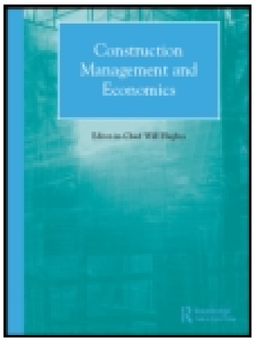

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Last among equals: a comparison of innovation in construction, services and manufacturing in the UK

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This paper contrasts the attitudes of firms towards innovation from the construction sector with those in services and manufacturing, using data from the UK innovation survey. We examine the liabilities that construction firms face in their innovative activities in comparison to other sectors, drawing from literature on the distinctiveness of construction as an economic activity. We find that the *liabilities of immobility and unanticipated demand* are among key distinguishing features that separate innovative behaviour in construction from other industries. The paper concludes with a discussion of the merits of cross-sectoral comparative research of this kind, together with issues for further research.

Keywords: Construction innovation, innovation, innovation strategy, manufacturing, services

Introduction

Efforts to promote innovation have been at the heart of attempts to support the modernization of the construction sector. In the UK, the Egan and Fairclough reports outline a new vision for the system of design, production and operation of the built environment, involving considerable investment in new technologies, management practices and techniques of production (Egan, 1998; Fairclough, 2002). In comparison to other sectors, construction is usually classified as a traditional or low-technology sector with low levels of expenditure on activities associated with innovation, such as research and development (R&D) (OECD, 2000; Seaden and Manseau, 2001). The Organization for Economic Co-operation and Development (OECD) argues that in aggregate, the construction sector is characterized by low barriers to entry, limited international competition, low quality, fierce price-based competition and poor rates of successful project completion. The main drivers of technological change in the industry are seen to be new components introduced by suppliers to the industry. It appears that many construction firms are in a vicious cycle of low performance, anaemic levels of profitability, limited investment, and poor organizational capabilities (OECD, 2000).

Innovation may offer an opportunity for some construction firms to escape this vicious circle. There have been a number of case studies of how successful firms have been able to make a range of different organizational, managerial or technological innovations to overcome the limits of their environment (Slaughter, 1993; 1998; Veshosky, 1998; Koskela and Vrijhoef, 2001; Sexton and Barret, 2003; Cleasby, 2004); yet there have been relatively few large-scale surveys of innovation in construction and what role these processes of innovation are having in reshaping practices. A recent Canadian survey explores the importance of innovation and the use of advanced practices in shaping the performance of construction firms (Seaden *et al.*, 2003). Seaden *et al.* (2003) focus on the sources of success and failure in innovation among construction firms. In this paper, we seek to extend this earlier study by comparing construction to manufacturing and service sectors exploring the distinctiveness of construction as an economic and innovative process. In so doing, the paper attempts to build on previous qualitative research on innovation in construction, trying to complement this work through comparative statistical analysis.

The paper begins by examining the concept of innovation in construction, locating our empirical

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research in the context of previous studies. This is followed by a description of the UK innovation survey and its applicability to construction. The data is presented and analysed in the penultimate section of the paper and this is followed by a discussion and conclusions.

Theoretical and empirical background

Innovation retains a central role in explanations of economic growth, industrial dynamics and international trade (Cohen, 1995; Krugman, 1995; Baumol, 2002). Indeed, microeconomic studies show that there are many benefits for innovators. Previous studies have found that firm-level innovation increases a firm's export potential (Bleaney and Wakelin, 2002), profits over long periods and during recessions (Geroski *et al.*, 1993), credit ratings (Czarnitzki and Kraft, 2004), chances of surviving in the market (Cefis and Marsili, 2004) and market value (Hall, 2000; Toivanen *et al.*, 2002). The ability to innovate can create possibilities for firms to gain competitive advantage over their industrial rivals.

Although innovation is common in all sectors, the potential for innovation for an individual firm is shaped by its own activities and the environment it operates within. In terms of a firm's own organizational resources, past studies have found a wide range of factors at the firm-level that shape the potential for a firm to achieve an innovation, including its size, its age, its levels of absorptive capacity, its strategies for organizing new product development and its ability to mobilize complementary assets (Cohen, 1995; Dodgson, 2000). There is also a wide range of different factors in the industrial environment that may shape the potential for innovation by individual firms, including the nature of technological opportunities, appropriability regimes, levels of industrial competition, the position of the industry in the Product Life Cycle, government policy and regulations (Pavitt, 1984; Dosi, 1988; Lundvall, 1992; Nelson, 1993; Utterback, 1994; Klevorick *et al.*, 1995). Taken together the firm and industry-level studies indicate that individual firms do have the potential for independent action, but that this potential is profoundly shaped or bounded by the industrial context they operate within (Nelson and Winter, 1982; Dosi, 1988).

In many studies of innovation, construction is seen as a low performing sector, exhibiting low rates of innovative activity (Bowley, 1960, 1966; OECD, 2000). In the literature on construction, however, although it is widely acknowledged that construction is a distinctive economic sector, there is no consensus about why construction differs from other sectors in its innovation behaviour. The literature on innovation in construction offers several possible explanations. For example, Nam and Tatum (1988) compare the characteristics of constructed products with those of manufacturing, arguing that five specific differences limit the development of construction technology, these being: immobility, complexity, durability, costliness and high degree of social responsibility. They cite these characteristics as creating the conditions for production processes that result in a 'locked system' in which innovation, or in their words, 'changing the status quo' becomes difficult. Developing these concepts and linking them to other contemporary studies, it is possible to identify six factors that shape the nature of innovation in construction. In identifying these factors, we draw from an analogy in organizational theory about the liabilities of new organizations (Stinchcombe, 1965; Carroll, 1984; Bruderl and Schussler, 1990; Baum, 1991, 1996; Carroll and Hannan, 2000). We characterize each factor below as a different liability to innovative behaviour.

