Construction Sector Innovation in Wales

Scoping the state of the art for construction innovation in Wales and determining future drivers for innovation within the construction industry

February 2019

Acknowledgements:
This paper is based on a report that was produced for Construction Futures Wales in 2015.

It was written by Dr Selyf Morgan of CLEC, Cardiff Metropolitan University, working in collaboration with:

- Prof Brian Morgan; Project Director and Director of the Creative Leadership and Enterprise Centre (CLEC), Cardiff Metropolitan University
- Rod Keeble; Project Manager at CLEC
- Jelena Kiselova (BRE)

Construction Sector Innovation in Wales

Contents

Section 1: Introduction

This report explores innovation activity within the construction sector in Wales. The research is informed by the perspectives of firms located and/or are operational within Wales. It has been conducted to offer a way of identifying firms that are innovators; the characteristics that make them active innovators; and to examine the main drivers of innovation in the sector in Wales. The research also contributes to developing an innovation company register, which would be designed to illustrate the kind of characteristic that belong to, or has been developed by, innovating companies, and which may be used by other firms to develop their own capabilities as innovators.

As has been reported in other research (see Section 2) innovation in the construction sector is often difficult to identify and quantify. Mainstream theories of innovation need to be adapted to the specific circumstances of the construction sector, in which work is often project-based and involves a range of partners. Identifying what is an innovation, where it has originated, and how it is being diffused can be challenging within this multi-actor system, whilst drivers and barriers can be varied and different for each firm. Innovation also takes a number of different forms that encompass a range of innovation categories: from product; process; and organisational; to marketing innovation. Firms within the sector may be innovators in one or many of these different areas.

Research interest in this area has been widespread over the last ten to fifteen years, promoted by academic programmes, but also because of a realisation among policymakers, as well as within construction firms, that the industry needs to develop better products and better ways of working in order to control and reduce the costs of construction. It is also encouraged by efforts to address the many environmental issues that confront the industry and society more generally. In addition, firms in the sector in Wales experience an ever more competitive market environment with cost pressures and changes in technology that make a 'do nothing' or 'business as usual' approach untenable. There are, therefore, a number of real and substantial drivers that affect the sector, but which may act on different firms to different degrees.

This paper has benefited from a review of research projects elsewhere and uses the insights provided by that research to establish the basis of this study. The research reported here provides an initial study of innovation activity and the conditions for innovation in construction in Wales. It also works toward describing how firms, who can be identified as innovators, are able to develop their activity, and what it is that these firms do to be active innovators. This research, therefore, should provide the basis for a set of characteristics of good practice, which may be continuously updated with details of e.g. innovative products, materials, and services. A register or database could then be developed from such information, which may be consulted and developed as understanding and knowledge of innovation in the Welsh construction industry improves.

The report is divided into three further sections. Section 2 reviews innovation research developed in the construction sector over the last ten to twenty years. It is followed, in Section 3, by a description and analysis of fieldwork that was conducted with firms in the sector; and completed by a section that summarises the findings and makes some conclusions based on the fieldwork in the context of knowledge from the wider literature. The final section discusses the basis and structure of a database and/or register of construction firms who are engaged in innovation activity.

Section 2: Literature Review

2.1 Introduction

It is a common comment in many research papers that the construction sector tends to be conservative, and that firms within it are more reluctant to originate and develop innovations than counterparts in other sectors.[1] This point of view has been challenged by work arguing that the particular circumstances, conditions, and structures that prevail in the sector require a somewhat different approach to, and perception of innovation.

The research work reported in this paper takes the need to understand these specific features as its starting point. The following, therefore, presents a broad review of literature, highlighting some of the main factors affecting innovation that have been the subject of academic and sector-body research in the last few years. These factors, as identified in the literature, form the basis of investigation into the innovation performance of firms, and contribute towards building a coherent approach to fieldwork. They inform our firm-based perspective and define the subject areas to be explored in our questionnaires and interview schedules (Section 3). The analysis of questionnaire and interview responses in Section 3 has also been carried out with reference to the material covered in this literature review.

2.2 Innovation in the Welsh Construction Industry: Scope of the Review

Innovations do not respect territorial (or sectoral) boundaries, and may be originated locally, imported, adapted, or copied from elsewhere.[2] However, some firms may work exclusively or predominantly within Wales, and specific characteristics may be identified within the local sector and local market that affect the level and kind of innovation activity that takes place. A focus on innovation in the Welsh construction sector will reflect this, but has also to include the links and channels that connect Welsh firms to the industry more broadly.

Whilst the research study focuses on the Welsh construction sector, this literature review draws from global sources to examine:

- the drivers and barriers to innovation
- the capabilities and current innovation performance of firms
- interaction between firms
- and the interaction between firms and other sources of knowledge

An understanding of interactions in terms of, for example, knowledge networks, will inform innovation support policy and assist action that would improve advice and training for firms to become more active and capable innovators.[3]

2.3 Definition

Innovation can be defined in a number of ways that may include a broad set of factors. A simple definition that states that innovation is "…t*he successful exploitation of new ideas*". The Chartered Institute of Building (CIOB) expand slightly on this to state that

[1] The list of references to the literature contained here are presented in Appendix 1

[2] Innovations are considered valid whether they are new to the world, new to the sector, or new to the firm.

[3] In-service management courses have been run by a number of HE institutions in Wales, and most contain a stream of work relating to innovation management. One example is Cardiff Metropolitan University's (CMU) 20Twenty Leadership Programme for which participants produce reports detailing how innovation processes were conducted in their own firms. CMU has carried out its own research to explore and evaluate the different approaches adopted by firms as evidenced by participant assignments and project reports. Participants represented organisations from all sectors, including a number from the construction sector.

''*Innovation will be defined as the successful introduction of new technologies or procedures into industry*'' (Dale, 2007)

Innovations may be developed and/or introduced in a number of different spheres of activity including new materials; production processes; construction techniques; information management; and environmental impact. All forms of innovation that contribute to the improved performance of the firm within the sector, and to the sector's performance in relation to economic, social, and environmental objectives are considered relevant in this review.

2.4 Drivers of Innovation

A survey by the CIOB (Dale, 2007) found that while improving cost efficiency was the leading desired outcome and driver for innovation, a number of other factor also contribute to firms' motivation to innovate. These drivers included:

- pressure to improve the environmental performance and sustainability of products and processes
- demands made by clients
- pressure of schedules and timelines
- new developments in technology
- global competition
- and the requirements of end users

The environmental sustainability driver was prominent and relevant to a number of different areas of technology, including with regard to innovations to produce and use carbon neutral construction materials; renewable energy systems; energy efficient heating systems; and better waste management products.

A more recent survey, run by the Construction Industry Council, found that many of the same issues continue to be important in influencing thinking about innovation (CIC, 2014). The main findings indicate that respondents believed that there is further scope for innovation particularly with regard to, and following from:

- materials, ICT, and prefabrication (off-site) developments
- the introduction and diffusion of BIM techniques and technology
- the sustainability agenda

Survey participants perceived that more needs to be done with regards to water management, biodiversity, and waste management. In addition, dealing with the effects of climate change, in terms of infrastructure resilience and flood mitigation, was considered to be an important challenge that required more innovative approaches and products.

2.5 The Character of the Construction Industry

The character of the construction industry and the project-based nature of much construction activity are important in considering both technological and organisational innovation in the industry (Winch, 2003). The project structure of construction creates discontinuity between the different elements of a construction product, and discontinuity in the transfer of knowledge between firms, and in knowledge transfers between projects (Miozzo and Dewick, 2004).

The particular character of the construction industry is reflected in the type of contracts and the method of procurement traditionally employed. A tendency to emphasize price competition has been noticeable and, in contrast to the situation in many industries, this emphasis has been widely identified as being a hindrance to innovation (Blayse and Manley, 2004). Firms are often reluctant to invest in the effort required to innovate, preferring to concentrate on reducing the costs associated with products and processes that are already well understood by them and by their clients. This

suggests that competition may not be a strong driver for innovation in this sector. However, the opposite view, which is considered important to innovation in other sectors and on which much innovation theory has been developed, is also quoted as relevant viz. that strong competition drives firms to innovate in order to improve their competitive position (Dubois and Gadde, 2002).

Dubois and Gadde (2002) also pose a third perspective or model of a stable and integrated supply chain, when long-term relationships may be built up, and in which different firms may work closely together to enable innovation. This model moderates the pressure of competition especially between firms in tendering and procurement processes, and again argues against the role of competition as a driver of innovation. A conclusion to this debate about the general effect of competition, and whether it should be regarded as a driver or a barrier, is probably not possible given that each effect is observed in different circumstances. Research into innovation processes in firms has thus to be conducted with each possibility in mind, and designed to anticipate competition acting as a driver or as a barrier.

2.6 Complexity

Construction projects often involve establishing new on-site focussed production facilities, which are by their nature temporary. Resources utilised to set up such sites are employed on a temporary basis, and any relationships between those organisations and individuals involved are also temporary and may have to be constructed anew for each project (Dubois and Gadde, 2002).

Given that construction projects require that a number of different elements be brought together to form the final product, any innovation proposed or developed is often not done by a single firm acting alone. Different firms and other actors must often negotiate the introduction of an innovation (e.g. centring on why a change is required and how it might be done), and any changes demanded need a number of organisation to work together to develop and implement it. [4] Implementing a new solution arrived at during one project must also be applied to successive projects for the new approach to become a successful innovation (Winch, 1998), and this may be inhibited by the change in the actors involved, and in potentially differing working relationships.

