Case Study

Integration and Leadership as Enablers of Innovation in Construction: Case Study

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Abstract: Adopting innovations in construction is challenging due to the fragmented and project-based nature of the industry. As construction innovation is a joint activity with a number of participants involved in the process, it is essential to consider the role of interorganizational factors in implementing successful innovations. The aim of this paper is to investigate the components of the innovation process by placing particular emphasis on the enablers of, as well as barriers to, innovation adoption. A case-study methodology was employed to gain insight on how innovation is achieved within a construction project setting. Modern methods of construction and lean construction were adopted in the examined case concerning an urban regeneration project. The findings of the case study suggest that resistance to change, inexperience, and unavailability of advanced products were the main barriers to innovation adoption. The project team benefited from several mechanisms to overcome these barriers, including integration of the project participants and effective leadership. The case study is expected to help participants of the construction industry reflect on their innovation processes and thereby enhance the rate of innovation adoption. **DOI: 10.1061/(ASCE)ME.1943-5479.0000204.**

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Introduction

Recently, innovation has been at the heart of the knowledge-based economy (OECD 2005). Despite increasing attention, there is a lack of a well established definition and classification of innovation (Ozorhon et al. 2010). The Department of Trade and Industry (DTI) in the United Kingdom states that innovation is "the successful exploitation of new ideas" and that "it is the key business process to compete effectively in the increasingly competitive global environment" (DTI 2007). Innovation is defined in more detail as "the adoption of an idea or behavior, whether a system, policy, program, device, process, product or service, that is new to the adopting organization" (Damanpour 1992). Slaughter (1998) presented five models of construction innovation categorized as incremental, modular, architectural, system, and radical, which can provide a basis upon which companies can select and implement the innovations. *Incremental innovation* is a small change based upon current knowledge and experience, whereas a *radical innovation* is a breakthrough in science or technology that often changes the character and nature of an industry. According to Lansley (1996), the occurrence of innovation within the construction industry is often characterized by the widespread adoption of new practices as a result of advances in technological and business processes. Ozorhon et al. (2010) also concluded that construction innovations are incremental rather than radical.

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The construction industry always has been among the driving forces of the economy. However, it also has been criticized for its lack of efficiency and unwillingness to innovate in comparison to other industries (e.g., Egan 1998). Much of construction innovation is codeveloped at the project level (NESTA 2007), and therefore elements of innovation at the project level should be key to identifying the actual level of innovation in construction. However, most of the literature has focused on investigating innovation at the firm level, with the project level being largely ignored. This is mainly because of the difficulties in monitoring the different activities carried out by different parties in each stage of a construction project (Dulaimi et al. 2002; Blayse and Manley 2004). Besides, the role of participants in a construction project should be examined in the innovation process. As Reilly et al. (2002) suggested that cooperative relationships lead to better decisions and more creative ideas in new product development projects. There is a limited number of studies in the construction area dealing with interorganizational innovation that emphasize the importance of cooperation among the members of the construction network (Dewick and Miozzo 2004; Doree and Holmen 2004; Holmen et al. 2005; Rutten et al. 2009).

Studies so far have ignored the project conditions for fostering construction innovation. The major objective of this study was to investigate the key mechanisms to the successful adoption of innovation in a construction project by examining the role of different parties. In this respect, an award-winning urban regeneration project in the North West region of England was selected as a case study to gain greater insight into the interorganization aspect of innovation adoption. The case highlights the role of integration of the project participants and leadership as enablers of innovation within the project environment. The main innovations successfully adopted in this project include modern methods of construction (MMCs) and lean production. Although MMCs and lean production have been well-known practices for the last few decades, they can be considered as innovation since they are new to the adopting organization. The paper identifies the motivation behind the innovations, barriers to the adoption, enabling factors, and benefits derived through the innovations.

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Innovation Adoption in Construction Projects

The diffusion of innovation is defined as "the process by which an innovation is communicated through certain channels over time among the members of a social system" and "the process in which participants create and share information with one another in order to reach a mutual understanding" (Rogers 2003). Most of the research on innovation diffusion are based on Rogers's diffusion theory and mainly investigate the diffusion rate of different type of innovations within an industry. Construction is known as a low-innovation industry, with the adoption of previously developed concepts being more common. Some of the recent research in construction include diffusion of wall system innovations (Taylor and Levitt, "A new model for systemic innovation diffusion in project-based industries," working paper #WP086, Center for Integrated Facility Engineering (CIFE), Stanford University, Stanford); diffusion of computer-aided design (CAD) technology among architectural design firms (Kale and Arditi 2005); and diffusion of the ISO 9000 certification in the precast concrete industry (Kale and Arditi 2010). These studies have investigated the innovation diffusion among the members of the construction industry.