The first factor relates to the *liability of projects* and is based on the fact that construction is largely a project-based activity with temporary coalitions of different organizations that come together to attempt to achieve a task over a specific period (Gann and Salter, 2000). The temporary nature of organizational factors makes the transfer of lessons from one project to another problematic given that teams often disband at the end of projects. The episodic nature of activities limits opportunity for the development of 'economies of repeatability' (Davies and Brady, 2000). There is a tendency to re-invent processes on each new project and some of the detailed technical activities performed on one project may be difficult or impossible to transfer to new projects.

Secondly, construction often involves high levels of *in-situ* production, relating to the immobility of the product described by Nam and Tatum (1988). This factor can be seen as the *liability of immobility*. Final production takes place at the point of consumption, or use of a building. Producing on-site limits opportunity to develop the routines associated with highly productive manufacturing industries. It also opens the construction processes to many uncertainties not faced in the controlled environment of a factory. The use of modular components in many parts of the construction process provides an opportunity to raise the share of construction output created in factory conditions, especially in markets such as housing (Gibb, 2001; Venables *et al.*, 2004).

Thirdly, demand usually depends upon fixed capital investment decisions, often involving several stakeholders, taking time and creating a degree of market complexity not found in many manufacturing or service sectors. This factor could be called the *liability of uncertain demand*. This tends to limit the influence construction firms have over their own future markets. In construction projects clients or customers often play a significant role in shaping design and production processes used in the creation of the final products. Many projects involve the creation of highly bespoke products, focused on meeting the requirements of individual customers and mediated by exigencies of local circumstances. In parts of the sector, architects and their clients prize the ability to create unique solutions. This pattern of new product development creates challenges in the downstream production and engineering processes that are not typical of other sectors, where standardized design elements are usually incrementally added to with minor modifications (Utterback, 1994).

Fourthly, construction displays a unique industrial structure, dominated by small firms with little or no professional staff. Here construction appears to suffer from the *liability of smallness* (Stinchcombe, 1965; Baum, 1991). The large number of small firms is in part a reflection of lack of barriers to entry and few economies of scale. Although there is a growing international market for construction, much of the competition is local in orientation. There is a relatively small number of large contracting organizations who themselves rely on a vast array of small subcontractors. Many of these small firms have little innovative capability. One estimate suggests that 99% of the firms operating as contractors have fewer than five technical staff working in them (Gann, 2000).

The fifth factor in construction reflects the fact that design is usually separate from production and production is often separate from maintenance (Nam and Tatum, 1988; Groak, 1994). It could be called the *liability of separation*. Clients or their representatives often offer a range of different tenders to different parts of the sector, such as structural design, electrical and mechanical and cost consultancy. In a traditional procurement process, clients or their representatives choose among those who bid for the work and therefore determine the configuration of the design and production teams for particular projects. The selected organizations need to find new ways of working together, common practices and procedures. It is hard to ensure high levels of feedback between the different stages of the process. To overcome this problem, many construction projects are organized around design and build contracts, partnering arrangements or in longer-term service contracts (Barlow *et al.*, 1997; Dissanayake and Kumaraswamy, 1999; Bresnen and Marshall, 2000). In theory, these contracts and arrangements allow the design, production and the use of the building to be more highly integrated, creating opportunities for feedback and knowledge sharing between partners. Similar approaches can be found in the production of other complex products and capital goods (Davies *et al.*, 2003).

The sixth factor relates to the nature of the supply chain that can impair the rate and extent of innovation. Construction encompasses both those organizations responsible for on-site production, assembly and installation of systems, as well as a range of suppliers, such as architects, engineering consultants, cost consultants and users. This factor could be called the *liability of assembly*. The contractor is usually responsible for the assembly of a range of different components and the integration of different systems and suppliers. It acts as a system assembler, bringing together different subsystems and assembling these components on site. Architects, engineering consultants and cost consultants provide a wide range of services that have a profound impact on the product and its process of construction (Nicolini *et al.*, 2001). Winch (2003) argues that when attempting to understand whether construction is performing worse (or better) in a technological sense than other industries, it is important to reflect upon differences in the way the construction process is organized. He suggests that using national account statistics and productivity comparisons between construction and manufacturing can be potentially misleading. Using the Porter (1985) framework, Winch (2003) argues that every industry is part of a larger innovation system with linkages between different value chains of the system. It is important to avoid false comparisons that encompass different parts of different value chains. Construction in the national accounts covers manufacturing, distribution and installation activities. Yet, it does not include the design component of the value chain, where most of the product and process development activity takes place. In order to deal with this problem it is necessary to have a broad definition of construction that incorporates the design element within it.

Taken together, these six liabilities to innovation have a potential to significantly influence the character of innovative behaviour in construction. By using UK innovation survey data, we examine these liabilities through a statistical analysis that compares construction with other industries. Our goal is not to create direct 'like-for-like' comparisons, but to examine the broad differences between firms from a variety of industrial sectors. In order to develop the comparison, we compare construction to low and high technology manufacturing, knowledge-intensive services (KIS) and other service industries (traditional services). Our goal is to find features relating to the innovative behaviour of construction firms that makes them distinct from the rest of the economy.

In order to do so, we created an expanded category of construction that includes much of the product design elements of the construction process. In particular, we grouped architecture, engineering consultancy and associated services into a broad definition of the construction sector. This strategy of industrial aggregation helps to offset the problems raised by Winch (2003). By including services in the comparisons, we can also remove the problem of comparing construction to particular manufacturing industries, such as automotive production.

