and
- A final seminar event that brings together the wider industry and academics with project participants to summarise and publicise findings and good practice.

The study will investigate recently completed projects that have been commended for their innovation. Detailed case studies of the innovation process and the measurement of its results will be produced for each project. Participating firms will be given insights as to their processes for innovation at the firm level and the effectiveness with which this is translated to the project level. The project workshops will bring together project participants in a facilitated manner to consolidate lessons and formulate future good practice. An overall project report will be produced highlighting the contributions of the project participants.

CONCLUSIONS

Innovation is a dynamic, interactive, open, global, and a multidimensional activity that increases competitiveness, generates economic benefits, and improves the quality of living standards through the successful exploitation of new ideas and technologies. Due to its
contribution to several performance indicators at firm and national level, management and accurate measurement of innovative activities in all industries are becoming more important. Since all sectors have their own unique characteristics, therefore those characteristics should be taken into account in innovation studies in order to stimulate, foster and control innovation effectively.

The patterns of innovation in the construction industry are different in many ways from those of others. The construction industry is largely project based and fragmented, so the majority of innovation occurs at a project level and it is difficult to capture this hidden innovation by using conventional measures. Understanding how innovation occurs at this project level is key to improvement yet most existing research is at the firm level.

This paper has set out a case study approach that employs a case study methodology using an innovation value chain approach to enable an improved understanding of how innovation actually occurs at the project level and how this relates to innovation at the firm level. In each case, the relevant supply-chain members will be fully involved so that the collaborative ways in which the successful innovations have been generated can be tracked and the consequent benefits of innovation at the project and company level investigated. Project partners are expected to participate in the interviews, followed by a workshop and a final seminar.

The proposed lifecycle approach will help observe and measure the underlying drivers, enablers and the contextual variables related to the whole process and understand the role of different actors and improve their capability in facilitating innovation. The proposed research will shed light on hidden innovation and in doing so aid project stakeholders to better understand and improve their innovation processes and activities, thereby increasing firm level competitiveness and value creation at the project level. Findings of the case studies and following activities can lead to a more detailed analysis of different disciplines within the construction industry and provide guidance to analyse innovations in other project-based industries as well.

REFERENCES