Much literature has focused on how construction companies manage the innovation process at the firm level since the principal drivers for innovation often are created at that level (Seaden and Manseau 2001). For example, Tatum (1987) described the technological innovation process within individual construction firms. He identified the following major elements of innovation as recognizing forces and opportunities for innovation; creating a climate for innovation; developing the necessary capabilities; providing new construction technologies; experimenting and refining; and implementing. Slaughter (2000) presented a detailed framework in which the six stages of innovation implementation activity are defined as identification, evaluation, commitment, preparation, use, and postuse evaluation. Dikmen et al. (2005) defined construction i nnovation as a system where the elements of the model are objectives, strategies, environmental barriers/drivers, and organizational factors. These studies discuss innovation management from an individual firm's point of view.

In order to understand how innovations are developed and implemented successfully throughout a construction project, it is essential to understand the role of each project participant, both individually and collectively (Ozorhon et al. 2010). Construction is a complex, diverse, and project-based industry. It is partly manufacturing (materials, components, and equipment) and partly services (engineering, design, surveying, consulting, and management) (Blayse and Manley 2004). Unlike other industries, construction involves production of unique projects on site by a variety of teams that are brought together temporarily. In addition, business processes are ongoing and repetitive, whereas project processes have a tendency to be temporary and unique (Gann 1998; Brusoni et al., "Mapping and measuring innovation in project based firms," CoPS working paper, Brighton, CENTRIMrSPRU). Therefore, the organizational context of construction innovations differs significantly from a great portion of manufacturing innovations (Slaughter 1998). Each participant in construction has a different responsibility and a role in the innovation process. For example, clients can act as a catalyst to foster innovation by exerting pressure on the project participants to improve overall performance, as well as by helping them devise strategies to cope with unforeseen changes (Gann and Salter 2000). They also might drive innovation by demanding high standards of work (Barlow 2000) and by identifying specific novel requirements for a project (Seaden and Manseau 2001). Although contractors are expected to introduce different types of innovations depending on their specialty areas, they tend to implement process and organizational innovations (NESTA 2007) and they are regarded as the adopters of innovation. Manufacturing firms are reported to invest far more in research and development (R&D) than contractors, and they are found to be more likely to develop product and process innovations (Gann 1997).

Construction projects involve the collaborative effort of multiple organizations. The same principle is valid for implementing construction innovations. As Mention (2011) states, innovation is the "outcome of an interactive process between the firm and its environment, as the result of the collaboration between a wide variety of actors, located both inside and outside the firm." Scholars argue that successful innovation often requires effective cooperation, coordination, and working relationships between the different parties in construction projects, such as the contractors, subcontractors, suppliers, architects, engineers, clients, the government, and universities (e.g., Ling 2003; Ozorhon 2013). Gann and Salter (2000) stated that project-based firms need to manage innovation across organizational boundaries, within networks of interdependent suppliers, customers, and regulatory bodies. This issue has been further investigated by Dewick and Miozzo (2004), who discussed the effect of positive interorganizational relations in the diffusion of sustainable technologies in the housing market. Holmen et al. (2005) emphasized the significance of building relationships for technological innovations. Rutten et al. (2009) presented a literature synthesis on the role of cooperation as an enabler of construction innovation. While these studies emphasize the need of strong interorganizational relations in enabling innovation, they do not analyze the project-specific conditions fostering innovation.

The research presented in this paper analyzed construction innovation at the project level by taking into account the roles of different participants. As mentioned previously, Tatum (1987), Slaughter (2000), and Dikmen et al. (2005) developed frameworks to examine construction innovation at the firm level. Therefore, they fail to explain the role of project conditions in innovation completely. This study benefits from a framework proposed by Ozorhon (2013) and employs it in a case study to better understand the innovation process at project level. The details of the framework are explained in the next section.