Data and method

The data for the analysis were drawn from the UK innovation survey. The survey was implemented in 2001 and is based on the core Eurostat Community Innovation Survey (CIS) of innovation (Stockdale, 2002, DTI, 2003). The method and types of questions used in innovation surveys are described in the Organization for Economic Co-operation and Development's (OECD) Oslo Manual (OECD, 1997). CIS data are increasingly being used as a key data source in the study of innovation at the firm level in Europe, Canada and Australia (for a recent prominent contribution using CIS data, see Mairesse and Mohnen, 2002). Within Europe, CIS surveys are normally conducted every 5 years. CIS surveys of innovation are often described as 'subject-oriented' because they ask individual firms directly whether they were able to produce an innovation. They are widely piloted and tested before implementation and, since its first use in the early 1990s, the questionnaire has been revised a number of times. The CIS questionnaire itself draws from previous generations of research on innovation, including the Yale survey and the SPRU innovation database (Pavitt, 1984; Klevorick *et al.*, 1995). It provides an opportunity to investigate patterns of innovation across a large number of industrial firms. It also enables researchers to explore the relationship between indicators of performance and different strategies for innovating. Although imperfect, CIS data do provide a useful complement to the traditional measures of innovation, such as patent statistics (Kaiser, 2002; Mairesse and Mohnen, 2002).

The CIS questionnaire asks firms to indicate whether the firm has been able to achieve a product and/or process innovation. Product innovation is defined as: 'goods and services introduced to the market which are either new or significantly improved with respect to fundamental characteristics. The innovations should be based on the results of new technological developments, new combinations of existing technology or utilisation of other knowledge by your firm' (DTI, 2003). Process innovation is defined as: 'the use of new or significantly improved technology for production or the supply of goods and services. Purely organizational or managerial changes should not be included' (DTI, 2003, p. 5). Alongside these performance questions, there is a number of questions about the sources of knowledge for innovation, the effects of innovation, intellectual property strategies and expenditures on R&D and other innovative activities. All firms are asked to complete the questionnaire, regardless of whether or not they innovated during the period of the survey.

The UK innovation survey instrument is 12 pages long and includes one page of definitions. The survey was sent to the firm's official representative for filing information on the firm's activities, such as surveys for calculating the UK Gross Domestic Product and R&D expenditures. The survey was sent to 13 315 business units in the UK in April 2001 and a supplementary sample of 6287 was posted in November 2001. It received a response rate of 41.7% (Stockdale, 2002). Only firms with over 10 employees were included in the sample. The responses were voluntary and respondents were promised confidentiality and that the survey would be used to shape government policy. The sample was stratified by 12 Standard Industrial Classification classes and includes all main sectors of the UK economy, excluding public bodies, retail, and hotels and restaurants. The sample was also stratified by region and by size to reflect the total demographic characteristics of the UK economy. The response rates for different sectors, regions and size were largely consistent with the overall response pattern (Stockdale, 2002).

There are, however, considerable problems with using the UK innovation survey for understanding innovation in construction. As mentioned above, the processes of production in construction can differ considerably from traditional consumer goods manufacturing. Innovation surveys and the Oslo manual have tended to focus on innovation in manufacturing industries. Underlying the survey is a model of product and process development that is rooted in an understanding of how consumer goods manufacturers attempt to innovate. Since its development, it has been extended to cover other industrial sectors. Accordingly, it is an imperfect instrument for understanding innovation in construction. In order to help deal with the problem, we have included in the analysis service industries, which suffer from similar problems with the CIS approach as construction. The survey also fails to capture the innovative experiences of very small firms that have less than 10 employees and therefore it omits many of the firms which are active in the construction sector.

As previously mentioned, we created an expanded category for the construction sector. We have included all firms in traditional construction (SIC 45) and added all firms involved in architectural activities, urban planning and landscape design, quantity surveying and engineering consultancy and design activities in the variable broad construction sector. We have also created two classes of manufacturing industries: low and high technology manufacturing. These have been categorized according to the OECD classification on the share of R&D expenditure over sales and employment (see Hatzichronoglou (1997)). For services, we have divided the sample of service firms into two groups: Knowledge Intensive Services (KIS) and traditional services (after removing the services relating to construction) [see Nählinder (2002) for the classification used]. KIS sectors cover a range of high value services, such as advertising, environmental consultancy, R&D services and business consultancy and traditional service contains the remaining service sectors.

There are 8172 firms in the UK innovation survey and of these 1141 can be categorized as part of the broad construction sector. Within this, 947 are from construction-related industry codes (SIC codes 45000–45500) and the rest (194) are drawn from architecture (SIC codes 74200 and 74201), engineering design and consultancy (SIC codes 74204, 74205 and 74206), urban planning (SIC codes 74202 and 74203). Housing and construction statistics published by the Government Statistical Service (December, 1999) reveal that in 1998 there were just over 10 000 construction firms with eight or more employees in the UK, indicating the survey covers roughly 10% of the total population of construction organizations with 10 or more employees in the UK.

Given the importance of size in shaping the propensity for innovation, it is important to control for the effect of size when exploring innovative behaviour (Cohen, 1995; Sexton and Barret, 2003). In order to do so, we split the sample into two groups: firms with less than 50 employees and firms with 50 or more employees. For each sectoral grouping, we report results for small and large firms, contrasting differences between the two groups of firms in Table 1.

