Innovation Barriers at the Project Level: Study of a UK Construction Firm

Yigang Wei¹ and Patrick T. I. Lam²*

¹ School of Public Policy and Management, Tsinghua University, Beijing, China
² Department of Building and Real Estate, The Hong Kong Polytechnic University, Hong Kong, China

Abstract: To meet today’s accommodation needs, financial protocols and environmental aspirations, the construction industry is under great pressure to innovate. However, this industry is still fraught with criticisms for its low level of innovation. Numerous inhibitors are responsible for this poor reputation. This study is aimed at identifying the major barriers for innovation in the UK construction industry. A range of postulated inhibitors, as summarized from a literature review, were formulated into a questionnaire survey which was sent out to contractors in the UK. The barriers were ranked by the use of the ‘relative index ranking technique’ and the correlations between the inhibitors were evaluated. It was found that client-industry relationship, procurement, organizational culture, organization management are the major barriers to innovation as perceived at the project level, with varying level of correlations amongst them. More efficient innovation transfer may result if contractors and decision makers address these underlying barriers while managing innovation activities.

Keywords: Construction innovation, inhibitors, project level, UK

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1 INTRODUCTION

The construction industry is recognized as an important sector for human living and social production capacities (Manseau and Seaden 2001). It is also a principal economic driver, occupying a significant status in modern economy. Taken from a broader view, the construction industry includes all the whole-life value-adding activities such as components manufacture and maintenance. As such, it is one of the most significant contributors to the UK economy as it represents 15% of the GDP (Abbott et al. 2007).

Construction is generally regarded as a traditional industry, but its performance is far from being satisfactory. Compared with other key industries, such as IT or the manufacturing industry, the development of construction is far from being advance. Measured by various indicators such as labour productivity, client satisfaction, R&D expenditure, or the level of workers’ skills, this industry is lagging behind many other sectors (Manseau and Seaden 2001). Construction is often labelled as one with poor performance such as bad coordination, adversarial relationships and environmental pollution (Emmerson 1962; Banwell 1964; Latham 1994; Simon 1944; Egan 1998; Fairclough 2002; Barrett et al. 2008). Besides the infamous image of the industry itself, other adverse conditions such as cyclic economic recessions, wage and material cost increases, ‘cut-throat’ competition, etc. have formed the backdrop. Innovation is imperative if the industry is to free itself from these bondages, and the fruits of innovations must be transferred to the industry stakeholders if they are to succeed.

The research is aimed at identifying the barriers of innovation at the project level. Recommendations are provided for construction organizations to identify and adapt new and innovative practices. After an introduction, this paper is organized as follows: Section 2 provides a literature review on the importance and present conditions of innovation in the construction industry. Section 3 depicts the research methods. The findings and discussions are presented in Section 4. Finally, conclusion and recommendation are provided in section 5.

2 LITERATURE REVIEW

Innovation is widely recognized as an effective way to improve an organization’s competitive position
through adoption and application of new ideas. Bowley (1960) summarized that there are two types of innovation in the construction industry: the one that improves product functions, and the one that promotes costs and availabilities. The former type of innovation leads to tangibly better products that are superior in forms of functional, structural and aesthetic performance. Contributions by the latter type of innovation are intangible, but are vitally important in terms of costs, building lifespan, etc. In order to overcome the above-mentioned setbacks and strive for higher efficiency, there is an urgent need for the construction industry to innovate. Egan (1998) addressed the significance of construction innovation, and advocated that performance enhancement and corporate profitability could only be achieved via innovation. Innovation is often viewed as the key contributory factor to the success of the Japanese construction industry, which builds upon a supporting culture to integrate the ‘innovation slogan’ into its corporate strategy and thus maintains its long-lasting core competitiveness (Kangari and Miyatake 1997). Slaughter (1998) postulated that enormous gains and savings will be harvested from innovation in terms of monetary benefits, improved technical performance and productivity problems would disappear and innovation would flourish." Undeniably, there is huge room for construction to improve its innovation capacity (Blayse and Manley 2004). Numerous research efforts have been spent to investigate the poor innovation scenario. Risk aversion, low level of research and development (R&D) investment, fragmented supply chains, insufficient cooperation with institutions are highlighted as the key barriers for the slow rate of innovation transfers (Egan 1998; Dulaimi et al. 2002).

Despite some initial studies as cited, the barriers to successful innovation have not been effectively dealt with in the construction industry. CERF (1998) stated that ‘the construction industry is infamous for the barriers it places in the way of innovation’. Winch (1998) also suggested the use of “more case studies of the trajectories of construction innovation” to improve innovation development. Therefore, there is a need to identify the key inhibiting factors, and provide recommendations to benchmark the best innovation practices. Contractors, in particular, can reap the beneficial innovation outcomes by detecting and removing the identified barriers. A study was therefore undertaken to bridge the knowledge gap.

3 RESEARCH METHODS

A mixed research approach was adopted, since quantitative and qualitative data were sequentially collected and analysed (López-gamero et al. 2008). A questionnaire survey was applied as the principal method, supplemented by two semi-structured interviews. The combined use of both research methods is supported by Denzin (1970), who adds that triangulation amongst the data so collected is one of the best means to enhance construct validity and substantiate findings. Upon the emergence of consistent patterns from the analysis, useful recommendations may be deduced (Dulaimi 2005).