Research Methodology

In this research, a qualitative case study methodology has been employed to gain a better understanding of the mechanisms that enable construction innovations at the project level. Case studies try to answer the "how" and "why" questions via research, allowing a more in-depth analysis (Yin 1994). As suggested by Aronson et al. (2013), the case study method allows for highlighting the issues that are difficult to describe based on only empirical data. It is also possible to design the case study so that both secondary data (project-specific information) and primary data (experiences and opinions) are analyzed (Eriksson and Nilsson 2008; Zuo et al. 2013). The details of data collection in this study are explained next.

This paper is built upon the findings of a previous study done by Ozorhon et al. (2010), who investigated the ways in which innovation occurs in a project setting. The aim of this research was twofold: (1) to explore innovation practices within the construction industry and (2) to examine several components of innovation including the inputs, enablers, barriers, and outputs. In this respect, Centre for Construction Innovation (CCI) Northwest was chosen as a research collaborator. CCI is the regional partner of Constructing Excellence, which aims at enhancing the performance of the U.K. construction industry. It organizes the North West Regional Construction Awards every year, which recognizes projects that

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demonstrate best practices, with particular emphasis on innovation. In the first phase of the research, a questionnaire was administered to the applicants of the 2009 awards. The survey was followed by four case study projects that were chosen among the 17 award winners. For the case studies, an innovation framework was developed to analyze the determinants and outcomes of construction innovation process, taking into account the characteristics of the project environment, and interview questions were prepared accordingly.

Fig. 1 shows the framework modeling innovation process that is developed based on previous work (Ozorhon et al. 2010; Ozorhon 2013). The innovation process is represented as a system involving a number of interacting factors. The main components of this system are (1) the drivers (the need or main reasons) of innovation; (2) the inputs (resources, tools, and strategies) utilized to implement innovations; (3) the innovations; (4) the barriers that hinder the innovation process; (5) the enablers that facilitate the innovation process; and (6) the outputs of innovation that relate to the benefits at the project level.

Based on the innovation framework, the following issues were addressed during the interviews:

- Main reasons/drivers to innovate (client, regulations, end user, competition, performance requirements, technology, etc.)
- Major innovations introduced within the project (type of innovation and stage within the project life cycle)
- Inputs of innovation (human, financial, technical, and nontechnical resources, as well as internal/external knowledge sources)
- Barriers to innovate (such as cost and culture)
- Enablers, major tools/strategies employed to realize innovation (innovation policy, measurement system, strategies at firm and project level, etc.)
- Outputs of innovation (productivity, profitability, image, new markets, etc.)

The core focus of this paper is to discuss the mechanisms that enable the innovation process. In that respect, the innovation journey of an urban regeneration project was examined. The innovation process in this project was explored through a series of half-day interviews with three participants from the client and contractor organizations. The client was a registered social landlord often referred to as a "housing association." The participant from the client was a performance and quality manager. The participants from the contractor were a project manager and a business development manager. These participants were chosen for the interviews based on their roles in stimulating and achieving the innovation process within the project. Due to difficulties in interviewing other parties, such as the architect, supplier, and lean consultant, this set of interviewees provided the relevant information on the project and explained the innovative activities, placing emphasis on their relationships with the other parties.

In addition to the interviews, the client organization provided the application form and its appendices for the 2009 awards that describe the details of the project, innovations adopted, outcomes of the innovative activities, and achievements of the project. Company documents, including innovation policies and performance records on innovation, were shared by the contractor. These documents were examined before, during, and after the interviews. The transcribed recorded interviews, as well as company documents and the application forms for the awards, were used to generate the innovation story for the case study.