Apart from descriptive statistics in the form of frequencies and percentages, we will apply the chi-square test and the Kendall's tau-b statistics. Both are statistics specifically developed to analyse categorical data and hence are appropriate in the present context. The χ^2 is a measure of association and tests the observed frequencies in a table against the expected number of observations in each cell. In our case, the expected number is expressed as a relatively even distribution of observations in the number of cells analysed. Kendall's tau-b statistics is also a measure of association. It is mostly used when analysing 2×2 tables with either binomial or ordinal data. It is a useful measure for producing a statistic for the direction of the correlation between two categorical variables. The result varies between -1 and 1, with 1 indicating all observations being positioned on the diagonal going downwards from the upper left corner to the lower right corner of a given table. A value of -1 hence indicates all observations are located on the diagonal from the upper right corner to the lower left corner of the tables studied. A value at 0 signifies a statistical independence between two variables (Kendall, 1945).

Table 1 Percentage of innovators and distribution of firm size

Variable	Number of Innovators	Percentage of Total Obs.	Low-Tech Manufacturing	High-Tech Manufacturing	Traditional Services	KIS	Broad Construction	Chi^2-value
Product Innovation								
Size<50	791	10.3	16.2	30.3	14.7	21.3	9.1	**106.3**
Size=>50	882	11.5	33.4	47.6	20.7	36.9	14.4	**156.7**
Process Innovation								
Size<50	659	8.6	17.2	17.5	10.7	18.2	8.2	**60.8**
Size=>50	765	10.0	31.0	36.5	18.8	26.2	16.6	**78.2**
Size								
Size<50	4759	62.2	58.9	46.7	64.7	71.1	70.3	
Size=>50	2895	37.8	41.1	53.3	35.4	29.0	29.7	**175.1**

Source: Own calculations based on UK innovation survey.
Note: The χ^2 values for the size variable covers the table of the five sectors and the two size categories.
Note: The four remaining χ^2 values indicate the skewness in tables between the five sectors and the binomial innovation variables.
Note: Bold χ^2 values indicate the observations are significantly skewed across the tables at a 1% level.

Empirical results

We start the empirical analysis by looking at the distribution of innovation across the five industrial sectors. In this analysis, we compare the innovative performance of construction to each of the other four sectors. We then investigate the attitudes of managers towards innovation in construction compared with other sectors. The first part of this analysis explores the factors that hamper innovation efforts. The second part of the analysis examines sources of information for innovation. Finally, we examine differences in reasons for not innovating and in market orientation across the five sectors.

Distribution of innovation

Table 1 presents the distribution of the observations across the two innovation-related variables as well as the distribution of the observations according to firm size (measured by number of employees). As expected by organizational theory, the effect of size on innovative activity tells us that large firms have a higher probability of having carried out either product or process innovations than small firms (χ^2 values at approximately 202 and 188, respectively – not reported in Table 1). This corresponds to the findings of Seaden *et al.* (2003), who state that smaller firms may be more risk averse and have a lower intensity of use of innovative practices than large firms.

Overall, we find that the size distribution of the sectors is highly skewed. The size distribution of the construction sector seems to correspond more to that of KIS and traditional services than to that of high and low technology manufacturing. It appears that the manufacturing sectors contain more large firms than the other sectors. Table 1 shows that about 70.3% of the construction firms in the sample may be categorized as small firms, leaving 29.7% of the observations with 50 or more employees. It appears that the percentage of firms achieving product compared to process innovation is similar in each sector. This suggests that product and process innovation are intimately related and that new products can begat new processes and vice-versa (Reichstein and Salter, 2004). The construction sector holds the lowest percentage of innovative firms. Indeed, only 9.1% and 8.0% of the smaller firms in the construction sample indicated that they have carried out product and process innovation, respectively. For large firms, the percentages are somewhat higher with 14.4% and 16.6% of the firms reporting a product or process innovation. In all sectors, it appears that large firms are more likely to be innovators than small firms. We found that there is a significant skew in the percentages of process and product innovative firms across the five sectors. This is expressed by the high χ^2 values. It seems that high-tech manufacturing and KIS have a higher percentage of innovative firms, regardless of firm size. The results also suggest that there may be fewer economies of scale in construction and services than in manufacturing.

In Table 2, we compare the levels of innovation in construction with other sectors. The analysis is based on Kendall's tau-b statistics (described in Section 2). The corresponding asymptotic standard errors and 95% confidence limits are reported. It appears that fewer construction firms are focused on innovative activity than any of the other sector groups. Fewer large and small construction firms engage in product and process innovation than high and low-tech manufacturing. However, the picture for traditional services is mixed. Small traditional service sectors have significantly more firms innovating in both products and processes. However, for large traditional services firms, there is no statistical difference with construction when considering levels of process innovation.

Considering the asymptotic standard errors and the confidence limits, it appears that high-tech manufacturing has the largest technological distance to construction no matter which size group and type of innovation is considered. In this respect, high-tech manufacturing remains an outlier in terms of innovative performance. This pattern may be due, in part, to the fact that the survey instrument was designed to understand innovation in these types of industries.

Factors hampering innovation

In order to understand whether attitudes towards innovation in construction differ from other sectors, we investigate the different obstacles that may be hampering innovative activity. Table 3 shows the percentages of firms in each sector that indicated that a specific hampering factor had importance to their firm. It is evident from Table 3 that small construction firms seem to find more factors hampering innovation than large firms. For small construction firms, the main barriers to innovation appear to be the cost of finance, the lack of qualified personnel and the impact of regulations or standards. For large construction firms, the main hampering factors for innovation are the lack of customer responsiveness, costs of finance and the lack of qualified personnel. The differences between the various factors that hamper innovation are modest between small and large firms in construction. Both groups cited the lack of personnel and the cost of finance as an important source for hampering innovation.