3.1 Questionnaire Design

The questionnaire consists of four sections (See Appendix). At the introduction, project-based innovation was defined to focus the respondents’ mind during answering. A list of 35 potential innovation inhibitors was presented for the respondents to rank their levels of agreement. A five-point Likert scale (Kothari 2003) was applied, with “1” representing “Strongly Disagree” and “5” representing “Strongly Agree”. Open-ended space was also provided for respondents to express their own views on innovation inhibitors. Unanticipated factors were thus explored. In addition, profiling information was solicited including the project values, contract types, etc. undertaken by the respondents.

3.2 Pilot Study

Six persons with construction industry experience (over 3 years each) were requested to respond to a pilot survey. Their feedback was used to polish the content and wording to avoid misunderstanding and improve readability. Some important feedback is as follows: The content effectively covers the main innovation barriers at the project level. There are some overlapping factors, which should be deleted or combined. This was acted upon.

3.3 Sampling Frame

This research adopts the method of cluster sampling. A cluster is a naturally occurring unit, such as a university, a company, or a project (Fink and Kosecoff 2002). The ‘cluster’ method is often applied in large scale surveys. For this research, a company “A” is randomly selected as the cluster, and all its UK staff are covered for the sample. Company A is one of the top-
tier UK construction companies. Being recognized as an innovation pioneer in the global construction industry, it adopts the most advanced technologically innovative construction methods for its projects around the world.

3.4 Survey Response

A total of 42 replies were gathered from 744 questionnaires delivered via e-mails to the regional offices of a national UK contractor. One response was discarded for the strong biases indicated. The 41 samples represent a 5.51% valid response rate. Although the response rate is not satisfactory, the total number of replies still forms a valid basis of statistical analysis based on the Central Limit Theorem, which requires a minimum sample size of 30, assuming normal distribution of the population samples within the company.

The profiles of the data collected are shown as Figure 1. Project managers, business management, technical and financial staff respectively make up 20%, 17%, 54% and 8% of the total number of respondents. These positions were the key positions of each respective a project department. Their positions and diverse expertise were essential to develop and implement innovation activities. All the respondents thus have appropriate perceptions about innovation. It is worth noting that project manager accounts for 20% of the respondents. Obviously, this figure is higher than the member proportion in a general construction project team. This relatively high rate addressed the preference of project managers’ perspectives. As the top managers in the project level, their considerations are crucial to the success of innovation activities. Therefore, the structure of the data covered the research aims.

Figure 2 shows the construction experience of the respondents. The majority of respondents (76%) had more than 5 years’ working experience; especially, 37% represented more than 20 years experience. These experienced practitioners ensured the quality of the data.

The value of the contracts varied greatly from 6 million to 800 million pounds. By reviewing the responses, medium sized projects with values ranging from £20 million to £80 million, predominated the market. Although two projects were less than £9 million, projects of £20 to £50 million showed to be the most frequently needed by the market. This figure was also assumed to be a threshold of the projects above which big contractors have the sufficient interests to compete. The descriptive question qualified the characteristics of common projects’ value which is hypothesized as an inhibitor to innovation. It shows medium projects are dominant in the market.

As Figure 3 shows, building and commercial projects were the main type of projects which clients need, accounting for 27 out of 39 projects. This proportion is overwhelmingly larger than the sum of the other types of works. However, the typical values are substantially lower than transport and water projects.

3.5 Checking for Consistency

Cronbach’s $\alpha$ internal consistency analysis was used to test the reliability of the questionnaire results. When Cronbach’s $\alpha$ is more than 0.7, it stands for a relatively high level of reliability. As Table 1 shows, the Cronbach’s Alpha values for the individual items range from 0.816 and 0.852 after one sample was discarded. The Alpha value for the overall questionnaire is 0.847, indicating strong reliability of internal consistency.
As shown in Table 2, the overall Importance Index for each group represents the mean of its sub-attributes’ index. Each obstacle within the group is ranked, to demonstrate its relative importance within the prob-

**Construction Experience**

![Construction Experience Chart]

**Figure 2.** Construction experience of the respondents

**Types of Projects**

![Types of Projects Chart]

**Figure 3.** Types of construction contracts

<table>
<thead>
<tr>
<th>Question Group</th>
<th>Cronbach's Alpha</th>
</tr>
</thead>
<tbody>
<tr>
<td>Client and industry relationship</td>
<td>0.840</td>
</tr>
<tr>
<td>Procurement</td>
<td>0.821</td>
</tr>
<tr>
<td>Resources</td>
<td>0.829</td>
</tr>
<tr>
<td>Regulation/Standards</td>
<td>0.852</td>
</tr>
<tr>
<td>Project Characteristics</td>
<td>0.847</td>
</tr>
<tr>
<td>Organizational Culture</td>
<td>0.822</td>
</tr>
<tr>
<td>Project Manager</td>
<td>0.831</td>
</tr>
<tr>
<td>Structure of Production</td>
<td>0.829</td>
</tr>
<tr>
<td>Project Management</td>
<td>0.835</td>
</tr>
<tr>
<td>Organization Management</td>
<td>0.816</td>
</tr>
</tbody>
</table>