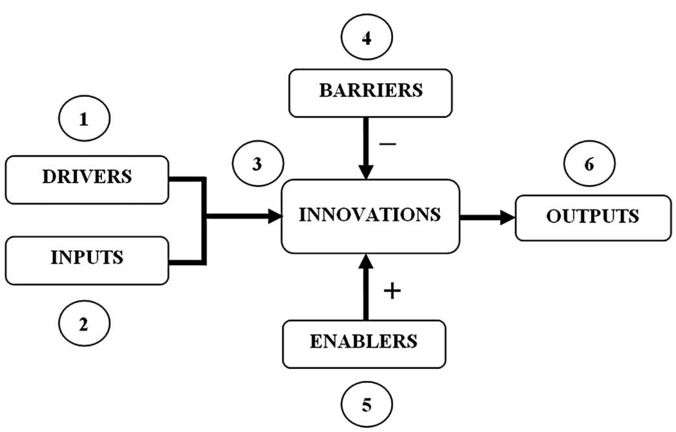

Fig. 1. The innovation process

The Case Study

The urban regeneration project investigated in this study was a unique 10-year partnering regeneration scheme as part of the vision for a sustainable future for the area. The scheme comprised of 12 phases, 8 of which are investigated in this study. The first 8 phases delivered over 500 units of new housing. The contractor, architect, consultants, and structural engineers were brought together in late 2001 and the project started in March 2002. Its contract value was £29 million. The project has received awards from various organizations in the United Kingdom, including "the best regeneration scheme," "the best partnering project," and "environmental best practice and sustainable development." The project also received the "best practice award" in the CCI 2009 Awards. As mentioned previously, the original research included four case studies. The main reasons for selecting this case among the others are as follows:

1. There are two innovations for the contracting organization in this project, so it has been challenging to implement both innovations in a single project.
2. This project has been undertaken by a partnership, so the integration of project parties is more visible.
3. The scale of the project is much bigger than the others, so the success or the failure of innovations was critical.
4. The contractor has an innovation plan and monitors the innovation activities. In this respect, it is a unique project because in other cases, innovation activities were not documented.
5. The project has become an exemplar that won numerous awards. Based on these reasons, the case offered rich information for analysis, and it is expected that lessons learned in this project will be helpful for future projects.

The innovation process is presented here based on the dimensions of the innovation framework in Fig. 1.

Drivers of Innovation

The project is notable for its use of a "client-driven" approach to innovation. Building regulation on social housing had a great impact on the processes and performance of this regeneration project. The U.K. government's initiative to create sustainable homes is specified in the Code for Sustainable Homes (CfSH) (DCLG 2006). This code requires the contractors to use innovative products in their construction processes in order to deliver the specified sustainability performance levels. Due to the recession in the private housing market in the United Kingdom, contractors and suppliers have diverted to social housing. Based on the CfSH, Housing Corporation promoted the increased use of MMC in social housing, particularly off-site manufacturing (OSM), as a key method for achieving higher sustainability performance within the construction industry. Sustainability and carbon reduction was

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a prime consideration for the analyzed case, so the project parties committed themselves to achieving high levels of environmental performance.

Inputs of Innovation

Inputs of innovation include the sources from which companies acquire knowledge on innovation; and financial and human resources utilized to initiate the process. The client was experienced in terms of MMC and introduced the idea of using closed timber frames to achieve sustainability in the project. Both the client and the contractor devoted resources from across their organizations to ensure that they understand and are able to deploy new technologies and techniques effectively as they emerge, ranging from renewable energy sources through sustainable housing solutions to MMC, to create high-value, low-cost solutions. They also employed consultants to aid in the development of methods and procedures to improve site processes. The contractor created an Innovation Plan, and based on this plan, they monitored and recorded the resources utilized for innovation.

Innovations

As mentioned previously, MMC was identified as a solution to enhance environmental sustainability performance of the project. Use of MMC introduced a necessity to adopt lean production as well, which emerged as the second innovation within the project.

Modern Methods of Construction (MMCs)

MMCs embrace a range of innovative construction methods that involve units manufactured off-site and on-site. Off-site manufactured MMCs involve volumetric, panelized, or hybrid frames (structural units), and prefabricated components such as roofs, slabs, and beams. On-site MMCs include a variety of innovative systems, such as tunnelform. MMCs involve both product innovation and process innovation. For example, closed panelized frames made of timber are innovative products since they deliver high environmental performance by using timber as a structural element. In addition, manufacturing these systems off-site is an innovative process.

Timber frame is the most environmentally friendly form of construction available that conforms to MMC and OSM principles. The Building Research Establishment (BRE) reported that modern timber frame construction produces near-zero carbon emissions (Reynolds and Enjily 2005). Timber frames deliver a number of other advantages, such as reduced construction time, higher-quality units, decreased cost, and enhanced thermal performance. The closed timber frames were used as the structural elements of the superstructure in the project among the many forms to choose from, including, volumetric, panelized, and hybrid systems. By using MMC, the closed timber framed and paneled units went from ground-floor slab to panels in place in just 12 weeks—half the time of a similar traditional build. The wall panels and floor cassettes were delivered to the site with windows and doors already fitted in the factory.