When considering the difference between construction and other sectoral groups, it is evident that fewer

Table 2 Innovative performance in construction in comparison to other sectors

Variable	Kendall's Tau-b	Asymp. Std. Err.	Left C.L.	Right C.L.
Size<50				
Product Innovation				
Low-Tech Manufacturing	**−0.0986**	0.0196	−0.1371	−0.0600
High-Tech Manufacturing	**−0.2729**	0.0287	−0.3292	−0.2200
Traditional Services	**−0.0792**	0.0192	−0.1168	−0.0416
KIS	**−0.1719**	0.0260	−0.2228	−0.1210
Process Innovation				
Low-Tech Manufacturing	**−0.1242**	0.0190	−0.1614	−0.0870
High-Tech Manufacturing	**−0.1402**	0.0297	−0.1984	−0.0819
Traditional Services	**−0.0404**	0.0200	−0.0795	−0.0012
KIS	**−0.1494**	0.0181	−0.1348	−0.0638
Size=>50				
Product Innovation				
Low-Tech Manufacturing	**−0.1817**	0.0235	−0.2277	−0.1356
High-Tech Manufacturing	**−0.3387**	0.0294	−0.3963	−0.2811
Traditional Services	**−0.0724**	0.0274	−0.1261	−0.0187
KIS	**−0.2608**	0.0399	−0.3390	−0.1825
Process Innovation				
Low-Tech Manufacturing	**−0.1398**	0.0246	−0.1881	−0.0916
High-Tech Manufacturing	**−0.2140**	0.0313	−0.2753	−0.1526
Traditional Services	−0.0260	0.0288	−0.0823	0.0304
KIS	**−0.1174**	0.0415	−0.1988	−0.0360

Source: Own calculations based on UK innovation survey.
Note: Bold Kendall's Tau-b values are significantly different from 0 at a 5% level.

construction firms are hindered by the factors listed in the survey than firms in other sectors. Percentages of manufacturing firms who indicated that they were hampered by different factors are higher across all size classes and for every hampering factor. However, the service sectors are somewhat similar to construction. In particular, traditional services have similar percentages of firms, indicating that they were hindered by factors listed in the survey. There are, however, some differences in the importance of different hampering factors between construction and service industries, but these differences are modest. One possible explanation for these differences could be explained by the fact that few construction firms reported achieving an innovation, there are as a result fewer firms reporting hampering factors.

Sources of information and knowledge for innovation

The UK Innovation Survey asks firms about the importance of different sources of information and knowledge for innovation. In total, 18 different sources are presented in the survey and firms are asked to indicate the importance of each source on a 0–1–2–3 scale. Table 4 shows the percentages of firms reporting the importance of different sources of knowledge for innovation. Overall, we find construction firms rely heavily on 'market-based' and 'specialized' sources of knowledge rather than 'internal', 'institutional' or 'other sources'. In particular, health and safety standards and regulations appear to be important sources of knowledge for innovation, as well as suppliers and customers.

When comparing sources of innovation in construction to other sectors, the pattern is mixed. It appears that a higher percentage of construction firms than traditional service firms use a number of external sources. In some areas, construction firms seem to be close to KIS and low-tech manufacturing in their patterns of using sources of knowledge for innovation. However, high-tech manufacturing firms appear to attach greater importance to all different sources.

Are the differences in the use of sources between construction and industrial sectors significant? In order to investigate this question further, Table 5 presents the results of a statistical comparison between construction and other sectors. The analysis explores the differences between construction and other sectors for different baskets of sources, including internal, market, institutional and specialized sources. Overall, no single pattern emerges. High-tech manufacturing firms always use more sources than construction firms. However, for services and low technology manufacturing the results are mixed.

Table 3 Percentage of firms indicating they are inhibited by hampering factors

Hampering Factor	Low-Tech Manufacturing	High-Tech Manufacturing	Traditional Services	KIS	Broad Construction
Size<50					
Economic factors					
Excessive perceived economic risk	63.8	64.3	51.7	51.1	49.6
Direct innovation costs too high	66.5	68.8	53.1	57.5	50.1
Cost of finance	66.0	65.2	53.9	55.5	55.9
Availability of finance	61.0	60.0	49.4	51.1	51.8
Internal Factors					
Organisational rigidities with the enterprise	43.7	44.4	40.1	44.2	38.8
Lack of qualified personnel	56.2	60.9	51.0	56.0	52.8
Lack of information technology	52.3	55.2	48.7	50.7	46.0
Lack of information on markets	53.0	60.7	45.9	51.5	44.4
Other factors					
Impact of regulations or standards	58.9	63.8	53.2	51.3	52.8
Lack of customer responsiveness to new goods or services	58.7	63.8	52.9	54.6	48.5
Number of observations	1242	417	1315	548	673
Size=>50					
Economic factors					
Excessive perceived economic risk	68.1	73.6	59.9	60.3	57.0
Direct innovation costs too high	73.9	79.9	64.9	63.4	56.3
Cost of finance	69.8	70.5	60.1	57.8	58.4
Availability of finance	64.9	67.3	53.9	55.2	53.1
Internal Factors					
Organisational rigidities with the enterprise	59.9	67.1	59.2	58.6	49.8
Lack of qualified personnel	68.3	72.4	62.6	64.2	58.8
Lack of information technology	63.7	69.5	59.2	55.2	53.1
Lack of information on markets	65.1	68.3	56.0	58.2	55.2
Other factors					
Impact of regulations or standards	61.0	71.1	60.3	55.2	54.1
Lack of customer responsiveness to new goods or services	70.1	76.4	62.2	63.8	60.6
Number of observations	917	492	740	232	279

Source: Own calculations based on UK innovation survey.