**Table 1.** Group statistics

<table>
<thead>
<tr>
<th>Cronbach's Alpha</th>
<th>Cronbach's Alpha Based on Standardized Items</th>
<th>N of Items</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.847</td>
<td>0.847</td>
<td>10</td>
</tr>
</tbody>
</table>

**Table 2.** Overall reliability statistics
lem area. The Importance Index ranges from 0 to 1. The higher the index, the more adverse influence to innovation the barrier indicates. Looking at the overall Index, the values for all the ten groups are more than 0.55, showing that the questionnaire well captured the commonality of the innovation barriers which projects suffer from.

3.6 Analysis Approach

The survey applies an ordinal scale, which can numerically express the respondents’ views on the importance of each inhibitor. The numerical data generated was analyzed by means of the ‘relative index ranking’ technique to investigate the relative importance of the inhibitors as postulated. The scorings obtained for each question was transformed to an Relative Importance Index by means of the following formula (Kometa et al. 1994):

Relative Importance Index = \( \frac{\sum w}{A \times N} \) (1)

Where \( w \) refers to the score given to each inhibitor by each respondent, \( A \) is the highest weighting in the scale while \( N \) is the number of samples.

4 FINDINGS AND DISCUSSION

In light with their relevance, all inhibiting parameters were grouped into ten areas namely: client and industry relationship, procurement/contractual issues, organization resources, regulation/standards, project characteristics, organizational culture, project manager, structure of production, project management, and organization management. The survey set out to investigate to what extent the inhibitors hamper a project team’s innovation performance. The results are presented in Table 3.

In general, the first seven groups are the most important barriers with a relatively high overall index (over 0.64). The regulation group shows a boundary for the overall rankings. The last three groups (project management, project manager, project characteristics) display comparatively lower importance to innovation, with apparently decreased indices (below 0.59).

Client and industry relationships

This group takes up the first rank with the overall index, 0.69. Three items in the group are related to clients. It highlights the prominent role of clients. It is consistent with the literature review findings. The client is a critical determinant to trigger and support innovations in the industry (Blayse and Manley 2004; Dewick and Miozzo 2004). Besides, this echoes findings from the interviews. One interviewee recognized weak ‘demand-pull’ as the most serious barrier to innovation. Another interviewee opined that experienced clients are more likely to be convinced of innovation adoption, and they are more collaborative during the implementation phase. However, these innovation-supporting clients are rarely encountered, except some experienced big corporate clients who have constant streams of orders and in-house supporting teams, such as Tesco or universities. He said that clients generally have a conservative attitude and are willing to use only well-proven solutions. In general, this uncovers the problem that the ‘demanding’ and experienced clients are common but they infrequently require innovative design solutions.

Besides, the data analysis indicates that support from designers is ranked first in the group. It implies that the potential conflicts and authority from the client substantially influence the achievement of innovations. Innovative contributions from the suppliers are ranked the fourth with 0.64. The reality in the construction industry is that suppliers, especially the manufactures, are the traditional sources for innovation, by supplying innovative building materials and components (Anderson and Manseau 1999). There are also views that purchasing construction plant and equipment makes up the bulk of research and development expenditure in a construction company (Bulli 2007). The findings from case studies prove that suppliers and specialized contractors are the most important organizations for contractors to ‘outsource’ innovation. The high ranking from the data collected indicates it has been a common difficulty in securing suppliers’ supports. This can be explained from two perspectives. First, the more radical the construction innovation is, the higher the technological threshold becomes. The rating may explain contractors’ complaints that the technological capacities of suppliers are usually incompetent to fully respond to their innovation requirements. More importantly, it is commonly referred to as contractors’ problem in supply chain management.

Procurement

Procurement was ranked the second most important with an overall index of 0.67. Having reviewed the literature, the high ranking should not be surprising. Blayse and Manley (2004) argued that procurement systems which discourage contractors from venturing into novel building solutions are most deleterious to innovation.

Looking at the rankings and the interview results, the overall index was elevated by the phenomenon that clients were willing to pay a premium on speed and cost alone. It expresses contractors’ substantial concern about the unhelpful procurement system for innovation. In this situation, innovation cannot beat traditional solutions to vitalize its value.

Risk allocation is the second barrier. This is understandable, because construction projects are always associated with high risk profiles (Manley and
Table 3. Grouping and ranking of the data