A construction project also often poses new challenges or variants of challenges and issues, which must be resolved within the timeframe of the project. This can create the opportunity for firms to learn about new solutions, imposing the need for innovation, and these may also be implemented in other project settings, whether these are technological or organisational problems and solutions. However, it has often been noted that firms have difficulty in securing new knowledge gained in a particular project within their internal 'knowledge bank', and in carrying the learning process over the boundary of the project, and over time. In order that an innovation may contribute to longer-term change, learning from a particular project must also be effective in more than one firm (Miozzo and Dewick, 2004).

Solutions to problems, or new and more efficient products or processes must be learned, codified and applied in a structured way so that new knowledge and understanding that has been gained, often at a tacit level, is transferred successfully both within any one firm and between different project participants. Miozzo and Dewick (2004) note that a lack of co-operation between organisations make this process of learning and securing long term impacts more difficult. Commitments to other members of the supply chain may often be temporary as noted above, and

[4] While the need for this type of interaction to develop innovations is particularly apparent in construction, the same kind of interaction is also found in other industries and may even be considered a requisite condition, given that successful innovations must be accepted and implemented by more than one actor in the supply and consumption chain (Ingemansson and Waluszewski, 2009).

the lack of continuous and consistent interaction hinders the development of innovations (e.g. Miozzo and Dewick, 2004).

These difficulties in building long-term relationships leads to what can be described as a 'loosely coupled network' (Doree and Holmen, 2004; Dubois and Gadde, 2002). As the discussion above identifies, the looseness of such a network hinders learning between project partners, while such relationships, since they are relatively shallow, do not encourage the build-up of trust and may more easily develop into adversarial, contractually based, and demand led interactions (Dainty, 2001). Such interactions are in contrast to mutually beneficial, interactive, and knowledge sharing relationships.

The focus of the preceding research is on the effects of external relationships, networks, and channels for knowledge acquisition and learning. The approaches adopted by researchers in innovation management has also become more aware of the importance of external factors in shaping the innovation potential of a firm (Saad et al., 2002). In summary, successful innovation within the complex environment of a construction project, often requires effective cooperation, coordination and working relationships between different parties (Gann and Salter, 2000; Ling, 2003). Construction components and subsystems in the built environment are interdependent and are becoming more so as technological developments in IT control systems are applied in building projects (e.g. BIM). Such interdependence demands that knowledge sharing and interaction occurs between organisations and individuals occupying different roles.

Construction projects employ diverse human resource and skills, which is distributed among contractors, subcontractors, suppliers, manufacturers, consultants, designers and other construction professionals (Gann and Salter, 2000). As is the case for the roles and contributions of organisations discussed above it is important for innovation that these different elements are integrated as much as is possible, and developed to allow knowledge exchange and learning to take place between individuals.

2.7 Skills, Competence, and Training

UK government policy is to emphasise the role of skill development in all sectors in order to improve productivity and to enable greater innovation. Despite this policy objective, skill levels and the supply of skilled personnel within the construction sector have been subject to continuing concern over the last decade, both before and following the 2007/8 recession (Nadim and Goulding, 2009; Morgan, Raiden and Naylor, 2008).

The 2010 Skills Assessment by the Construction Industry Training Board (known as ConstructionSkills) noted the impact of the recession on employment levels, and on retained skill profiles within the sector in Wales (ConstructionSkills, 2010). This followed the normal pattern during and after a recession, where the most experienced workers leaving the industry tend not to return. However, in this instance the decline in skill levels was greater and faster than experienced in previous recessions. Similarly, a survey of the state of the construction sector and of skills within it by the UK Commission for Employment and Skills in 2012, noted that the skills shortage has been more pronounced during this decade than following other recessions (Gambin et al, 2012).

Advances in technology, including Modern Methods of Construction (MMC) and the drive toward a more environmentally sustainable sector, have also exposed a shortage of skills. The skills in short supply include those needed to use more sustainable materials and methods effectively; to manage construction sites; to reduce carbon footprints; and skills required for off-site construction. The shortage of skills is not simply in terms of numbers but also in the quality of the skills that are in demand, which is leading to a change in the skills profile of the industry. New technologies, new

processes, and different management methods require personnel with new skill sets, supported by an increase in higher levels of vocational and professional qualifications (Gambin et al, 2012). Given these developments, however, new working demands will not require totally different skill sets, but an expanded set is likely to be needed along with high quality leadership and management.

Many of these skill demands are being addressed by training providers in Wales within FE, HE and the private sector. These providers currently supply the kind of training and continuing professional development support that is forecast (ConstructionSkills, 2010). However, the recession across the UK construction sector has in the recent past continued to have an adverse effect on trainee numbers and on recruitment forecasts, while both apprenticeship numbers and HE enrolments, as reported in survey work conducted during 2013, has continued to decline (CITB, 2013).

Skill shortages directly affect the capacity of firms to innovate. Skill shortages create a barrier to innovation not only because of decreased capacity and capability within individual firms to develop new methods and materials, but also because there will be insufficient knowledge and skills available within the sector to ensure that changes can be sustained, widely diffused, and developed into fully fledged innovations.

2.8 Clients, End Users, and the Procurement Processes

Understanding user's needs (i.e. beyond the client's specifications) has been recognised as important in the construction industry (Ivory, 2004), and the way that this knowledge is conveyed via the client to developers, builders, suppliers, and component manufacturers is an important feature of the construction project. Users' needs and demands, which may require innovative approaches, have to be communicated effectively, and a combination of supply chain actors must work together to deliver the new product. This combination of actors and the relationships between them may be considered in organisational system terms, in which each element of the system receives a variety of inputs and generates a variety of outputs (Blayse and Manley, 2004; Gann; 2000).

Project partnering and other forms of longer term relationship structures (e.g. Early Contractor Involvement and Project Alliances) have been developed[5] that recognises the organisational systems created for a construction project. These structures are seen to be positive for innovation because they address the lack of continuity in relationships beyond the end of a particular project, and support mutual learning during the project (see above and e.g. Wynn et al, 2008; Eriksson, Dickinson and Khalfan, 2007). The early involvement of tier 2 and 3 subcontractors, for example, is one way to focus their attention on the collective interest of the project rather than to focus solely on their own specific contribution, which may itself have been defined and controlled by the higher tier contractor (Dulaimi et al., 2003).

Partnering promotes improved performance through collaborative business relationships based on best value rather than lowest cost, and reinforces the value of openness and trust between firms engaged in a construction project. Although normally client-led, project partnering can also be driven by contractors and suppliers who can demonstrate that such a relationship brings advantages to the client, and offers an improved procurement method.

Partnering contrasts with the confrontational attitudes that has often characterised the construction industry, and that was highlighted as detrimental to better performance in the 1998 report '*Rethinking Construction*: *Construction Task Force Report for Department of the Environment,*

[5] The value of long term relationships has been studied and promoted for well over a decade as evidenced by the following references: Bygballe et al, 2010; Gadde and Dubois, 2010; Ingirige and Sexton, 2006; Roe and Jenkins, 2003; Barlow, 2000

Transport and the Regions' (Egan, 1998). These findings have been repeated in the McClelland Report on *'Maximizing the Impact of Welsh Procurement Policy'* to the Welsh Government in 2012 (McClelland, 2012). These reports highlight the adversarial and low price methodologies prevalent in the past, which appear to continue to be barriers for improved performance in the present day context of continuing pressure on budgets and of increasing competition.

2.9 Innovation Culture within the Firm

Project-partnering and a more collaborative approach may require firms to adopt change in their organisational cultures. An organisational culture may be understood as deriving from the pattern of basic assumptions that is adopted or developed within the organisation to integrate internal elements, and to cope with the external demands placed on the organisation (Schein; 1986). A value system, based on these assumptions, becomes integral to the way the firm operates and is shared among members of the organisation. Successful collaboration (and partnering) between firms in a construction project depends to some extent on how compatible the organisational cultures are within each participating firm.

Within the construction industry, culture has been described (Ankrah et al, 2009) in terms of:

- the way characteristics of the industry are understood within the firm
- the way that the firm operates within the industry and its own particular approach
- the way that the strategy, goals and values of the firm is related to the industry
- the level of competence and skill of the workforce

Firms that can find large areas of overlap in their organisational cultures allow them to form alliances more easily and to build up trust, which allows them to strengthen working relationships and knowledge sharing (Fletcher and Fang, 2006; Ngowi and Pienaar, 2005).

In addition, differences in organisational cultures may be turned into strengths, where firms may find synergies in the way that they operate and in the organisational cultures that give rise to their operating modes, allowing each firm to expand the areas within which they may be able to operate successfully (e.g. Chan et al, 2005). This may be particularly advantageous when firm are involved in trans-national projects where the range of cultural differences may be greater.

Nifa and Ahmed (2010), in a review of organisational culture in construction companies, propose a list of seven dimensions around which collaborating firms may find compatibilities and synergies and which may be identified in terms of the orientation that the firm adopts in each dimension to the client; the workforce; leadership and management; performance and outcomes; reward; innovation; and teamwork. Being aware of, and be able to modify these dimensions of organisational culture can allow the firm to improve their working relationships with other firms and enhance their ability to originate, adopt, share and develop innovations.

2.10 Product and Process Innovation

Underpinning the drivers of *product* innovation is a need, noted in the CIC survey (CIC, 2014), for innovation in *processes* in order that firms may respond more effectively to the drivers for innovation. Hence, innovation in the practices relating to collaboration, procurement, and contract negotiation and management was considered highly desirable. More generally, the influences on innovation in construction may be considered in terms of the role of clients and manufacturing firms; the structure of production; industry relationships; procurement systems; regulations and standards; and organizational resources (e.g. see Blayse and Manley, 2004).