For internal sources, a significantly lower percentage of construction firms use internal sources than other sectors across both size groups. This result may be a product of the division of labour in the industry between different organizations and reflects a lack of internal R&D departments in construction organizations.

In terms of external sources, construction firms appear to be heavy users of institutional and specialized sources. In particular, construction firms use more institutional and specialized sources than traditional services. Knowledge-intensive service firms appear to have a similar pattern of use of institutional and specialized sources. For small low-technology manufacturing firms, there is no significant difference in the use of institutional and specialized sources. Construction firms generally use fewer market sources of innovation than other sectors. Only large traditional service firms use these sources to the same extent as large construction firms.

In summary, the results suggest that construction firms are heavily reliant on specialized and institutional sources of innovative ideas. The findings are consistent with the results of papers published in the BRI *Special Issue*, emphasizing the importance of universities and regulations in the construction innovation process (BRI, 1997). However, the low importance attached to internal and market sources by construction firms indicates that these firms search less and differently for innovative ideas than many other industrial sectors. This suggests that some construction firms may be too insular and may fail to take full advantage of sources of innovation outside the firm. They may lack the 'second face' of R&D: the ability to absorb knowledge from the external environment (Cohen and Levinthal, 1990; Gann, 2001).

Table 4 Percentage of firms that indicate that they use sources of knowledge for innovation

Sources for innovation	Low-Tech Manufacturing	High-Tech Manufacturing	Traditional Services	KIS	Broad Construction
All Sizes					
Internal					
Within enterprise	63.3	78.0	51.3	60.9	41.9
Other enterprises within the enterprise group	35.8	49.8	30.9	31.4	22.8
Market					
Suppliers of equipment, materials, components or software	64.9	75.2	52.4	58.4	48.4
Clients of customers	62.2	74.9	48.6	53.2	45.9
Competitors	50.0	62.5	42.2	45.3	34.3
Consultants	34.5	46.2	33.6	45.0	35.8
Commercial laboratories/R&D enterprises	22.4	37.1	11.5	15.2	13.4
Institutional					
Universities or other higher education institutes	22.4	38.2	10.7	22.4	16.6
Government research organisations	15.5	23.6	9.7	15.9	14.5
Other public sector eg. Business links, Government Offices	21.9	29.1	16.2	22.0	20.7
Private research institutes	16.5	22.2	9.8	14.7	12.4
Other					
Professional conferences, meetings	37.5	51.6	34.4	56.9	33.6
Trade associations	45.9	53.1	41.4	39.4	40.2
Technical/trade press, computer databases	48.5	64.2	42.3	49.0	41.5
Fairs, exhibitions	53.5	68.0	37.6	42.4	31.1
Specialised					
Technical standards	51.6	69.9	35.7	42.4	45.0
Health and safety standards and regulations	59.8	71.2	42.8	34.7	52.1
Environmental standards and regulations	56.6	69.5	39.4	31.4	48.3
Number of observations	1919	838	1788	729	791

Source: Own calculations based on UK innovation survey.

Inability to innovate

Because many firms in construction are unable to innovate, it is appropriate to investigate the reasons they give for failing to do so. The UK innovation survey includes a question about the possible reasons that firms fail to be able to innovate. The survey lists three reasons: (1) no need due to prior innovations, (2) no need due to market conditions and (3) factors impeding innovation. Column 1 in Table 6 reports the percentages of responses for low-tech manufacturing, high-tech manufacturing, traditional services and KIS for each of the three reasons for not innovating. Overall, it appears that construction firms find market conditions are the main reason for not innovating. In fact, 7.8% of the small construction firms and 76.2% of the large construction firms indicated that market conditions did not require them to innovate. These figures were considerably higher than for other sectors.

In order to explore whether these differences are significant, we compared construction to the other sectors. This is represented by the Kendall's tau-b statistics in the remaining part of Table 6. The data show that there are no significant differences between the sectors when considering the question of prior innovations. Only in the case of small KIS firms do we find relatively more firms seem to indicate that they need not innovate due to prior innovations. All significant estimates with reference to impeding factors are negative, suggesting that lack of innovation in the past in construction undermines efforts to achieve innovation in the present. Only in cases where we compare construction with service industries is the difference not significant. It is interesting to note that all Kendall's tau-b estimates are positive when considering the market condition reason for not innovating. The positive Kendall's tau-b indicates that emphasis needs to be placed on the role of market conditions in the search for explanations for the distinctiveness of construction. The results suggest that construction firms are under less pressure to innovate in their markets.

There are several possible explanations for this finding. First, it might be a result of managerial strategies that focus on incremental improvements in processes among the population of UK construction firms. Secondly, it might reflect a lack of

Table 5 Use of sources of knowledge for innovation, construction compared to other sectors