<table>
<thead>
<tr>
<th>Group</th>
<th>Original Item No.</th>
<th>Inhibitors to Innovation</th>
<th>Rank of sub-attributes</th>
<th>Relative Importance Index of sub-attributes</th>
<th>Overall Rank</th>
<th>Overall index for each group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Client and industry</td>
<td>B27</td>
<td>The need for support and consensus from owners and designers</td>
<td>1</td>
<td>0.75</td>
<td>1</td>
<td>0.69</td>
</tr>
<tr>
<td>relationship</td>
<td>B2</td>
<td>Uninformed and inexperienced clients</td>
<td>2</td>
<td>0.69</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>B1</td>
<td>Clients’ low desire to pay for innovative solutions</td>
<td>3</td>
<td>0.66</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>B29</td>
<td>Difficulties of access to innovations from suppliers in terms of equipment and consultancy</td>
<td>4</td>
<td>0.64</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Procurement</td>
<td>B9</td>
<td>Procurement systems which place a premium on speed, urgency or price alone</td>
<td>1</td>
<td>0.74</td>
<td>2</td>
<td>0.67</td>
</tr>
<tr>
<td></td>
<td>B32</td>
<td>Require a cascading legal contract to pass risk down to the supply chain</td>
<td>2</td>
<td>0.65</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>B8</td>
<td>Inappropriate contracts</td>
<td>3</td>
<td>0.63</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Organization Culture</td>
<td>B18</td>
<td>Insufficient motivators for innovation</td>
<td>1α</td>
<td>0.71</td>
<td>3</td>
<td>0.66</td>
</tr>
<tr>
<td></td>
<td>B11</td>
<td>A blame culture for risk, failure and mistakes because of risk aversion</td>
<td>2</td>
<td>0.71</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>B19</td>
<td>Hostile or skeptical attitudes within bureaucratic organizations</td>
<td>3</td>
<td>0.66</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>B24</td>
<td>Managers neglect front-line staff’s initiatives for change</td>
<td>4</td>
<td>0.57</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>B18</td>
<td>Insufficient motivators for innovation</td>
<td>1α</td>
<td>0.71</td>
<td>3</td>
<td>0.66</td>
</tr>
<tr>
<td>Organization Management</td>
<td>B13</td>
<td>Inefficient management of knowledge transfer</td>
<td>1</td>
<td>0.71</td>
<td>4</td>
<td>0.66</td>
</tr>
<tr>
<td></td>
<td>B15</td>
<td>Lack of procedures to monitor/measure the innovation processes and outcomes</td>
<td>2</td>
<td>0.66</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>B16</td>
<td>Training/educational deficiencies</td>
<td>3α</td>
<td>0.64</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>B17</td>
<td>Need for innovation champions to stimulate and develop creative ideas</td>
<td>4</td>
<td>0.64</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>B12</td>
<td>Poor inter-organizational cooperation by the project team members</td>
<td>5</td>
<td>0.63</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Resources</td>
<td>B3</td>
<td>Limited budgets</td>
<td>1</td>
<td>0.75</td>
<td>5</td>
<td>0.65</td>
</tr>
<tr>
<td></td>
<td>B4</td>
<td>Inability to tap into many trusted sources to gather market/technology information</td>
<td>2</td>
<td>0.63</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>B7</td>
<td>Lack of organizational drive to innovate</td>
<td>3</td>
<td>0.63</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>B6</td>
<td>Lack of professionally qualified and informed employees for innovation development and implementation</td>
<td>4</td>
<td>0.63</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Structure of Production</td>
<td>B33</td>
<td>Shot-term budgets and planning horizons</td>
<td>1</td>
<td>0.69</td>
<td>6</td>
<td>0.65</td>
</tr>
<tr>
<td></td>
<td>B20</td>
<td>The one-off nature of the project limits the degree to which a given innovation will be applicable to other projects.</td>
<td>2</td>
<td>0.66</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>B21</td>
<td>Short-term relationships between participating organizations</td>
<td>3</td>
<td>0.66</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>B5</td>
<td>Limited range of technologies within a typical construction project</td>
<td>4</td>
<td>0.63</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Regulation</td>
<td>B26</td>
<td>Stringent regulations lead to lawsuit aversions</td>
<td>1</td>
<td>0.65</td>
<td>7</td>
<td>0.64</td>
</tr>
<tr>
<td></td>
<td>B25</td>
<td>The need for regulations stimulating innovations (e.g. sustainable construction)</td>
<td>2</td>
<td>0.62</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Project Management</td>
<td>B31</td>
<td>High level of subcontracting</td>
<td>1</td>
<td>0.62</td>
<td>8</td>
<td>0.59</td>
</tr>
<tr>
<td></td>
<td>B10</td>
<td>Lack of skills to manage risk</td>
<td>2</td>
<td>0.61</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>B30</td>
<td>Hierarchical (internal and external) communication structure</td>
<td>3</td>
<td>0.63</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>B35</td>
<td>Poor usage of IT (e.g. computer-aided construction-oriented tools)</td>
<td>4</td>
<td>0.55</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Project Manager</td>
<td>B14</td>
<td>Lack of support and commitment from project managers</td>
<td>1</td>
<td>0.59</td>
<td>9</td>
<td>0.57</td>
</tr>
<tr>
<td>Project Characteristics</td>
<td>B34</td>
<td>Project manager’s poor leadership for innovation</td>
<td>2</td>
<td>0.55</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>B28</td>
<td>Project timescale does not allow for innovation</td>
<td>1</td>
<td>0.63</td>
<td>10</td>
<td>0.56</td>
</tr>
<tr>
<td></td>
<td>B22</td>
<td>The small size, value and low complexity of typical construction projects</td>
<td>2</td>
<td>0.58</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>B23</td>
<td>The small size and low competency of a project team</td>
<td>3</td>
<td>0.49</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: α - Tied Relative Importance Indices in accordance with the mean and standard deviation of the data set.