Lean Construction

Lean construction brings a new approach to project delivery; it is a "way to design production systems to minimize waste of materials, time, and effort in order to generate the maximum possible amount of value" (Koskela et al. 2002). The goal is to build the project while maximizing value, minimizing waste, and pursuing perfection for the benefit of all project participants. In order to apply lean principles fully in construction, the whole project life cycle needs to be improved. This can be achieved through various mechanisms applied in the design, procurement, construction, and operation phases.

The client had identified lean construction as a potential innovation during its R&D on MMC. Lean construction could save time and cost through eliminating waste and achieving continuous improvement of processes on site. The client employed a consultant on lean construction. Having observed lean construction as a promising method, it asked the contractor to adopt lean principles in the project. In this project, MMC required tighter and more reliable processes leading to the adoption of lean production principles. As mentioned earlier, the project consisted of eight phases. In the first three, the team did not benefit from lean production. The adoption of lean principles started at the fourth phase and continued until the end of the project. Lean construction may require more time in the design and planning phases, but this attention eliminates or minimizes conflicts that can change budgets and schedules dramatically. The team focused on identifying the activities that cause waste; they standardized the finishing processes and reduced the waste of materials on site, as well as wasted operations.

Lean construction is not limited to lean production in construction; it is also extended to lean project delivery systems. Lean construction principles include integration of project design with process design, empowering project participants in decision making, integrated teams of all project participants, and early involvement of parties in the process. The lean principles regarding project delivery were evident in many ways in the case study; integration of project participants as an example of this is discussed further below.

Barriers to Innovation

In the case study, adoption of innovations by the project team has not been free of challenges. Among the barriers to adopting MMC and lean construction were the inexperience of the work force, resistance from the contractor employees, and unavailability of advanced products on the market. Research on how to adopt MMC was initiated 10 years ago by the client by testing the sustainability performance of different timber frames available on the market. On the other hand, the contractor had no experience in implementing MMC. Based on the housing regulations to improve environmental sustainability, the client asked the contractor to adopt MMC in the project. However, implementing innovative methods was a challenging task for the contractor. The contractor has been specialized in traditional brick and block construction; hence, it had to change both the company processes and the company culture. Another barrier to adopting MMC was the limited supply of products complying with the requirements of CfSH. The number of the suppliers producing timber frames that could deliver required environmental performance levels was very limited. Based on the costs of developing such products, most of the suppliers were not willing to work with the team.

Enablers of Innovation

In the innovation framework, the factors that act as vehicles to mobilize the innovation efforts and to mitigate the negative impacts of the barriers are named as "enablers of innovation." The main enablers that helped eliminate these barriers in the case study were the integration of the project participants through the use of partnering between the client and contractor, which then was extended to the supplier, consultant, and the community; and the effective leadership of the client and the contractor, who committed to the adoption of innovations.

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Integration of the Project Participants

The inefficiencies identified in the "Constructing the Team" report by Latham (1994) point out the need for greater partnering and cooperation in the construction industry. This issue was discussed further in the "Rethinking Construction" report by Egan (1998). Egan emphasized the importance of committed leadership, focus on the customer, integrated processes and teams, a quality-driven agenda, and commitment to people as the key drivers of change in construction. Similarly, the "Lean Construction" report by Constructing Excellence (2004) in the United Kingdom emphasizes the role of integrated design-build arrangements, including partnering and supply chain management for increasing the effectiveness of the industry. Following the principles of these reports, integration throughout the project life cycle was achieved through partnering between the client and contractor, as well as through supply chain partnering.