Variable	Kendall's Tau-b	Asymp. Std. Err.	Left C.L.	Right C.L.	Number of Obs.
Size<50					
Low-Tech Manufacturing					
Internal Sources	**−0.1257**	0.0245	−0.1737	−0.0776	1612
Market Sources	**−0.1284**	0.0250	−0.1775	−0.0794	1612
Institutional Sources	0.0140	0.0250	−0.0351	0.0631	1612
Other Sources	**−0.0783**	0.0248	−0.1314	−0.0341	1612
Specialised Sources	−0.0212	0.0249	−0.0663	0.0261	1612
High-Tech Manufacturing					
Internal Sources	**−0.3245**	0.0309	−0.3850	−0.2639	917
Market Sources	**−0.2441**	0.0310	−0.3049	−0.1834	917
Institutional	**−0.0915**	0.0333	−0.1568	−0.0261	917
Other	**−0.2306**	0.0317	−0.2927	−0.1684	917
Specialised	**−0.1709**	0.0321	−0.2338	−0.1081	917
Traditional Services					
Internal Sources	**−0.0803**	0.0242	−0.1278	−0.0329	1665
Market Sources	**−0.0572**	0.0246	−0.1054	−0.0091	1665
Institutional	**0.0807**	0.0253	0.0312	0.1303	1665
Other	**−0.0598**	0.0244	−0.1077	−0.0120	1665
Specialised	**0.0668**	0.0245	0.0187	0.1148	1665
KIS					
Internal Sources	**−0.1860**	0.0303	−0.2454	−0.1267	1054
Market Sources	**−0.1240**	0.0305	−0.1838	−0.0642	1054
Institutional	−0.0447	0.0308	−0.1050	0.0157	1054
Other	**−0.1559**	0.0304	−0.2155	−0.0963	1054
Specialised	**0.0760**	0.0307	0.0158	0.1362	1054
Size=>50					
Low-Tech Manufacturing					
Internal Sources	**−0.2653**	0.0328	−0.3295	−0.2010	1098
Market Sources	**−0.2140**	0.0335	−0.2797	−0.1482	1098
Institutional	**−0.0878**	0.0294	−0.1455	−0.0301	1098
Other	**−0.1615**	0.0323	−0.2247	−0.0982	1098
Specialised	**−0.1283**	0.0319	−0.1908	−0.0659	1098
High-Tech Manufacturing					
Internal Sources	**−0.3660**	0.0357	−0.4045	−0.2646	712
Market Sources	**−0.2819**	0.0384	−0.3572	−0.2067	712
Institutional	**−0.2316**	0.0363	−0.3028	−0.1604	712
Other	**−0.2348**	0.0384	−0.3101	−0.1595	712
Specialised	**−0.2448**	0.0385	−0.3202	−0.1694	712
Traditional Services					
Internal Sources	**−0.0845**	0.0334	−0.1500	−0.0190	914
Market Sources	−0.0397	0.0335	−0.1053	0.0259	914
Institutional	**0.0794**	0.0340	0.0126	0.1461	914
Other	−0.0011	0.0331	−0.0660	0.0637	914
Specialised	**0.0735**	0.0327	0.0094	0.1375	914
KIS					
Internal Sources	**−0.2171**	0.0447	−0.3048	−0.1295	466
Market Sources	**−0.1595**	0.0451	−0.2479	−0.0711	466
Institutional	−0.0594	0.0463	−0.1501	0.0313	466
Other	**−0.0987**	0.0459	−0.1887	−0.0088	466
Specialised	0.0350	0.0463	−0.0558	0.1258	466

Source: Own calculations based on UK innovation survey.
Note: Bold Kendall's Tau-b values are significantly different from 0 at a 5% level.

Table 6 Reasons for not innovating, construction compared with other sectors

Variable	Kendall's Tau-b	Asymp. Std. Err.	Left C.L.	Right C.L.	Number of Obs.
Size<50					
Low-Tech Manufacturing					
No need due to prior innovations	−0.0022	0.0273	−0.0557	0.0512	1342
No need due to market conditions	**0.1040**	0.0264	0.0523	0.1556	1342
Factors impeding innovation	**−0.1227**	0.0249	−0.1715	−0.0739	1342
High-Tech Manufacturing					
No need due to prior innovations	−0.0490	0.0382	−0.1238	0.0258	709
No need due to market conditions	**0.1525**	0.0389	0.0764	0.2287	709
Factors impeding innovation	**−0.1771**	0.0403	−0.2562	−0.0980	709
Traditional Services					
No need due to prior innovations	−0.0057	0.0266	−0.0579	0.0464	1407
No need due to market conditions	0.0374	0.0263	−0.0141	0.0890	1407
Factors impeding innovation	−0.0219	0.0262	−0.0733	0.0294	1407
KIS					
No need due to prior innovations	**−0.1502**	0.0357	−0.2202	−0.0801	797
No need due to market conditions	**0.1175**	0.0359	0.0471	0.1879	797
Factors impeding innovation	−0.0259	0.0359	−0.0962	0.0444	797
Size=>50					
Low-Tech Manufacturing					
No need due to prior innovations	0.0004	0.0412	−0.0804	0.0812	589
No need due to market conditions	0.0750	0.0399	−0.0032	0.1531	589
Factors impeding innovation	**−0.0955**	0.0271	−0.2032	−0.0607	589
High-Tech Manufacturing					
No need due to prior innovations	−0.0524	0.0539	−0.1580	0.0532	346
No need due to market conditions	0.1050	0.0539	−0.0006	0.2106	346
Factors impeding innovation	**−0.1384**	0.0535	−0.2432	−0.0336	346
Traditional Services					
No need due to prior innovations	0.0611	0.0407	−0.0187	0.1409	629
No need due to market conditions	0.0478	0.0389	−0.0285	0.1241	629
Factors impeding innovation	**−0.0758**	0.0367	−0.1478	−0.0038	629
KIS					
No need due to prior innovations	−0.0930	0.0604	−0.2114	0.0253	283
No need due to market conditions	**0.1981**	0.0611	0.0783	0.3179	283
Factors impeding innovation	−0.0953	0.0629	−0.2185	0.0279	283