Hampson 2000). Besides, it implies the blames may be laid on the ineffectiveness of traditional contracts. For example, the widely used lump-sum contracts lead to risk-intensive conditions for contractors (Kumaraswamy and Dulaimi 2001). Innovations may bring additional risks, from which they shun.

Inappropriate contract is the third barrier, with an index of 0.63. According to the questionnaire results, lump-sum contracts were predominately used in the market, more than 90%. However, Walker and Hampson (2003) criticized it as the most conservative and the most hazardous barrier against innovations. It is most likely to give rise to adversarial relationships, poorly integrated team and impairing the innovation outcomes (Kumaraswamy and Dulaimi 2001). Additionally, according to the survey responses, innovative contracts such as BOT, management contract, etc., which are beneficial to reap innovation outcomes, were scarcely used. Furthermore, the survey also shows that the market still preferred the two-stage bidding process. Design-Build contracts can bring innovations through the improved communication and learning, with a well-
integrated team (Blayse and Manley 2004). However, although use of this type of contract has grown, it has not overtaken the traditional form of procurement.

**Organizational Culture**

Culture was ranked as the third most important barrier with an index of 0.66. Organizational culture is a key determinant for innovation, because innovation cannot flourish without a supportive alignment of company culture. The high index reveals that the lack of an innovation-friendly culture is a widely confronted barrier. Ironically, if the project team is conservative to innovation, how can they convince clients to be open to innovation? Analyzing the data, poor motivational and penalizing culture are the main problems. Staff tend to adopt the ‘business as usual’ attitude, with no enthusiasm to venture. An interviewee argued that there was a lack of ‘innovation atmosphere’. The managers were not supportive. Besides, he complained that there was no monetary reward for any innovation efforts in his company. Even if there were alluring monetary incentives, he would also be reluctant to innovate because of the lack of commitment to the organization.

**Organization Management**

Organization management is relevant to organizational innovation, from the technological perspective. It ranked fourth with the same index as the third. The interviewees explained about this surprisingly low ranking. From the theoretical level, they acknowledged that organizational innovation is indispensably embedded in the innovation domain. However, in practice, they interpreted organizational innovation as ‘meaningless’ with little contribution to projects. The indifference to organization management can throw some light to the fourth ranking.

Knowledge management which ranked first within the group is important to innovation because contractors always improve their capabilities by learning from their former projects and interactions with participants. The temporary project team structure always hampers knowledge diffusion, by a broken ‘knowledge loop’. Lack of innovation measurement ranked the second. The importance of measurement systems has been addressed by Mulgan and Albury (2003), in that they can assess the outcomes of innovation thus support a robust analysis and learning. Construction is embedded within a complex context, with numerous participants, different activities, at diverse time points. The barrier may result from this complexity which challenges effective measurement of innovation results. The interview results supplement that there was no tracking procedures for small projects until the completion of the projects.

Training and education deficiencies were ranked the third obstacle. Training is an effective way to improve in-house technical competence. A trained workforce is vital for innovative projects (Alinaitwe et al. 2007). Poor training and education are always blamed for the poor linkage between contractors and the academia. It may impair the innovation outcomes by high incidences of reworking, risk, and delay. Besides the implementation phase, it constrains capabilities for research and development. Another research confirms this finding that many construction firms are not keen on training their employees (Sha and Jiang 2003).

Cooperation is the least important barrier in this group. This result is surprising. However, its index is only slightly lower than others. Construction innovation is based on a temporary coalition of members who rely on each others’ capability. Therefore, the importance should not be neglected. Dewick and Miozzo (2004) have drawn a similar conclusion that stronger organizational cooperation is much needed to enhance construction innovations. In the construction industry, problematic cooperation may hamper innovation due to adversarial relationships, and a poorly-integrated team with conflicting tension may result.

**Resources**

The resources issues ranked fifth with an index of 0.65. The sub-attributes include limited budget, information provision, organizational slack, and qualified staff, ranked sequentially. It highlights that the presence of external and internal conditions favourable to innovation are much needed (Blayse and Manley 2004). External resources include trusted information, recruitment of qualified staff. Internal resources represent sufficient slack buffers, adequate budgets. Insufficient budget was ranked first. It always reflects the biggest challenge in a project. One interviewee said that the dangers of over-budget always compel them to adopt traditional solutions which are safe and cheaper. Another interviewee expressed a surprising opinion that the limited budget was a trigger for innovation. He argued that contractors were always forced to optimise their building process (i.e. innovation) in order to combat with the foreseeable cost overruns. Facing the controversy, the technical prerequisite may be a plausible explanation. The triggering function of limited budgets only exists in the specific conditions where trivial changes (i.e. incremental innovation) can adequately cope with technical challenges while reaping savings. However, in most cases only radical innovation rather than traditional solutions can meet the technical prerequisites. However, radically innovative solutions are more costly than their traditional counterparts. As a result, it is understandable why limited budgets are overwhelmingly recognized as a principal innovation barrier.