These areas of interest centre on organisational and relational factors, and suggest that any perceived lack of innovation in the sector may be due more to such management issues than to the

capacity of the sector to produce building product and process innovations. They also echo the findings of the Egan Report in 1998 (Egan, 1998), and the McClelland Report (McClelland, 2012).

2.11 Interaction with Universities and Research Institutes

The conservative nature of the construction sector with regard to innovations has been observed and studied by researchers[6] over a number of years. Whilst the recession has adversely affected skill development and, hence, reduced the capacity of the sector to deal with and develop innovations in products and processes, a major contributing factor has also been the fragmentation of the sector. The relatively poor long-term co-ordination and integration between different firms reduce the role of any single innovative actor, particularly with regard to product and process innovation. In other sectors, manufacturers are prominent as innovators, frequently acting as lead innovators. The fragmented nature of the construction sector, however, limits the role of construction companies and inhibits the assumption of a similar role to that played by manufacturers as innovators.

Given the reduced impact of manufacturers within the construction sector, universities and other dedicated R&D institutions have been identified as being of central importance for innovation (see for example a review in Shapira and Rosenfeld, 2011). Good university-industry relationships, therefore, should be important to construction firms to enable them to develop innovations and to put those into practice (Gann, 2001). The extent to which relations between firms, universities, and (usually) government sponsored R&D establishments are active can influence the capacity of firms to engage with and develop as innovation firms. Local knowledge networks that focus on (or are run by) universities and R&D establishment, can provide individual firms with the kind of access and interaction with advanced research that may be lacking from other sources in the sector, and which may be difficult for firms to maintain on a one-to-one basis.

2.12 The Effect of Government Regulation and Industry Standards

A number of factors that affect innovation performance are external to the firm, which firms are less able to influence than internal factors. Government regulations and industry standards are examples of such external factors, and these strongly influence the degree and extent of innovation.

Prescriptive government regulation has long been recognised as a driver for change in the sector (e.g. Blayse and Manley, 2004; Gann and Salter, 2000; Gann et al, 1998). But the sector is constrained by what may be termed a 'regulatory context' that includes not only prescriptive guidance and demands but also performance based standards (which to some extent are replacing prescriptive regulation), contract law, and industry policed standards and/or professional obligations (Hardie and Newell, 2013). Regulations related to climate change and reduction in the carbon footprint, along with other environmental and sustainability requirements have already been noted as important drivers to encourage innovation.

The regulatory context may inhibit innovative effort if regulations are drawn up that fossilize existing approaches and technologies (Dubois and Gadde, 2002), but regulation can also encourage firms to develop innovative solutions that address client needs and satisfy the regulators. Regulations that allow space for innovative solutions have to be drawn up carefully, and done so by regulators who have in-depth knowledge of current technologies; advanced practices and potential technological trajectories; capabilities within the sector; and the competitive structure of the sector (Gann et al, 1998).

[6] Notwithstanding, as noted previously, the different character of innovation and work organisation in a project based sector.

The scope for a firm to influence or change regulations is largely limited to contributions to collective representation of industry views. The extent of a firm's involvement in industry networks may thus indicate how active it may be in attempting to shape and to develop strategies to respond to regulations and standards, which itself reflects on its capacity and motivation to find new ways of operating and to develop innovations.

2.13 Conclusions

The literature review has focussed on a number of factors that affect innovation within the construction sector and the motivation to innovate within firms. These factors will be used to construct a questionnaire, and be the basis of interview questions with individual firms in the Welsh construction sector. Drivers of, and barriers to, innovation have been discussed both from the individual firm's perspective and from an overarching sector perspective.

Drivers of innovation in firms, as identified in a number of studies, are often similar. Unsurprisingly, costs and profitability are some of the most important outcomes that affect decisions to develop innovations. But a number of other innovation drivers, which impact directly on the firm, include environmental performance and sustainability; client demands; advances in technology; increasing competition and the globalisation of markets; and the voice of end users (as distinct to the client).

The character of the industry affects drivers and barriers to innovation as seen from a sector perspective. The project-based nature of much construction activity is important in considering both technological and organisational innovation in the industry, and produces discontinuities that inhibit innovative developments. These discontinuities affect industry relationships, which are often adversarial and which are reflected in the level of trust between firms.

Studies have suggested that a more collaborative approach to contracts, procurement, and project development can be positive influences on innovative activity. Innovation requires that a number of actors in the supply chain co-operate to develop and diffuse new products or processes. The level of inter-firm collaboration that a firm engages with is, therefore, important to diagnose the degree to which such a firm may be capable of improving innovation performance.

Membership of, and activity within, formal and informal knowledge networks indicates the firm's innovation capacity. Knowledge about the regulatory context and the degree to which regulations and standards may be influenced, and/or the way that the firm may respond can be diffused and learnt from knowledge networks, and this knowledge can help a firm to improve its capacity to innovate. These knowledge networks may also include universities and dedicated R&D institutions, which have become central to new knowledge generation and innovation in the sector.

The capacity of firms to innovate is also affected by internal factors. These factors include the level and range of skills available within the firm; the quality and dynamism of the leadership and management functions of the firm; and the overall cultural inclination of the organisation that may enable of hinder innovation performance.

Summary

The main factors that have been identified from the literature review and which will form the basis of the fieldwork can be summarised as:

- Knowledge about and understanding of innovation
- Specific Drivers and Barriers
- Funding and risk analysis
- Collaborative relationships
- Procurement relationships (e.g. Project Partnering)
- Skill levels and training
- Involvement in knowledge networks (e.g. with Universities)
- Internal organisational culture and attitudes to innovation
- Government and other standards and regulation
- Government and other support for innovation

Section 3: Fieldwork Report and Analysis

3.1 Introduction

The fieldwork was divided into two parts. The first part consisted of a structured questionnaire that was administered to a set of representatives from constructions firms who attend the 20Twenty Leadership Programme at Cardiff Metropolitan University (CMU) during 2014/15. This questionnaire acted in part as a pilot study (part 1 of the fieldwork) to test out the relevance and applicability of a set of questions that may be discussed in more depth with respondents from other construction firms via semi-structured qualitative interviews (part 2 of the fieldwork). The questionnaire also establishes a baseline with which to compare knowledge and understanding of innovation processes among representatives of construction firms over time, which may be used in future longitudinal studies. Part 2 of the fieldwork consisted of a set of semi-structured interviews, which were conducted with a sample of twelve construction firms currently active in Wales. The fieldwork is described and analysed in the following sections.

3.2 Limitations of the Research

The fieldwork reported here is an exploratory study of innovation processes in construction firms, and as such is limited in depth and extent. The pilot structured questionnaire was administered to a group of nineteen participants attending the CMU 20Twenty Leadership Programme, and whilst it is available to use as part of a longitudinal study, for the purposes of this paper the sample is too small to be statistically significant. Respondents were also not chosen on the basis of their role in their firms and, therefore, may not be placed in comparable positions or have comparable knowledge about their own firms. The semi-structured interviews conducted as Part 2 of the fieldwork were carried out with a sample of twelve firms. The research is limited by interview time constraints and the range of firms that were able to participate, and so some areas of interest could not be as fully explored as may be desirable.

3.3 Structured Questionnaire Analysis

A sample of nineteen representatives from construction firms were surveyed using a structured questionnaire. The questionnaire was administered during a period when respondent were attending course modules as part of the 20Twenty Leadership Programme at CMU, and research staff were on hand to discuss and explain the meaning of any of the survey questions.

Questions were based on the themes that were identified in the Literature Review (see Section 2) together with questions arranged in four sections comprising of questions about:

- characteristics of the firm
- the respondents' knowledge and informed opinions about innovation in general
- approach and attitudes to innovation within the respondent's own firm
- and comments about the support expected from government

3.3.1 Sample Description

The sample comprised of nineteen respondents who were asked to identify the particular sector segment that their firm belonged to from a range that included: Manufacturing; Construction; Engineering; Surveying; Architecture; Facilities Management; Education; Consultancy; and an open ended 'other' category. The overwhelming majority were from firms that described themselves as construction companies (Table 1), and did not specify their particular segment any further. One respondent was from a consultancy and one described their firm as an engineering company.

Firm sizes in terms of employee numbers ranged from less than 25 to more than 250 and the breakdown is provided in Table 2. Of the construction companies the majority (10) were large SMEs employing more than 50 staff (with one over 250 employees), whilst five firms employed less than

25. The consultancy firm also employed less than 25 staff, while the engineering company employed between 25 and 50 staff. Given the 'catchment area' served by the 20Twenty Leadership Management course at Cardiff Metropolitan University, firm location was focussed on the south east Wales region.

Table 1: Distribution of sample firms across segments

Sector:	Construction	Consultancy	Engineering	Total
Number of firms (no. of staff):	17	1 (<25)	1 (25-50)	19

Table 2: Number of staff and distribution of construction firm size (by staff numbers)

Number of staff:	<25	25-50	50-250	+250	Total
All firms:	6	3	9	1	19
Construction firms:	5	2	9	1	17

3.3.2 Knowledge and Opinion about Innovation

Respondents were asked to indicate what they thought were:

- The main drivers of innovation
- The main barriers to innovation
- Areas that required most innovation
- The main outcomes expected from innovation and innovative activity

*3.3.2.1 **Main drivers for innovation***

For the main drivers of innovation respondents were asked to indicate which they considered were the most important (Table 3).