Source: Own calculations based on UK innovation survey.
Note: Bold Kendall's Tau-b values are significantly different from 0 at a 5% level.

innovation-orientated competitive pressure in the different parts of the industry. Thirdly, it could be a result of low demand for new innovations by clients within the industry. A fourth possible reason is related to the nature of the market. As highlighted by Nam and Tatum, most construction markets are highly localized. Using a question from the innovation survey, it is possible to investigate the main geographical location of markets for different sectors. The survey asks firms to indicate whether their main markets are local, regional, national or international. Table 7 reports the results of this analysis and it shows that most smaller construction firms (45.3%) have a local market orientation. Only 2.5% of the smaller construction firms indicate that the international market was the most important to them. Large construction firms appear to be more national in market orientation, yet only 2.2% indicated an international market orientation. These figures separate construction from all other sector – each of which is more 'national' and 'international' in market orientation. The data suggests construction firms are firmly rooted in their local geographic markets. In this respect, construction differs from all other sectors, including traditional services.

Conclusions

The aim of this research was to compare attitudes and innovation behaviour in construction with other sectors. We began by highlighting some of the particular organizational liabilities that firms in the construction

Table 7 Market orientation of construction and other sectors

	Low-Tech Manufacturing	High-Tech Manufacturing	Traditional Services	KIS	Broad Construction
Size<50					
Local	26.8	13.4	36.8	45.7	45.3
Regional	21.0	13.6	17.7	14.8	30.5
National	44.4	52.9	38.5	27.6	21.6
International	7.8	20.1	7.0	11.9	2.6
Total	100.0	100.0	100.0	100.0	100.0
Size=>50					
Local	7.9	2.9	15.1	13.8	19.9
Regional	9.9	3.9	16.4	15.8	35.1
National	67.0	51.4	59.5	52.6	42.7
International	15.3	41.8	9.0	17.8	2.2
Total	100.1	100.0	100.0	100.0	99.9

Source: Own calculations based on UK innovation survey.

sector face when attempting to innovate. The statistical analysis shows that construction firms are distinct in their innovative behaviour and attitudes. In some respects, they are 'last among equals', exhibiting a low number of firms engaged in product and/or process innovation. Of the sectoral groups examined, service sectors were more closely aligned to construction in terms of their patterns of innovative behaviour than manufacturing. However, both traditional and knowledge-intensive services had significantly higher percentages of innovators compared to construction. When one looks at the population of smaller firms, it is possible to find considerable similarity between construction and some service sectors, especially traditional service industries. In this respect, low levels of innovation among smaller construction firms may reflect a *liability of smallness* rather than a fundamental characteristic of innovation in construction.

We also found that construction firms are less open to their external environment than manufacturing firms. The results suggest that construction firms (and some service sector firms) may have a poorly developed 'second face' of R&D, lacking the capacity to absorb ideas from outside the firm (Cohen and Levinthal, 1990; Gann, 2001). The results of the analysis also indicate that low levels of innovative behaviour in construction can lead some firms in the sector to attach less importance to the factors that hamper innovation. One of the reasons for this may be that construction firms have become inherently risk averse. This is partly because of experience in dealing with the factors identified by Nam and Tatum (1988). In particular the role of clients and the need to manage in an environment where there is a high degree of social responsibility may be highlighted. While each of the conditions that characterize construction can be identified separately in other sectors, when combined they provide a contextual environment for innovation that differs from other sectors. It is noticeable that the impact of factors hampering the firm was greater for traditional services than for construction, even though the differences in rates of innovation between the two sectors are modest.

We found that the nature of the market strongly influences the potential for innovation among construction firms. In this area, construction firms are truly distinctive and separate from the rest of the economic system. The result suggests that local market orientation of construction processes may be a key element in the separation of construction from other sectors. In terms of innovation, local markets can often mean undemanding customers. The finding indicates that *liabilities of immobility* and *unexpected demand* play a strong role in shaping innovative behaviour in the sector. Many construction firms do not need to innovate in order to remain successful or viable. They are able to sustain themselves by meeting local needs, responding to regulations and drawing new technologies from their suppliers and customers, in part fitting into the category of 'supplier-dominated' firms in Pavitt's taxonomy (Pavitt, 1984).

The use of UK innovation survey data opens several new avenues for research. It suggests that comparing and drawing lessons from manufacturing industries about innovation in construction is not the only option available. Service industries provide a body of knowledge about innovation that may be extremely useful for improving innovative performance in construction. Exploring the characteristics of service industries and their overlap with construction could provide a new window for research in construction management. At the level of the firm, further statistical analysis of the data will be required to draw inferences about the relationship between market orientation, sources of knowledge and innovation among construction firms. This work could build on the model presented in Seaden *et al.* (2003) and would seek to develop a robust conceptual framework for understanding the sources and determinants of innovative performance in construction. More work is also required on the 'sectoral system of innovation' in construction to explore how different mechanisms and institutions interact with one another and help to shape the innovative activities of UK construction firms (Malerba, 2002).

The use of a cross-industry survey to understand the specific features of innovation in an industry can create difficulties. As previously mentioned, the CIS was originally designed to collect information on manufacturing industries. It remains an imperfect tool for understanding innovation in construction. However, it does offer an opportunity to place the attitudes and behaviour of construction firms alongside other industrial sectors. Comparative statistical analysis also leaves many questions unanswered. New studies are required that explore the process of innovation in construction, to deepen and expand our knowledge of the economic, social and managerial decisions that shape potential for innovation among construction firms. We still know relatively little about the primacy of the different liabilities to innovative behaviour within construction firms. Greater research on these factors and how they might be mitigated by government and firm action would be greatly beneficial.

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