Information provision is the second barrier referring to contractors’ poor ‘absorptive capacity’ in capturing innovation opportunities and technological information. It was surprising to see the least important
ranking to be given to the factor of qualified staff. In the literature, the need for qualified staff in key positions to develop, administer and facilitate innovation is high. Professionally qualified staff is a critical component of in-house technical competence which determines the level of innovation the project team can achieve (Gann 2001; Blayse and Manley 2004). The interview findings supplement that innovativeness and creativity of the staff should be emphasised in recruitment. However, the low rating can be well explained by the rare occurrence of research and development activities in construction companies. They prefer to wait for innovative construction solutions from the designer or consultants. Rather than technologists, only skilled labours are needed to carry out the project at the front-line. And skilled labours are easy to be hired in the UK at least. In part, the surprising result can be explained by the nature of the cluster sample. Company A is a distinguished construction company in the UK. For large contractors, it has less pressure for talent provision.

Structure of Production

As shown, it is the sixth most important barrier to innovation. It has been addressed in a large body of literature that some inherent natures of the construction industry are ill suited to support innovation, and they even produce deleterious consequences (Dewick and Miozzo 2004). Both the one-off nature (ranking 2nd) and short-term relationships (ranking 4th) are detrimental for ‘organizational memory’, resulting in discontinued knowledge development and diffusion (Dubois and Gadde 2000). This situation is unavoidable. However, production approaches can to a large extent alleviate the harms via effective learning activities. Besides, the one-off nature of projects diminishes contractors’ incentives for innovation, because of the reduced applicable value.

“Shot-term budgets and planning horizons” was ranked first in the group. This nature arises from the project-oriented custom of the industry. On one hand, it results in investment strain for innovation. On the other hand, innovation needs a long-term horizon and continuous commitments. The drawback reduces the outcomes of innovation by dividing innovations into separate segments. The discontinuous innovation activities suppressed the possibility of success. As Mulgan and Albury (2003) argued, innovation conditions are exacerbated by the ‘short-termism’, because innovation cannot ‘survive an obligation to break even’.

The range of technology ranked fourth within the group with an index of 0.6. This ranking reveals that the contractor is confused with the abundant technologies available. This implies that sometimes contractors’ technological competence is insufficient to steer the technological resources to fruition.

Regulation

Regulation issues were ranked seventh. The existence of unfavourable regulations is supported by Dubois and Gadde (2000) that in general, many regulations are inhibiting innovation. Lawsuit aversions and stimulating regulations ranked the first and second respectively. The high scoring for the two barriers shows the importance of regulations in simulating demands and motivation. The stringent regulation was rated as the key barrier to an innovative motivation. The law aversion attitude produces a preference for traditional and well-proven techniques. An ambitious setting of standards can radically channel demand to innovative solutions. However, the ranking shows that the adoption of high standards is pressingly needed but the result is far from being satisfactory.

Project Management

Project Management was ranked as the last third, with a sharply decreased index of 0.59. Supposedly, project management should be paramount to innovation, because it is the implementation phase of innovation. Thus the quality of project management exerts an immediate impact. However, the low rating implies that the success of innovation mostly relies on the quality of the preparation phase of innovation. This perspective was demonstrated by an interviewee who argued that innovative schemes were always well piloted and tested by small-scale experiments before implementation. The strict procedures were carried out to ensure that the innovation activities were robust enough for formal application. This also explains why risk management was only ranked second in the group. It implies that contractors are prudent towards innovation, and they have developed precautionary systems and contingency plans in place. The risk averse attitudes also contradict a favourable custom to innovation.

A high level of subcontracting was ranked the first in the group. As the interview results show, contractors always resort to specialized subcontractors for innovative assistance. These practices ease the cost of innovation activities and make it achievable. However, this high rating as a barrier implies contractors’ concerns about the deteriorating cooperation and the diminishing innovation opportunities.

A hierarchical communication structure ranked the third with a low index of 0.6. Hierarchies are injurious for innovations because of the inflexible role definitions, and poor autonomy (Blayse and Manley 2004). One interviewee added that he had few opportunities to have a dialogue with project leaders and he was not qualified to participate in innovation workshops. This reveals that the hierarchical structure is also detrimental to communication, cooperation and decision making.
Project Manager

This was ranked the second lowest with an index of 0.57. Considering project managers’ supreme powers, this result is surprising and also contradictory to the interview findings. One interviewee complained that project managers did not support innovation. Other interviewees criticized the leadership issues too. One said, ‘many leading project managers and key decision makers are not university-educated, and have no links with the academic world, where innovation is fostered (in technological terms). This makes communicating a new idea upwards a very demanding and difficult task, which quite often fails’.

Project Characteristics

In general, project characteristics were viewed as the least agreeable barrier. Project timescale was ranked the first in the group. This is justified by the interview findings that ‘Innovative ideas need to be ahead of contract awards’. As relative short periods span between contract letting, design, tendering and construction, they do not allow for innovation to be employed within a typical project. Another interview even ranked risk of late delivery as the most important barrier. The small size of a team was ranked the least agreeable. Resources are embedded at both the project and the company level (Gann and Salter 2000). The ranking implies that the team’s capabilities will be constrained by the team size at the firm level.