- The highest score was given to Client Requirement followed by Commercial Profit increase. This order contrasts to some extent with the main drivers reported in most of the research literature where profit motivations are paramount (see Section 2). The results obtained in this questionnaire can not be compared on the same basis as those larger and more structured research exercises, but even so give an interesting pointer to local priorities and to the priorities of this range of firms.
- Health and Safety, Sustainability; Government legislation; and competitive pressures, are all considered significant drivers, with collaboration and partnering; time as a driver (to improve efficiencies), the push factor of technological improvement and grant funding for innovation support considered as least important.

Table 3: What do you think are the main drivers of innovation?

Driver	No. of Responses
Client requirement	16
Commercial profit increase	12
Health and safety	11
Sustainability	10
Government Legislation and/or procurement	10
Competition	9
Collaboration/partnering	7
Time restriction	6
Technological processes improvement	5
Grants/funding	5
Other	0

*3.3.2.2 **Barriers to innovation***

Barriers can be grouped into three main areas:

- Financial barriers, both in terms of limited resource, and in terms of an aversion to taking financial risks are among the top three most recognised barrier to innovation, but they are joined by an attitudinal reluctance to adopt change (Table 4). These three barriers are closely related and together constitute significant reasons why firms may not put more resources into developing or adopting innovations.
- A lack of awareness of innovations and their relevance is also a significant barrier, indicating that firms may need to be more proactive in explaining the benefits of innovations and/or to develop better working relationships with, and capacity among, the firms with which they do business. The circumstances of this barrier need to be explored in more detail to be able to explain how it is perceived to be significant.
- Other barriers noted, such as the fragmented nature of construction, lack of training, and a confrontational culture within the sector all contribute to an inability to be engage more fully innovative activity. Engaging in innovative activity also needs to have clear benefits for companies to devote resources to it and an inability to make these benefits clear can be a barrier.

Table 4 : What do you think are the main barriers for innovation?

Barrier	No. of Responses
Limit of financial resources	15
Unwillingness to change	14
Financial risks	12
Lack of awareness	10
Temporary nature of construction projects	9
Fragmented nature of construction	7
Inappropriate legislation	4
Lack of training	5
Confrontation within the supply chain	4
Lack of clear benefits	4
Other	0

*3.3.2.3 **Areas that require most innovation and the main outcomes of innovation***

These two areas show how respondent may value innovative activity, and what they may consider are the major benefits across the sector of developing innovations. For areas that need more innovation (see also Table 5) respondents identified that:

- Environmental performance as the most important area that needs further activity, with the allied energy management and waste management issues also scoring quite well
- New materials and products, and new techniques such as BIM and modern methods of construction figure highly emphasising the need to innovate in products and processes.
- Organisational innovation and improvements in on-site work management, project management and innovation in collaboration, while closely related do not appear to be considered together to carry the same weight. While Health and Safety retains a high priority, innovation in training and education is not considered to be as significant.

Table 5: Areas identified as in need for most innovation and change

Focus of Innovation	No. of Responses
Environmental performance	11
Materials and products	9
BIM	9
Energy efficiency improvement	8
Health and safety	8
Waste management	8
Modern methods of construction	8
On-site work management	7
Project management	6
Training and education	5
Innovation in collaboration	4
Other	1

The outcomes of innovation (Table 6) may be divided into those that are beneficial to the firm and those that apply more widely:

- Most respondents see increased profits as the main outcome of innovation, which matches the high score for it as a driver of innovation. It is closely followed by the effect of innovative activity on the firm's reputation and ability to grow their market. Outcomes that relate to internal performance are the next in prominence, such as Health and Safety, process and management effectiveness, and service provision.
- Environmental performance is regarded as a relatively low scoring outcome, which is in contrast to the high ranking it receives as an area that respondents thought should receive more innovative attention. The fact that respondent also do not score improved product quality and new products and services highly in relation to other outcomes is also interesting and deserves more exploration.

Table 6: The main outcomes of innovation

Innovation Outcomes	No. of responses
Increased profits	16
Better company reputation	13
New clients/market grow	13
Improved Health & Safety performance	10
Increase in process effectiveness	10
Increase in management effectiveness	10
Improvement of services	9
Improved environmental performance	6
Improvement of product quality	5
New products and services	3
Other	0

3.3.3 Innovation and supporting activity within the respondent's own firm

This area of the questionnaire aims to explore the respondent's direct experience of innovation processes within their own firms along with knowledge about how it might be supported both in terms of formal management and staff development. It also asks for knowledge about the importance of innovation, how much innovation, and in which areas of the firm it takes place.

*3.3.3.1 **Attitudes and Management***

On a Likert scale of 1-5 only four of the 19 respondents thought that innovation was considered as **very important** (scoring 5) (see Table 7). Three were firms employing fewer than 25 staff each, with one employing between 25 and 50, and included a representative from the only firm that described

itself as a consultancy. Seven respondents thought that innovation was **important** (score of 4), and of these three were also from small firms (<25 staff), one with 25-50 staff, and the remaining three between 50 and 250 staff.

Of the eight respondents that thought it was **quite important** (score 3) the majority were middle-sized firms with six employing between 50 and 250 staff. One of the firms employed between 25 and 50 staff while the largest firm in the sample, employing more than 250 staff was also in this group. No respondent thought innovation was considered as not very important or not important at all within their firm (score 2 and 1).

Table 7: The importance of innovation to the firm compared to firm size

Likert score/ Employee number	1	2	3	4	5	Total	Formal Innovation Management system
<25	0	0	0	3	3	6	1
25-50	0	0	1	1	1	4	1
50-250	0	0	6	3	0	10	2
250+	0	0	1	0	0	1	0
Total	0	0	8	7	4	19	4

A minority of only four respondents affirmed that their firms had a **formal management system** in place to monitor innovation activity, one employing less than 25 staff, one 25-50 and two up to 250 staff (Table 7). Twelve respondents say that they do not have such a system while two were unable to say. However, this data is unclear given that seven affirmed that their firms did set **targets** for improved performance (or **KPIs**) specifically to encourage innovation, while ten said that they did not and only one did not know. All respondents thought that their firm had been engaged in some level of change to the way that it operates within the last three years, but the data does not reveal the extent of this change or whether it was due to some form of innovation.

*3.3.3.2 **Areas of innovation and Training Support***

There seems to be more clarity about which areas of the firm innovation activity occurs as shown in Table 8. This indicates most activity takes place in relation to internal structures and organisations, but this is followed closely by innovation activity with regard to materials and products, methods of construction, design, and energy efficiency. Other supporting technologies such as waste management, BIM, and new production technologies score less highly.

Table 8: Areas in which the company innovates

Area of Innovation	No. of Responses
Training and education	8
On-site work management	7
Project management	7
Materials and products	7
Modern methods of construction	7
New design solutions	6
Energy efficiency	6
Health and safety	5
Waste management	5
BIM	4
New production technologies	3
Other	1

Skill development has been highlighted in the literature as important in order to support innovation activity and to increase the firms' capacity to originate, adapt, or adopt innovation. The respondents

were, therefore, asked to describe how their firm supports skill development and provided a range of comments:

- Nearly all the respondents indicated that their firm had some form of training provision or encouragement for staff to develop their skill base and knowledge (only one respondent did not provide a response). Some comments indicate a stronger and more formal training structure than other.
- Formal support includes Training and Development Plans, employing an 'active trainer', a management programme, and apprenticeship schemes
- A number of respondents state that their firm links training and skill development with a reward structure and contract reviews, employ appraisal schemes, and use action plans for improvement
- Some respondents note that their firm have a dedicated training budget, or substantial investment in training, and/or pay to send staff on training courses
- Matching the requirements of the business and individuals by using a 'training matrix', and a skills gap identification system.

Less formal support comprises of:

- encouragement for further learning and training
- pointing staff to opportunities for training and updating skills either externally or in-house
- encouraging staff to take more responsibility over decision making, or to gain more experience by working on different projects
- staff involvement encouraged through feedback and consultation exercises, with a positive attitude to new ideas, and access to courses to change behaviours
- commitment to training in some firms also extends to ensuring that contractors who work with the firm are trained
- firms deal with skill development in a practical on-going manner through training on specific new techniques, using new equipment, and to learn about and understand systems such as BIM

3.3.4 Support to develop innovation from external sources

*3.3.4.1 **Collaboration***

Fifteen of the nineteen respondents indicate that their firms are involved with some form of formal **collaborative processes**. Three firms engaged in Project Partnering (PP) only, and four in Early Contractor Involvement (ECI) only. The other firms were engaged in more than one, with seven firm engaged in both ECI and PP, and one in all three forms (including Project Alliances, PA), while four respondents were not aware that their firms participated in any of these processes.

In total twelve respondents indicating that their firms participate in ECI; 11 in PP and one in a PA (see Table 9)

Table 9: Participation in formal collaboration agreements

Collaboration form:	Project Partnering (PP) only	Early Contractor Involvement (ECI) only	Project Alliances (PA) only	PP + ECI	PP + ECI + PA	PP + PA	ECI + PA	PA total	PP total	ECI total	None
Number of firms:	3	4	0	7	1	0	0	1	11	12	4

While some form of formal collaboration was quite common, only one of the respondents thought it was very important for their firm to develop innovations with **manufacturers** on site (score 5 on the

5 point Likert scale). One respondent said that it was important (score 4), three quite important (score 3), nine as not very important (score 2) and five as not important at all (score 1).