- Partnering between the client and contractor: Partnering involves two or more organizations working together to improve project performance and organizational relations through agreeing mutual objectives, devising a way for resolving disputes, and committing themselves to continuous improvement, measuring progress, and sharing benefits (Egan 1998). Implementing new products (timber frames) and processes (OSM and lean construction) usually require intensive R&D, considerable investment, strong commitment, and collaborative partnering among the supply chain (Ozorhon et al. 2010). Since the construction industry is a conservative sector, it is difficult to change business processes. Adopting new principles and pushing the industry for innovation requires a cultural change as well. In this respect, mutual trust and teamwork was essential to ensure the successful diffusion of innovations in the case study project. The project team ensured that with the partnering approach in place through the procurement route, several steps were taken to establish trust and drive efficiency from the design process until the execution of MMC. Partnering provided the basis for project participants to adopt a "win-win" approach to solve problems and foster synergistic teamwork. One of the key decisions in this regard was early contractor involvement. Early contractor involvement is critical to establish a trust-based cooperative relationship in order to facilitate contractors' contributions in the design stage (Korczynski 1996). Increased integration and cooperation through early involvement of contractors is believed to help team members achieve efficient and value-adding solutions (Barlow et al. 1997; Briscoe et al. 2004). With the concept of partnering, the boundaries between organizations became less critical since the main objective was to share benefits. Upon the client's request from the contractor to adopt lean construction, the contractor seemed to be reluctant in the beginning. However, the client was determined to work on this with the contractor in order to reap long-term savings and benefits. They agreed to invest jointly in lean construction. The trust and good communication created through partnering enabled the joint utilization of resources. This was critical since it resulted in the efficient use of resources based on open-book accounting. The funding of this consultancy demonstrates both partners' willingness to engage other specialists that could help eliminate waste through the adoption of lean principles.
- Supply chain partnering: The client and contractor were strongly committed to environmental sustainability. In order to ensure the cost effectiveness of MMC, one of the critical steps was to secure a partnering agreement with the timber frame supplier. At the time that the project was undertaken, most suppliers could produce timber frames that meet CfSH Level 3, the standard required at the time. However, the client and contractor decided to look for a supplier that could meet Level 6, which would be introduced in the future. They managed to set up a partnering agreement with the only timber frame supplier they were able to identify that had completed its R&D on Level 6. This was critical since it is not easy to find the right product for a reasonable price in the market. Closed timber frame production results in higher unit costs for small suppliers. Large suppliers, on the other hand, are risk averse, so they are reluctant to change their operations process to comply with the demanding standards of CfSH. In this project, supply chain management has been an important support function for facilitating lean construction, and it has been based on effective communication of shared objectives of continuous improvement. Supply chain management integrates all parties contributing to the overall customer value into a seamless, integrated process (Constructing Excellence 2004). The basis for successful innovations started from the close relationship and integration of the project team. All members of the team, including key supply chain partners, were included in planning and programming as early as possible. The team met at regular intervals to deliver a quality scheme for the public; work together and maintain an enthusiastic team spirit throughout; communicate effectively with all those involved or affected by the scheme; ensure the achievement of best value for the budget; identify and implement innovative ideas and technology; and be considerate to the community and to the environment. This helped the team improve communication among them, ease coordination, and find effective solutions to problems. Another important ingredient of any successful regeneration partnership is the involvement of the local community. Residents of the regeneration scheme have been heavily involved in the regeneration process, as well as in the development of each individual scheme. Project team members have had the opportunity to establish positive working relationships with the local community and better understand the needs and wants of the residents affected by the redevelopment.

Leadership

Leadership has been referred to as one of the main enablers of innovation in the construction literature (Tatum 1987; Ozorhon et al. 2010). Previous research shows that leaders can play a critical role in shaping project spirit (Aronson et al. 2010, 2013). Effective leadership results in the project team committing to the project objectives (Aronson et al. 2006). According to Mention (2011), managers should put in place the mechanisms and tools that foster knowledge sharing within a group in order to facilitate innovation. The case study project revealed that effective knowledge sharing was essential in implementing innovation, not only in bringing the right ideas into the project, but also in ensuring that these ideas are communicated to the entire project team and incorporated into future projects.

The client's role as a leader was remarkable throughout the whole project. They guided the project team, first by engaging the contractor early in the project, and then by pushing it to innovate. In order to convince the contractor and overcome their reluctance, it shared its knowledge about MMC and shared half of the consultancy cost for lean construction. The client also was very interested in sharing its knowledge and best practices to lead the construction sector. It presented its experiences in several meetings with other construction professionals, and also played an important role in finding the right supplier and including the supplier in the partnership.

As Aronson and Lechler (2009) suggested, a project culture, which is constructive, entails a risk-taking, trusting, and proactive approach that encourages experimentation and open dialogue

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among the members. Therefore, in such a culture, members are receptive to change and innovation. Patanakul and Aronson (2012) found that organizational culture and team management competency have a significant direct effect on project success. At this point, the leadership of the managing director of the contractor organization should be noted. He acted as an innovation champion and created a culture in the company that facilitated innovation. Otherwise, the reluctance of the company members to change their routines could have prevented the adoption of innovative practices. The full commitment and strong leadership from the senior management was critical in this respect. Since the managing director showed such strong devotion to innovation, company resources and employees were well organized to create, share, and implement new ideas. This shows that open leaders empower their employees and encourage their creativity; they form an environment that is conducive for innovation (Aronson et al. 2008).