5 CONCLUSIONS AND RECOMMENDATIONS

Construction has been traditionally recognized as an industry with poor innovation performance. The sluggish innovation has led to many adverse impacts to the industry, such as low productivity, a high rate of health and safety accidents, poor client satisfaction, etc. This research is aimed at investigating the innovation inhibitors in the UK construction industry by means of a questionnaire survey administered on a top-tier national level contractor and a series of interviews.

There are numerous innovation barriers with which the contractor is confronted. Bearing in mind that the subject company is one of the top-tier firms in the UK construction industry, the situation would be obviously deleterious for smaller firms. Among these innovation barriers, client and industry relationship, procurement, organizational culture, organization management are the four most important barriers perceived in project level innovation. Most of the barriers to innovation are correlated with other factors. Therefore, a systematic approach is necessary to improve the status of innovation in contractors. From the above analysis of barriers in each group, the following specific recommendations are worth putting into practice:

In order to improve the client and industry relationship, contractors should proactively improve the mutual synergies and liaison with the clients and designers, thereby facilitating the innovation implementation activities; client involvement and commitment should be encouraged as early as possible in the design and construction stages; contractors need to improve the supply chain management by maintaining a both extensive and tight partnership with suppliers for technology provisions.

To promote efficient procurement management, contractors should integrate more innovation concerns on the building whole life costs and sustainability into the procurement process. Besides, the use of innovative contracts (e.g., design-build contract) should be encouraged to substitute the use of traditional lump-sum contracts.

To cultivate a supportive organizational culture for innovation, contractors should provide substantive rewards and showing recognition for innovation. Managers can integrate innovation promotional activities into routine works in order to thrive the creativeness of the team.

To strengthen organization management, the project team should strive to broaden organizational capacities and resource bases in terms of both technological and managerial aspects. Besides, the traditional hierarchical organisations should be converted to flat organisations.

For resources management, sufficient resource buffer should be allocated to innovation activities. Contractors are also encouraged to leverage their resources by establishing a network with their suppliers and stakeholders such as government agents and industry platforms.

For project management, project team should enhance the absorptive capacity by tapping the technological development. In addition, a flexible agenda should be adopted for innovation activities. Acting as a key facilitator for innovation, project managers should improve their technological capacities and innovativeness.

For structure of production, a learning-oriented interaction mechanism should be established to lead to an enabling framework for innovation development. Most importantly, in order to significantly improve innovation diffusion, a systematic approach is necessary rather than using isolated methods.

The limitations of this research study lie in the exclusion of small and medium enterprises (SME) from the broader innovation picture. Besides, the single sampling cluster may impair the representativeness of results for generalization. Future research may involve more samples to investigate how the identified barriers are hampering the success of innovation activities. More research may also be conducted in the small and medium contractor segment to shed light on the innovation dilemma they are confronted with.
REFERENCES


in construction, services and manufacturing in the UK." Construction Management and Economics, 23(6), 631–644.
APPENDIX: Questionnaire on Construction Innovation Inhibitors

Introduction:
This questionnaire will be used to gauge the relative importance of different barriers on construction innovation in the UK. Recent research has shown that innovation in construction may be considered at industry, organizational or project level. This survey focuses on project-based innovation. Your feedback will provide insights to innovation obstacles in the industry. Please take 4 or 5 minutes to give your opinions. The identities of respondents are strictly confidential.

Definition:
Project-level innovation is co-production of novel solutions arising from day-to-day problem solving on site during the production phase, upon different parts of participants’ tacit knowledge and ‘learning by doing.’ It includes not only technological innovation but also non-technological ones i.e. organizational and business innovation.

Please indicate your level of agreement with the following statements.

1. Clients’ low desire to pay for innovative solutions
   - [ ] Strongly Agree  [ ] Agree  [ ] Neutral  [ ] Disagree  [ ] Strongly Disagree

2. Uninformed and inexperienced clients
   - [ ] Strongly Agree  [ ] Agree  [ ] Neutral  [ ] Disagree  [ ] Strongly Disagree

3. Limited budgets
   - [ ] Strongly Agree  [ ] Agree  [ ] Neutral  [ ] Disagree  [ ] Strongly Disagree

4. Inability to tap into many trusted sources to gather market/technology information
   - [ ] Strongly Agree  [ ] Agree  [ ] Neutral  [ ] Disagree  [ ] Strongly Disagree

5. Limited range of technologies within a typical construction project
   - [ ] Strongly Agree  [ ] Agree  [ ] Neutral  [ ] Disagree  [ ] Strongly Disagree

6. Lack of professionally qualified and informed employees for innovation development and implementation
   - [ ] Strongly Agree  [ ] Agree  [ ] Neutral  [ ] Disagree  [ ] Strongly Disagree

7. Lack of organizational drive to innovate
   - [ ] Strongly Agree  [ ] Agree  [ ] Neutral  [ ] Disagree  [ ] Strongly Disagree

8. Inappropriate contracts
   - [ ] Strongly Agree  [ ] Agree  [ ] Neutral  [ ] Disagree  [ ] Strongly Disagree

9. Procurement systems which place a premium on speed, urgency or price alone
   - [ ] Strongly Agree  [ ] Agree  [ ] Neutral  [ ] Disagree  [ ] Strongly Disagree