*3.3.4.2 **Formal support to innovate***

Respondents were asked to indicate what kind of support their firms would like to help them to innovate, and replied with a range of comments.

- Access to funding was considered to be the form of support that would be most useful in supporting firms' attempts to innovate more. Such funding could also entail funds for training support and be accessible as grants or other forms of funding.
- Information about innovation and/or support was not always clear or readily available, with access to guides of past innovation activity and examples of successful innovation being useful
- Not knowing what reference information is available was considered an issue for one respondent and regular awareness raising meetings between organisations in the Public and Private sector that would discuss available support and information, and which might explore innovative solutions was thought desirable
- Any kind of regular updates about innovations and the process of innovating were welcome.
- Taking advantage of external expertise in order to improve knowledge within the organisation including organising additional internal seminars and taster sessions for members of staff; using mentoring and coaching approaches; and improving management skills in general
- Practical advice on specialist equipment that could be used in new processes or products, as well as access to skilled people whom the firm may not employ in-house.

Issues that were considered helpful in improving innovation within the organisation reflected many of these areas of support that were thought desirable. Knowledge about funding tops the list, while improving the firm's ability to network and take part in knowledge exchange, education and training schemes and learning from role models are also important. Other issues were related to internal factors such as the firm's work environment and reward schemes, and being more aware of client's needs, and of government schemes and policies (Table 10).

Table 10: Areas that could help to increase innovation within the organisation

Enablers	No. of Responses
Awards, grants, funds	12
Knowledge exchange with external networks	11
Education & training	11
Role models	8
Supportive work environment	8
Internal reward schemes	6
Deep understanding of the customer need	5
Government schemes	5

3.3.5 Summary of Questionnaire Findings

Main Drivers

- Client requirements followed by closely by commercial profit considered strongest
- Drivers from external regulation; Health and Safety; Sustainability; Government legislation and competitive pressures followed
- From the options provide collaborative relationships; technology; funding; and time/ work efficiencies scored lowest.

Main Barriers

- Financial barriers in terms of financial limitations or risk, which link to conservative attitudes with respect to change considered most important
- A lack of knowledge and awareness of the possibilities of innovations, which suggest a need to develop better relationships and to educate partners in the supply and delivery chain
- The fragmented nature of construction, a lack of training, and a confrontational culture within the sector all contribute to barriers
- Innovative activity needs to have clear benefits for firms to devote resources to it

Need for more innovation

- Environmental performance and related issues such as energy, waste management efficiencies were the most important areas
- New materials and products, new techniques and knowledge management (e.g. BIM MMC) followed
- Less need for further organisational innovation either regarding internal structures or work organisation, or for more innovation in training

Outcomes

- Profit increase and enhancement in reputation as the main outcomes of innovation activity
- Supported by improvement in internal systems and service provision
- Lowest scores went to environmental outcomes and improved products and services.

Innovation within the firm: Attitudes

- Innovation at least important if not very important for their firms, but only 4 had a formal innovation management plan, and 7 with innovation related KPI
- The data seems to indicate that whilst innovation is something that is considered to have importance to most firms, there is also some ignorance or uncertainty among those respondents about how it may be developed.

Area of innovation

- Most innovation in areas of internal structures and organisation
- Innovation in materials, products, processes, and energy efficiencies followed
- Innovation activity relating to waste management, BIM, and new product technology thought less important.

Training support and skills

- Training varies in its level of formality
- Some firms have staff development plans or similar in place and diagnosis of skill gaps and matching between the individual skill level and the need within the firm
- Some firms linked training and skill improvement to reward structures
- Less formal support via encouragement: to participate in internal and external training; by staff feedback and participation in developing new ideas
- Some firms training is an on-going practical process with specific training provided if or when needed with new techniques and new equipment.

External Support

- Most firms engaged in some form of collaboration: Project Partnering, Early Contractor Involvement and Project Alliances
- Only one respondent indicated that there was specific collaboration with manufacturers.
- Access to funding to support innovation as the most important external support provision
- Better information about innovation and about opportunities to improve performance required firms use external expert provision to improve their own internal knowledge in various ways

3.4 Semi-structured Interview Analysis

3.4.1 Introduction and Methodology

The interviews are designed to explore business patterns and the approaches that firms took to innovation activity in their firm. Interviews followed a common format but respondents could develop their own responses as appropriate to each firm. The themes addressed in the interviews are based on those arising from the literature review (section 2) and had also formed the basis of the structured questionnaires (section 3.2) that had been administered to a sample of representatives from construction firms. The main areas of discussion are outlined in Table 11.

Table 11: Semi-Structured Interview Themes and Discussion Points

Interview theme	Main areas of interest to be followed
Understanding innovation	How participants understand innovation in the construction sector, and what it might mean to their own firm. Innovations in products, services, organisation, marketing, other Original innovations or new to the firm, or to the construction sector in the region
Drivers of innovation	What firms perceive as the reasons or need for their firms to innovate, and what kind of innovations need to be / or are being developed within the construction sector. What are the major drivers of innovation in construction over the next 5 years
Collaboration and learning	Does the firm take part in any form of partnering activity What is the attitude of the firm to partnering and what is their experience
Skills and training	Internal training and learning systems Focus on external training provision and acquiring expertise
Project Management	Innovation culture Interaction with project partners
Product and process innovation	Capacities to generate new knowledge internally Capacities to adopt, adapt and copy new knowledge from elsewhere Where is innovation focussed within the firm
Sources of knowledge	Interaction with Universities and dedicated research centres Sector bodies and Networks
Government influence	Government support for innovation The effects of Standards and Regulation

The number and distribution of firms was guided by access consideration, and limited by time constraints. They are, therefore, concentrated in the south Wales region, primarily in Swansea, Cardiff, and Newport. A range of firms were approached in order to cover as wide a distribution of firm types within the sector as possible. However, problems were encountered in gaining access to many firms, often because firms report strong demand and pressure of work. Senior personnel, who could provide an informed overview of the firm's activities with regard to innovation, were approached and the interviews were conducted either by telephone or on a face-to-face basis.

Some of the companies that took part in the interviews work exclusively within Wales, whilst others operate across the UK and Worldwide. The size of the companies ranged from a single person private business to firms that employed up to 100 people. Firms had been in business for different lengths of time, with some having been just a year in existence whilst others had a history of some 30 years. A summary of firm characteristics is given in Table 12.

Table 12: Characteristics of interviewed firms operating in Wales

Firm	Staff No.	Years in operation	Description, Products, and Services	Main Area of Innovation
F1	60	>20	Care home/villages developer; Design and Build, Development, Funding	Modern methods of construction, training and education and project management.
F2	7	5	Renovation, Mechanical Services, Bespoke build and Design	Modern methods of construction, training and education and project management.
F3	30	>20	Social housing provider operating for nearly 60 years. Service portfolio continually evolving to meet client and customer needs. Current portfolio involves: new build, retrofit, maintenance, land and funding solutions	Materials and products, new production technologies and new design solutions.
F4	1	1.5	Service to construction contractors on company management systems, compliance, bid writing, employee training and on-site photography.	New services, project management
F5	44	>20	Small domestic works, domestic extension, small commercial outlets and refurbishments and industrial works up to and beyond £1m new build projects	Modern methods of construction (pre-fabrication), new design solutions and project management.
F6	40	>20	Design and installing smoke control, passive ventilation and building management systems. Services include design advice, CFD modelling, installation and maintenance.	New products/service technologies and project management.
F7	1	1	New products development, building products hire	New products
F8	11	2	Property services, new homes, Lettings, Waste management: a trading subsidiary of a housing association, initially created to manage Housing Association projects now also offers services to other clients. Aims to fulfil social and community obligations. It operates on a non-profit basis.	New service, project management
F9	66	127	Development and selling of real estate	Modern methods of construction, project management
F10	20	8	Complete building service - from planning to finishing Premium development projects for both domestic and commercial customers	Waste management, project management
F11	77	28	Originally formed as a small partnership with small to medium sized, private contracts clientele. Services: new build, refurbishment, EWI, joinery	Project Management
F12	60	16	Architectural Design Services with a full range of experienced and skilled professionals	Project management, sustainability

3.4.2 Interview responses

3.4.2.1 ***Understanding Innovation***

As was noted previously all forms of innovation that contribute to the improved performance of the firm within the sector, and to the sector's performance in relation to economic, social, and environmental objectives are considered relevant to this study. All the companies that took part in the interviews believe that they are innovating to some extent; whether these innovations originate locally, are imported, adapted, and/or copied from elsewhere. However, respondents gave different definitions of the term 'innovation' that range from regarding it as equivalent to invention, to considering it as an on-going process of incremental improvement (Table 13).

Table 13: Defining Innovation

Innovation is…..	Respondent
invention of new product and services	F6; F7
not something absolutely new but an idea, that might be adapted from somewhere else and then adjusted for the local requirements	F3; F9; F10
a constant improvement, and an on-going process of improving current services	F1; F11

What is a common thought among respondents in this regard is that innovation should entail some degree of change and improvement in products, services, and/or organisational structures and operation. The kind of changes, regarded as innovations within firms were developed and introduced in a number of different spheres of activity, and included project management, training and education, waste management, innovation in collaboration, new products and services development and on-site work management. A further examination of instances of these changes is made below.