The contractor tried to foster innovation based on their business and innovation plan. It discovered and shared new insights, worked with clients to explore new areas, worked with suppliers and construction materials companies to test new products and technologies, and provided technical and managerial training to staff. It strived to innovate both individually and collectively and aimed at becoming a learning organization. The following list presents the activities undertaken by the contractor, which has shown strong leadership and commitment to facilitate innovation:

- A scheme called "Innovator of the Month" was introduced to reward individuals with exceptional contributions—i.e., individuals who resolved a client's concerns imaginatively and effectively, got excellent client feedback, delivered a great project successfully, had a great idea to save costs, improved productivity, made a significant contribution to profitability, generated new business opportunities, or just undertook a job with enthusiasm and commitment.
- Lunches were arranged with the chairman of the company every two months to allow personnel direct access to the top and to firmly establish the fact that there is no hierarchy or monopoly on the generation of ideas.
- A sustainability group was established to research innovation regarding environmental sustainability within the industry. This group communicated their findings within the organization.
- Collaboration with a university-based research center was established to conduct a thorough survey of housing client expectations and satisfaction levels.
- "Innovation Circles" were formed with the same university to bring together the supply chain in an open approach to sharing ideas and tackling problems (Lu et al. 2007).

Outputs of Innovation

The project team managed to achieve several benefits, including saving on project duration and associated preliminary costs; reducing the impact on the local community (e.g., transportation); reducing waste; creating a safer working environment; saving on foundation costs; fostering flexibility of design; improving quality; and having higher achievements under the CfSH. These benefits are the result of the joint use of MMC and lean principles that helped the team standardize the operations. The productivity and sustainability improvements were measured by the project team by comparing two very similar phases (in terms of size and type), one traditionally built and the other based on lean construction. According to their measurements, through the use of lean principles, considerable amounts of savings were achieved compared to the earlier phase of the regeneration scheme as follows: reduction in construction waste by 50%, noise level by 50%, meter square costs by 7%, total unit cost by 3%, timber frame costs by 16%, and project duration by 6%. There were also benefits for local residents, with reduced levels of vehicle movements and noise. Through a design focus on energy efficiency, the development received a rating of GOOD in the BRE Eco-homes accreditation. This means that energy and water bills will be reduced and reflect the special design attention paid to the use of sustainable materials.

Discussion

The case study findings indicate that integration of project participants is one of the main enablers of adopting innovation. The use of MMC and lean production in the project was driven by the client. There was resistance from the contractor and supplier side to invest in innovative products and processes. Regarding the contractor, the main difficulty was related to lack of familiarity with the new processes and lack of a supportive company culture. The contractor did not want to employ MMC and invest in lean construction. This problem was overcome through joint investment in lean consultancy. Regarding the supplier, mass production of a special product was risky and costly. Although the decision was made to adopt MMC, unavailability of the products was a significant problem. The team managed to find a supplier who had already completed its R&D on timber frames that could comply with CfSH requirements. Having established a partnering agreement with this supplier, they removed the product obstacle.

One of the lessons learned in the case is that a win-win culture and trust is developed based on the integration of project participants. This in turn leads to transparency of the boundaries between those participants, facilitating knowledge exchange and the adoption of innovations. This observation is in line with much research concluding that construction innovation can be achieved only by means of cooperation, coordination, and working relationships between the parties involved with the development of designs, products and processes (e.g., Gann and Salter 2000; Ling 2003; Holmen et al. 2005).

Another important ingredient of innovation success was the effective leadership of the contractor, which has been reported in the literature as one of the main enablers of construction innovation (e.g., Ozorhon 2013). In order to break the resistance to change in the construction firm, the managing director acted as an innovation champion; he introduced an Innovation Plan to stimulate innovation within the project. If the contractor had not been willing to become a learning organization and had not been fully devoted to implementing innovations, the innovation experience in this project could have been a failure rather than a success. Without the contractor being fully committed to innovation, the inexperience of the staff relative to initiating and implementing innovation, their reluctance to participate in the innovation process, their resistance to change, and the uncertainty about the results of innovation could not be turned into positive outcomes.