10. Lack of skills to manage risk
    - [ ] Strongly Agree  [ ] Agree  [ ] Neutral  [ ] Disagree  [ ] Strongly Disagree

11. A blame culture for risk, failure and mistakes because of risk aversion
    - [ ] Strongly Agree  [ ] Agree  [ ] Neutral  [ ] Disagree  [ ] Strongly Disagree

12. Poor inter-organizational cooperation by the project team members
    - [ ] Strongly Agree  [ ] Agree  [ ] Neutral  [ ] Disagree  [ ] Strongly Disagree

13. Inefficient management of knowledge transfer
    - [ ] Strongly Agree  [ ] Agree  [ ] Neutral  [ ] Disagree  [ ] Strongly Disagree

14. Lack of support and commitment from project managers
    - [ ] Strongly Agree  [ ] Agree  [ ] Neutral  [ ] Disagree  [ ] Strongly Disagree

15. Lack of procedures to monitor/measure the innovation processes and outcomes
    - [ ] Strongly Agree  [ ] Agree  [ ] Neutral  [ ] Disagree  [ ] Strongly Disagree

16. Training/educational deficiencies
    - [ ] Strongly Agree  [ ] Agree  [ ] Neutral  [ ] Disagree  [ ] Strongly Disagree

17. Need for innovation champions to stimulate and develop creative ideas
    - [ ] Strongly Agree  [ ] Agree  [ ] Neutral  [ ] Disagree  [ ] Strongly Disagree

18. Insufficient motivators for innovation
    - [ ] Strongly Agree  [ ] Agree  [ ] Neutral  [ ] Disagree  [ ] Strongly Disagree

19. Hostile or skeptical attitudes within bureaucratic organizations
    - [ ] Strongly Agree  [ ] Agree  [ ] Neutral  [ ] Disagree  [ ] Strongly Disagree

20. The one-off nature of the project limits the degree to which a given innovation will be applicable to other projects.
    - [ ] Strongly Agree  [ ] Agree  [ ] Neutral  [ ] Disagree  [ ] Strongly Disagree
21. Short-term relationships between participating organizations
   ○ Strongly Agree ○ Agree ○ Neutral ○ Disagree ○ Strongly Disagree

22. The small size, value and low complexity of typical construction projects
   ○ Strongly Agree ○ Agree ○ Neutral ○ Disagree ○ Strongly Disagree

23. The small size and low competency of a project team
   ○ Strongly Agree ○ Agree ○ Neutral ○ Disagree ○ Strongly Disagree

24. Managers neglect front-line staff’s initiatives for change
   ○ Strongly Agree ○ Agree ○ Neutral ○ Disagree ○ Strongly Disagree

25. The need for regulations stimulating innovations (e.g. sustainable construction)
   ○ Strongly Agree ○ Agree ○ Neutral ○ Disagree ○ Strongly Disagree

26. Stringent regulations lead to lawsuit aversions
   ○ Strongly Agree ○ Agree ○ Neutral ○ Disagree ○ Strongly Disagree

27. The need for support and consensus from owners and designers
   ○ Strongly Agree ○ Agree ○ Neutral ○ Disagree ○ Strongly Disagree

28. Project timescale does not allow for innovation
   ○ Strongly Agree ○ Agree ○ Neutral ○ Disagree ○ Strongly Disagree

29. Difficulties of access to innovations from suppliers in terms of equipment and consultancy
   ○ Strongly Agree ○ Agree ○ Neutral ○ Disagree ○ Strongly Disagree

30. Hierarchical (internal and external) communication structure
   ○ Strongly Agree ○ Agree ○ Neutral ○ Disagree ○ Strongly Disagree

31. High level of subcontracting
   ○ Strongly Agree ○ Agree ○ Neutral ○ Disagree ○ Strongly Disagree

32. Require a cascading legal contract to pass risk down to the supply chain
   ○ Strongly Agree ○ Agree ○ Neutral ○ Disagree ○ Strongly Disagree

33. Short-term budgets and planning horizons
   ○ Strongly Agree ○ Agree ○ Neutral ○ Disagree ○ Strongly Disagree

34. Project manager’s poor leadership for innovation
   ○ Strongly Agree ○ Agree ○ Neutral ○ Disagree ○ Strongly Disagree

35. Poor usage of IT (e.g. computer-aided construction-oriented tools)
   ○ Strongly Agree ○ Agree ○ Neutral ○ Disagree ○ Strongly Disagree

Background Information

Construction experience: __________ years
Current Position: __________

Type of construction work:
□ lump-sum □ Unit price □ Cost plus fixed percentage □ Cost plus fixed fee
□ Target estimate □ Guaranteed maximum cost □ Full cost reimbursable □ Cost plus variable percentage
□ Design-build □ Construction management □ Project management □ On-call multi-task contracting
□ BOOT □ PPP □ PFI

Others (please specify): ____________________________

Comments and Suggestions
If you have any comments or suggestions to this survey, please write it down

Acknowledgement
Thank you very much for your time in completing this survey!