3.4.2.2 ***Drivers of Innovation***

The drivers for innovation that were identified by firms in this study can be categorised in terms of

- those that impact on internal aspects and operation of the firm
- those that affect their position relative to other firms in the sector
- and those that come from changing demands and expectations that are conveyed most clearly through clients but also through changes in standards and regulations

During this study firms identified an internal aspect as being the most important in terms of improving cost efficiency and increasing profits. This was considered as the leading desired outcome and driver for innovation. Reducing underlying costs and improving efficiencies within the firm and its operations form major element of this driver. Innovations that contribute to this goal are valued, including those that will reduce the time period over which defects need to be addressed

> "*…innovation is very important for the improvement of the work efficiency and reducing defect time periods"* (F5)
>
> *"..we see innovation as crucial to achieve sustained growth and even to maintain (our) current steady state position"* (F9)

A major factor relating firms to their peers within the sector clearly is the pressure of competition, which is also translated by many of the firms as a motivation to innovate, although not all firms identified competition as a driver in this respect. Some firms point out that they are obliged to differentiate themselves by innovating.

> "…..*you just can't survive in the modern world without innovations….*" (F1)
>
> *"…we have to innovate in order to improve our competitive position…*" (F3)

This, however, is about more than just producing better or more competitive products and services. The firm's innovation performance demonstrates its capabilities and enhances its status within the sector, thereby improving reputation, and credibility and, hence, its competitive position,

"Innovation is very important for our recognition within the construction industry…" (F3)

Innovation drivers also come from client demands for better value and better quality, along with environmental and sustainability concerns:

"*Increasingly we are asked about the environmental impact of our work, as a result and with our customer's approval we exceed the minimum thermal insulation requirements and can install solar water heating, heat pump and wind turbine solutions*" (F10)

"*Sustainability is now at the core of our design output and is reflected in our commitment to staff skills and our design review processes*." (F12)

Firms also note that changes in attitudes to procurement have also resulted in increased motivation to innovate. Past tendency to award contracts on the basis of the cheapest options has been overtaken to some extent by an increased emphasis on quality. The balance has, therefore, been tilted away from a drive solely to reduce the cost of products and services to offer better value through better quality. Firms see this change as positive for innovation, encouraging more opportunities to develop new products and methods:

"….procurement moved from the 'Just Cost' approach to the 'Cost/Quality' approach…." (F11)

''*Lowest price (first past the post) tendering inhibits innovation. Fortunately, more and more tenders are being offered with price and quality scoring which allows for innovation''* (F9)

Hence, firms (e.g. F1, F3, F11) quote a need to increase product and service quality that aims to satisfy client requirements as a prominent driver for innovation, while these may also be developed in collaboration with clients and the supply chain (F9).

For small and entrepreneurial companies drivers for innovation also include those that relate to personal motivations, satisfaction, and ambitions, which highlight aspects of working culture, and the firm's capacity and inclination to take risks. Innovation, for these type of firms means looking for ways of doing things in an improved way and…

"…*fits our personality and personal drive*" (F4; F8)

The interview sample is not large enough to consider how factors such as firm size, or the relevant segment of the construction industry affects this driver, but working culture has already been referred to in considering how definitions of innovation varied across the sample, and will arise again when considering attitudes to collaboration and interactions between firms.

Looking ahead, firms expressed a desire to improve their innovation performance, not least since pressures to innovate continue to increase. They considered that, over the next five years, the greatest change will be in terms of more demand and need for collaborative working. This will impose considerable changes on working culture and organisational systems, and can be regarded as considerable innovatory change in a sector that has not traditionally been open to, or capable of sustained collaboration and mutual learning. This change will itself be driven by the impact of BIM (Building Information Modelling), and to greater use of IT in general, which will change the basis of information transfer and knowledge sharing across projects and across the sector:

"BIM is changing the industry. Even small companies, who do not work on big public sector capital projects, will need to understand BIM" (F5)

3.4.2.3 ***Barriers for Innovation***

Financial risk is a major barrier to innovation, which can affect attitudes within firms of all sizes, and was quoted as significant by all the firms in the sample.

"Small companies are not keen to invest in innovation, as they just don't have money to invest in R&D…… preferring to concentrate on reducing the costs of the products and services that already exist" (F4)

An allied barrier is that firms do not have, or do not allocate, time to consider and to develop new ideas (e.g. F8; F5). This barrier is exacerbated by tendering processes that emphasise cost competition. As noted in the 'Drivers' section above procurement processes have presented a barrier to innovation because of the disincentive to add value, but these are being modified to allow more consideration of quality and value in products and services.

As is the case for drivers of innovation, barriers can also be encountered outwith the firm, and interview participants perceived a lack of understanding about some innovations on the part of clients. Respondents considered that more needs to be done with regards to client education in this respect, not only to overcome a 'fear' of the unknown and to show that innovations are soundly based, but also to expand horizons and to demonstrate that new and better approaches and products are available:

> "…..*one of the main barriers for innovation is lack of clients' awareness of new products and approaches*" (F3)
>
> "*Some clients are just not ready for innovations*" (F5)

This kind of barrier clearly demonstrates one of the salient differences between an invention and innovation, where to be relevant the innovation must gain acceptance, and that the changes entailed by it are sustained and diffused across the sector. Firms have to be more proactive in developing their innovations and…

> *"…..to demonstrate the benefit of change to their clients*" (F3; F5; F8)

For this process to be successful firms in the construction sector realise that they have to pay increased attention to clients and be prepared to develop long term relationships

> "….*it is necessary to build trust between the organisation and clients and (to) educate clients*" (F1)

Personal attributes figured as important factors for some respondents, and could create barriers against the innovation process, mirroring what was said about the influence of personality and attitudes in relation to the factors that drive innovation. It was thought by some respondent that an 'openness' to innovation is highly dependent on particular people's personalities. In some respondent's opinions this is a barrier that is not always amenable to change through training or education (F1; F5), but others disagree, noting that

> "……*being innovative is a skill that can be learned*" (F8)

This 'learnable skill' applies to both construction company personnel and to those of the client, and reaffirms the need to consider innovation as an interactive process that includes all actors in the construction supply and delivery chain.

3.4.2.4 ***Collaboration***

It has long been noted that successful innovation within the complex environment of a construction project often requires effective co-operation, co-ordination, and good working relationships between different stakeholders. Most of the respondents highlight the importance of collaboration for the innovation process. However, they also recognised that the character of the construction industry does not encourage collaboration. This deficit is often due to the procurement process, as noted above. Firms highlighted the competitive culture that is engendered by the way tenders are structured and presented, whilst companies are reluctant to share information with potential competitors during a procurement process, and neither aspect encourages collaboration.

> "*One-off bespoke projects, with transient teams hinder long term relationships (and) make it difficult to transfer innovations from project to project"* (F9)

Despite these difficulties, some firms confirmed that entering a collaborative relationship with other firms had helped them to grow and to develop new markets. In many of these cases the collaboration is not with direct competitors or firms offering the same products and services, but with firms that occupy different positions in the supply and delivery chain. The need to find other

firms who can help develop products and bring them successfully to market is not new, but nevertheless it is an essential stage in transforming a new idea into a successful innovation:

> "*We are a small consulting company and signing the contract with the big training company to develop a new educational course for contractors helped us to push our business forward. Collaboration is essential for a small business to innovate and to succeed*" (F4)

Another respondent (F7), illustrated the same process in the development of a proprietary cement mortar spot board, which required the help of two manufacturers to bring the original idea to market at a commercial scale.

In both cases collaboration enables new products and services to be developed and diffused, supporting the originating firm's approach and commitment to innovation, but also involving the collaborating firms in the innovation process to the benefit of both parties.

> "*We partner with many private clients and our supply chain. This offers long term project teams who learn together and the benefits are then passed on from project to project"* (F9)

This process depends on building good relationships and trust between companies, much of which originates from a commitment to network and become known and understood by other firms in relevant segments of the construction sector, and also, in some cases, in other related sectors.

> *"..building long term relationships, which lead to greater collaboration.."* (F9)

Firms who are more engaged in construction project management are obliged to collaborate, and firms note that the level of collaboration and co-ordination increases with project complexity where there may be multiple organisations and specialists involved. Such interaction may also extend to considering and working around the whole life cycle of the built asset, which might involve different sets of firms and which might change as the project advances. Client requirements and expectations become more important in this latter area of work as one or two of the respondents who deal more directly with end users confirm (e.g. F1; F8; F9; F10). Managing an innovatory change within this context is dependent on how well the relationships within the project have been established, and how well information is communicated both within the firm and between the firm and other actors in the project. An example of the approaches employed is provided by F6 who have an intensively managed multi-disciplinary team approach to utilise the various expertise of a team and which elicits and responds to client and end-user needs.

3.4.2.5 ***Skills, competence, and training***

The maintenance and development of skills within the sector is recognised as a major factor in developing the firms' capabilities and in enabling it to become more innovative. Respondents link the level of skills directly to innovation, although many were not able to illustrate such direct links. The links are made on a more general level and firms are confident that they will only survive and flourish if their capabilities in terms of skill levels are enhanced and continue to develop.

The skill level within the firm is arguably a more acute issue for small companies given the relative lack of leeway and depth that is available in such firms. F2, for example, with a staff of just seven people recognised that skill shortages affected "*the capacity of companies to innovate*", and see the problem not only in terms of the shortage of skilled workers, but also in terms of the quality of skills available. Whilst attracting more trained construction workers was a major need, firms and training providers also need to work together to develop highly skilled staff. Apprenticeship programmes are important tools in this respect, where training is tailored to develop skills that are required within

firms that aspire and need to innovate to succeed. F2 has changed its recruitment policies to enhance this process and is taking the risk[7] of developing their apprenticeship programme.