Through innovative activities, the team achieved a number of project-level benefits, including improved environmental performance, minimized waste, reduced costs, and shortened project duration. It should be noted that benefits were not achieved only at the project level. The innovation process had a positive impact at the corporate level as well. The project team received many awards for realizing such an exemplary regeneration scheme, enhancing company visibility and reputation. There was also an opportunity for the contractor to collaborate further with the supply chain members in the future based on the successful implementation of innovations. Another lesson learned is that innovation benefits are not only

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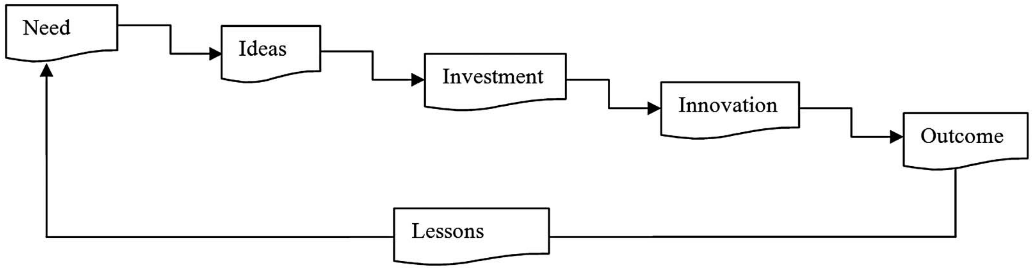

Fig. 2. The phases of innovation

short-term but also long-term; therefore, construction participants should be encouraged to get engaged with innovative activities.

Based on the findings of this research, the framework shown in Fig. 2 represents the steps of construction innovation. The critical phases of innovation can be characterized as Need, Ideas, Investment, Innovation, and Outcomes. All the members of the project team can identify their roles and responsibilities for each phase and plan their actions accordingly. In most projects, clients demand innovation; however, there might be a need based on problems faced during the project. Ideas should be generated in a collective manner by the project team. Depending on the type of innovation, project parties, including clients, suppliers, and contractors, should invest in R&D or receive consultancy, either individually or jointly. Contractors are the implementers of innovation. The innovation process is challenging, and it requires full commitment; therefore, contractors should apply the necessary mechanisms to overcome the barriers to innovation. After implementation, the final component of the process is the outcomes. Benefits should be measured by the contractor in order to see the return on innovation investment. Each innovation process offers lessons for all parties involved, and these lessons should inform the future projects. It is critical to create a team spirit in the beginning of the project and act together.

In a collaborative environment such as the construction industry, mechanisms that remove innovation obstacles are critical in ensuring the success of any innovation. A win-win attitude is necessary to take advantage of the innovations. Integrated teams overcome the issues related to the fragmented and adversarial nature of construction. The construction firms should concentrate on the longer-term benefits of innovation and overcome their resistance to learning new methods and applying them. Senior-level managers have an important role to play; they can act as innovation champions to create a suitable climate in their organizations to foster innovation. In this respect, research has shown how a leader can shape project spirit and in turn influence the project outcomes (Aronson et al. 2010, 2013).

Conclusions

The case of a successful regeneration project was discussed in this paper. Innovative activities were triggered by the client's requirements about sustainability that required MMC, and thereby lean principles. Building regulations shaped the way the client, contractor, and suppliers worked in harmony to implement innovations. The main conclusion is that adoption of innovative activities in construction requires the joint effort of the project participants. The stronger the relationship between the project parties, the better the results of innovation process will be; interorganizational cooperation supports the performance of innovation in the construction industry. This has been realized in the case study through partnering agreements along the supply chain and joint investment in lean consultancy. Another important factor to emphasize is the role of the effective leadership of the managing director, which indicates that innovation champions play a key role in seeing through the challenging innovation process. All in all, project environment should be conducive and open to increase the success of innovation adoption in construction.

A better understanding of the innovation process at the project level can be considered as the main contribution of the study. The individual and joint contributions of the project team were observed in this research, and thereby the interorganizational nature of construction innovation was illustrated. This work is based on a successful innovation implementation in a project undertaken in the United Kingdom, so the variables associated with the innovation performance reflects the conditions and relationships within the analyzed project. The research can be enriched further by detailed work involving more case studies to observe commonalities or differences in the innovation process. In addition, the findings of this case study and analysis of additional cases are expected to provide guidance in analyzing innovations in other project-based industries.

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