Skill development and new training programmes are a core part of the services that a firm such as F4 offer and, whilst they have a vested interest in promoting the value of expenditure on training, they are also looking to develop their service to enhance their training programmes and to develop better quality skills among client workforces. Innovation in course development in this instance is driven by the general demand within the sector for increased quantity and higher quality skills.

A further aspect of the barriers that inadequate training and skill levels present to innovation is that firms encounter deficiencies within other firms with which they do business or with whom they interact. As discussed in relation to collaboration and to general attitudes to innovation, the level of knowledge and capability to absorb new ideas among clients is an important aspect of developing an innovation and can present a difficult barrier if not addressed robustly. As a consequence many companies make efforts to educate their clients in order to increase the demand for innovative solutions and products (for example F3; F5; F8), with some, such as F8, prepared to offer free training to develop competencies in other firms and to enable their own innovations to gain market share and to diffuse through the sector. F8 does this by educating their contractors in Health and Safety, Environment and Sustainability awareness and other relevant topics in order that they can improve their standards and capacity to work together.

3.4.2.6 ***Product and Process Innovation***

At present, few of the companies interviewed have a developed systematic procedure for distributing new ideas within the company. New ideas generally are discussed at team meetings where applicable, and these tend to be more formal in the case of larger firms (e.g. F1; F3; F11). Where there is a more formal review mechanisms, experience of current work practice, product, and service delivery is used to incrementally improve their offer. The product and service aftercare department run by F1 illustrates this approach, where direct feedback from clients is used to modify and improve future projects.

For smaller firms, who have often developed from an initial entrepreneurial idea, the generation and development of an idea derives partly due to experience and partly due to specific insight into current practices within the sector and being able to recognise gaps that had not been addressed by existing products or services. This is the case for F4, for example, where the founder, who had long experience in the industry, recognised that there was a gap in contractors' knowledge with regard to demonstrating compliance with current building regulations.

Other business developments within firms are in response to a lack of suitable suppliers for a particular service or product within the local area. This is the case for F8, who decided to start their own waste recycling after failing to find a suitable local recycling company, although they had no previous experience or specific knowledge in this area. F8 expanded the firm's internal capabilities changing what they did, importing and adapting knowledge to address their own needs.

The changes demanded by new technology and processes that are being introduced into the sector more generally encourage firms to learn new ways of working and to change their own systems and products. The development of BIM is a fundamental change that may affect most firms in time, although not all are currently planning how they will deal with this sector wide innovation. Some

[7] Where risk in this regard is due to the investment in training not being repaid in improved performance and/or that trained individuals are lost to competitors.

firms interviewed describe their efforts in this respect, for example, F12 has made significant investments, into BIM training and into the necessary hardware and software, over the last three years and now a significant proportion of their projects are delivered by means of this platform. Adoption of BIM changes the way that they may organise their work flow, and to maintain better controls on product and service quality

> "*We are currently using BIM platforms on a number of projects with major UK clients and have recently developed two major acute hospital projects. The AMHU at the University Hospital Llandough, near Cardiff, is a Level 2 fully collaborative BIM project in which BIM data is being used directly for off-site prefabrication. We integrated the Department of Health Activity Database into the BIM model at an early stage to allow for detailed checks on areas, acoustics, equipment and pricing schedules on a regular basis."* (F12)

> "*…Full use of BIM on our own developments – where we have control over the design team from the outset of the project"* (F9)

3.4.2.7 ***Interaction with Universities and Research Institutes***

Although they acknowledged the potential value of tapping into the resources and expertise of university and R&D establishments, none of the firms interviewed were involved in collaboration of this type. The kind of interaction envisaged by some respondents was in terms of accessing universities' resources to develop ideas that may originate within firms. The responses from interview participants suggest that a more in-depth study into the best ways of encouraging more general use of university and other R&D expertise by Welsh construction firms is required.

3.4.2.8 ***Government support for innovation***

Government support and encouragement for innovation was considered in general to be adequate. There were, however, some reservations about publicity, and about clarity in terms of information and signpost to sources of financial support. These responses allied with the general level of understanding and commitment in the sector to innovation suggest that there may be room for a more focussed and intensive programme of development for innovation in Welsh construction firms, which goes beyond encouragement to dealing with some of the practical innovation management challenges faced by firms.

3.4.3 Summary of Semi-Structured Interview Analysis:

Understanding Innovation:

- Firms believe they are innovating in project management, training and education, waste management, innovation in collaboration, new products services development and on-site work management.
- Differing definitions of the term 'innovation'

Drivers:

Internal aspects:

- Improving cost efficiency and increasing profits
- Reducing underlying costs and improving efficiencies within the firm
- Pressure of competition (not for all firms)
- To differentiate by innovating demonstrates capabilities and enhances status
- Personal motivations and organisational culture
- Management capabilities and skills

External aspects:

- Client demands for better value and better quality, environmental, and sustainability performance
- Attitudes to procurement- offering better value through better quality
- More demand and need for collaborative working – requiring changes in organisational culture and systems
- Impact of BIM and information transfer/ knowledge sharing

Barriers

- Financial risk is a major barrier to innovation
- Do not have, or do not allocate, time
- A lack of (internal to firm) understanding of the benefits of an innovation especially client knowledge: education required to overcome 'fear' of unknown and demonstrate value of new and better approaches
- Innovation must be diffused to be successful hence increased attention to clients and need to develop long term relationships
- Personal attributes can be a barrier – conservatism and lack of training/skills
- Openness to innovation through training is 'learnable'

Collaboration

- Weak collaboration is often due to procurement processes
- Collaboration help firms grow/develop new markets/ diffuse innovation
- Good relationships/ trust often originates from commitment to network
- Construction projects oblige collaboration to some degree
- Collaboration extends to whole life cycle of the built asset: hence client/end user requirements and expectations important

Business patterns affecting how firms appproach innovation

- Good collaboration dependent on quality of relationships and information sharing (note impact of BIM)

Skills and Training

- Skills directly linked to innovation important, and is a more acute issue for SMEs
- Skill shortages affects the capacity of companies to innovate
- Need to developing more apprenticeship programmes
- Need to develop enhanced training programmes and better quality skills
- General sector demand for increased quantity and higher quality skills.
- Deficiencies within other firms affecting capability to absorb new ideas

Internal Innovation Management/ Developing New Ideas

- Systematic procedures for distributing new ideas internally are rare
- Processes include team meetings; review of client feedback; incremental improvement procedures of product; production processes and services
- Entrepreneurial attitudes partly due to experience/ partly due to specific insight into current practices within the sector/ being able to recognise gaps
- Changes demanded by new technology and processes e.g. BIM as a fundamental change

Relationships with University, R&D and Government

- Little current interaction with University or other R&D
- More in-depth study required into ways of encouraging (major) R&D
- Government support/encouragement for innovation adequate but room for a more focussed and intensive programme of innovation development

Section 4: Discussion and Conclusion

This report provides an exploration of innovation activity within the construction sector and is based on responses from firms that are located and/or are operational within Wales. It was conducted to identify how construction firms perceive innovation; to examine the main drivers and barriers to innovation; to identify the characteristics of innovating firms; and to explore the conditions that may make firms into active innovators.

Academic Basis
Innovation processes in the construction sector have been widely studied over the past ten to twenty years. The sector has posed specific challenges to mainstream innovation theories, which have had to be modified to account for the particular procurement processes, project-based practices, and the complexities and differing types of working relationships and resource-deployment that have been prevalent in the sector. We have distilled major themes and features that describe the innovation process, and the conditions that help to underpin and develop innovation in construction companies (see a summary of themes Section 2, p9) and these formed the basis for the questions used in fieldwork during the study.

Policy Interests and Drivers for Innovation
The need to encourage innovation becomes important in order to address and control the costs of construction. Added to this is a need to address environmental issues that range from reducing the carbon footprint of the sector; improving resource use efficiencies; and adapting the industry to new demands on built assets that rapidly developing IT technologies are making. Increasingly, firms must also be able to benchmark themselves against global competition.

The Response of Firms
The firms that have contributed to this study indicate that they are aware of, and are attempting to respond to these challenges, and understand that developing a capacity to innovate is central to that response. They are conscious of the drivers to innovate and attempt to respond to these in ways that are appropriate and achievable for their particular segment of the construction sector, as well as for their own particular firms. A study of these responses and plans for developing innovation capabilities can offer lessons to other firms and to policymakers.

Research Fieldwork
The fieldwork conducted for this study (Section 3: pp 10- 16) has indicated how firms regard drivers for, and barriers to, innovation. In many ways, these influences are generic across the sector, with major changes in practice, such as changes in tendering processes; or changes in technology and management, e.g. the development of BIM, affecting all the firms within the sector. They also have specific effects on each firm that varies with the particular characteristics of those firms and their motivations, ambitions, and capabilities.

The structured questionnaire provided the basis for a set of semi-structured interviews that were conducted with senior representatives of construction companies, which aimed to follow some of the themes discussed in more detail and with reference to the particular characteristics of each firm. A report and discussion of these interviews is provided in Section 3 pp18- 26.

Insights from Fieldwork
The research reported in Section 3 describes innovation activity and the conditions for innovation in construction in Wales. In identifying features of their innovation activity, firms indicate what their motivations are, and how their innovation activity is influenced by:

- the characteristics of the firm
- the kind of product and service that the firm provides
- the way that the firm interacts with their clients and other actors through tendering processes
- interactions and relationships with suppliers, project partners, and contractors in their work practices and organisation
- interactions and relationships with clients, end users of built assets, standards, and regulations

The firm's characteristics, productive output and external interactions shape, and are shaped by, their internal management structures, their capabilities, skills, and access to expert external knowledge and advice. Management capabilities and skills are central to overcoming many of the barriers experienced, and deficiencies in these are relevant both internally to the individual firm and in terms of the capacity of other firms in a supply chain to enable innovation.

Building Profiles of Firms and their Innovation Activity

The reported fieldwork provides a basis for building a set of robust criteria for, or characteristics of, good working practice and approaches to innovation activity, which may be continuously updated, along with details of innovative products, materials, and services, and from which other firms may learn. A matrix of characteristics and attributes of firms, their markets, and the drivers and barriers influencing their innovation performance may be constructed. The matrix may form a database from which profiles of innovation active firms may be built, which may be used as learning resources for other firms and for policy makers in constructing and maintaining support services and advice.

A Long Terms Action Research Programme

A robust register or database that provides profiles of the kind suggested above is only credible if detailed knowledge of firms and their activities can be built up and updated. This report acts as a pilot study in this regard. It adds to previous studies of the sector in Wales[8], and can be the basis for a coherent long-term study in contrast to one-off snap-shots of circumstances and conditions that are designed to address goals that are more limited.

A long-term study should be conducted with the co-operation of firms in the sector in what may be termed an Action Research process that aims, in an interactive way, to educate and develop capabilities, and at the same time to research current processes and capabilities. A longitudinal perspective is necessary to show that the research and learning is cumulative, which can show progress over a sustained period, and demonstrates a long-term commitment to developing the sector's innovation capacities.

Further research may also be related to the impact of innovations; how these impacts contribute to economic, social and environmental objectives in Wales; and how these objectives in turn act as drivers to innovation. There is scope in this respect to explore and develop the role of policy makers in actively promoting innovation activity and innovative solutions to deliver policy objectives, for example in the specifications and standards that are set for construction projects, and the way that policy makers learn and understand about their role as drivers of innovation in the sector.

---

[8] For example, the 20Twenty Leadership and Management programme at Cardiff Metropolitan University (CMU) has produced valuable data and insights into innovation within local companies that spans a period of over ten years.

Appendix 1

Literature Review References

Ankrah, N A, Proverbs, D and Debrah, Y (2009): 'Factors influencing the culture of a construction project organization: an empirical investigation'. *Engineering, Construction and Architectural Management*, **16**(1), 26-47.

Barlow, J. (2000): 'Innovation and learning in complex offshore construction projects'; Research Policy; Volume 29, Issues 7–8, pp 973–989

Blayse, A.M. and Manley, K. (2004): 'Key influences on construction innovation.' Construction innovation, 4(3), 143–54
Bygballe, L., Jahre, M. and Swa¨rd, A. (2010): 'Partnering relationships in construction: a literature review'; Journal of Purchasing and Supply Management, 16, 239–53.

Chan, A.P.C., Daniel, W.M., Chan, Y.H., Chiang, B.S., Tang, E.H.W.C. and Ho, K.S.K. (2004), "Exploring critical success factors for partnering in construction projects", Journal of Construction Engineering and Management, Vol. 130 No. 2, pp. 188-98

CIC (2014): *CIC 2050 Group Construction Industry Survey 2014*; Construction Industry Council [accessed at http://cic.org.uk/networks-and-committees/2050group.php December 2014]

CITB (2013): *Training and the Built Environment 2013*; Construction Industry Training Board, [Accessed http://www.citb.co.uk/research/research-reports/training-built-environment/ December, 2014]

ConstructionSkills (2010): *Construction Skills Assessment for the Construction Sector 2010: Construction Skills Wales Report*; ConstructionSkills, King's Lynn, UK

Dainty, A.R.J., Briscoe, G.H. and Millett, S.J. (2001): "Subcontractor perspectives on supply chain alliances", Construction Management and Economics, Vol. 19 No. 8, pp. 841-8.

Dale, J.; (2007): *CIOB Survey 2007*; The Chartered Institute of Building; www.ciob.org.uk

Doree, A.G. and Holmen, E. (2004), "Achieving the unlikely: innovating in the loosely coupled construction system", Construction Management & Economics, Vol. 22 No. 8, pp. 827-38.

Dubois, A. and Gadde, L-E. (2002):' The Construction industry as a loosely coupled system: implications for productivity and innovation'; Construction Management and Economics 20, 621-623.

Dulaimi, M.F., Ling, F.Y. and Bajracharya, A. (2003): "Organizational motivation and inter-organizational interaction in construction innovation in Singapore", Construction Management and Economics, Vol. 21 No. 3, pp. 307-18.

Egan, J.S. (1998): *Rethinking Construction*: *Construction Task Force Report for Department of the Environment, Transport and the Regions;* HMSO, London.

Eriksson, P.E.; Dickinson, M.; Khalfan, M.M. A. (2007): "The influence of partnering and procurement on subcontractor involvement and innovation", Facilities, Vol. 25 (5/6), pp.203 – 214

Fletcher, R.; Fang, T. (2006): 'Assessing the impact of culture on relationship creation and network formation in emerging Asian markets'; European Journal of Marketing Vol. 40 No. 3/4, 2006pp. 430-446

Gadde, L.-E.; Dubois, A. (2010): 'Partnering in the construction industry-problems and opportunities'; Journal of Purchasing and Supply Management, 16, 254–63.

Gambin, L.; Hogarth, T.; Atfield, G.; Li, Y.; Owen, D.; Breuer, Z.; Garrett, R. (2012): *Sector Skills Insights: Construction - Evidence Report 50*; UK Commission for Employment and Skills, London, UK

Gann, D. (2000): Building Innovation: Complex Constructs in a Changing World; Thomas Telford, London.

Gann, D. (2001): "Putting academic ideas into practice: technological progress and the absorptive capacity of construction organizations", Construction Management & Economics, Vol. 19 No. 3, pp. 321-30.

Gann, D. and Salter, A. (2000): "Innovation in project-based, service-enhanced firms: the construction of complex products and systems", Research Policy, Vol. 29 No.s 7-8, pp. 955-72

Hakansson & Malena Ingemansson (2013): 'Industrial renewal within the construction network'; Construction Management and Economics, 31:1, 40-61

Hardie, M. (2010): 'Influences on innovation in small Australian construction businesses'; Journal of Small Business and Enterprise Development 17 (3), pp. 387-402

Ingemansson, M. and Waluszewski, A. (2009): 'Success in science and burden in business: on the difficult relationship between science as a developing setting and business as a producer-user setting'; IMP Journal, 3(2), 20–56

Ingirige, B. and Sexton, M. (2006): "Alliances in construction. Investigating initiatives and barriers for long-term collaboration"; Engineering, Construction and Architectural Management; Vol. 13 No. 5, pp. 521-35.

Ivory, C. (2004), "Client, user and architect interactions in construction: implications for analysing innovative outcomes from user-producer interactions in projects", Technology Analysis & Strategic Management, Vol. 16 no. 4, pp. 495-508.

Ling, F.Y. (2003), "Managing the implementation of construction innovations", Construction Management and Economics, Vol. 21, pp. 635-49.

McClelland, J. (2012): Maximizing the Impact of Welsh Procurement Policy; Welsh Government, [Available at http://wales.gov.uk/topics/improvingservices/bettervfm/publications/mcclellandreviewsummary/?lang=en [Accessed, December, 2014]

Miozzo, M. and Dewick, P. (2004): Innovation in Construction: A European Analysis; Edward Elgar, Cheltenham.

Morgan, A., Raidén, A., Naylor, G. (2008): 'Unlocking the potential to influence government skills policy: A case study of the UK construction industry'; International Journal of Training and Development 12 (4), pp. 238-252

Nadim, W., Goulding, J.S.(2009): 'Offsite production in the UK: The construction industry and academia'; Architectural Engineering and Design Management 5 (3), pp. 136-152

Ngowi, A B and Pienaar, E (2005): 'Trust factor in construction alliances'; *Building Research and Information*, **33**(3), 267-278.

Abdul Nifa, F A and Ahmed, V (2010): 'The role of organizational culture in construction partnering to produce innovation'. *In:* Egbu, C (Ed) *Procs 26th Annual ARCOM Conference,* 6-8 September 2010, Leeds, UK, Association of Researchers in Construction Management, 725-734.

Roe, S; Jenkins, J. (2003): Partnering and Alliancing in Construction projects; Sweet & Maxwell Ltd, Andover, UK

Saad, M., Jones, M. and James, P. (2002): "A review of the progress towards the adoption of supply chain management (SCM) relationships in construction", European Journal of Purchasing & Supply Management, Vol. 8 No. 3, pp. 173-83.

Schein, E H (1986): *Organizational Culture and Leadership*. San Francisco: Jossey-Bass.

Shapira and Rosenfeld, (2011): 'Achieving Construction Innovation through Academia-Industry Cooperation—Keys to Success'; J. Prof. Issues Eng. Educ. Pract., 137(4), 223–231.

Winch, G. (1998): 'Zephyrs of creative destruction: understanding the management of innovation in construction'; Building Research & Information, 26(4), 268–79

Winch, G. (2003): 'How innovative is construction? Comparing aggregated data on construction innovation and other sectors – a case of apples and pears'; Construction Management and Economics 21(6), pp. 651-654.

Wynn, M.; Jones, P.; Roberts, C; Little, E. (2008): 'Innovation in the construction and property management industries: Case studies of the knowledge transfer partnership scheme'; Property Management; Vol. 26 No. 1, 2008; pp. 66-78
