Innovation diffusion process in the Australian construction industry

W Wipulanusat1, K Panuwatwanich2, R A Stewart3, and J Sunkpho4

1 School of Engineering and Technology, Walailak University, Thailand
2 School of Civil Engineering and Technology, Sirindhorn International Institute of Technology, Thammasat University, Thailand
3 School of Engineering and Built Environment, Griffith University, Australia
4 College of Innovation, Thammasat University, Thailand

Email: wwarit@wu.ac.th

Abstract. Innovation diffusion process is an important component for construction companies to remain competitive in today’s changing business environment. The aim of this study is to examine how innovations in the Australian construction industry can be understood through innovation diffusion theories and empirical works. To achieve this goal, the author reviewed theoretical frameworks, and then analysed empirical works to shed light on the innovation diffusion in practice. The review found that effective innovation diffusion has played an important role in providing organizations with competitive advantages. From a socio-psychological perspective, leadership and team climate have had a direct effect on organizational culture, which indirectly impacts on innovation diffusion outcomes and business performance. Emphasizing the drivers and obstacles of innovation diffusion is also necessary to effectively develop a conceptual framework of innovation diffusion at project level which begins with knowledge and idea generation, and progresses to implementation and confirmation.

1. Introduction

Innovation is essential for the development of the industrial and economic sectors in Australia because being an important driver for the Australian economy, which is currently one of the fastest growing economies in the world and has witnessed dramatic changes in recent years. Because of these changes, policies on national and regional systems of innovation to encourage this adoption must be coupled with appropriate mechanisms to develop awareness of new innovations available, and to encourage and facilitate their appropriate exploitation [1]. The construction industry is an important sector contributing considerably to the economy of Australia. Therefore, the construction industry needs to adjust in order to innovate in delivering more effective social and economic infrastructure, and to find a more effective way to diffuse innovation.

2. Theoretical backgrounds

Innovation plays an important role in leveraging the competitiveness of companies operating in the construction industry. Stewart and Fenn [2] defined innovation as the profitable exploitation of ideas, practices and technologies novel to the organisation in seeking competitive advantage. Innovation in construction can, therefore, be regarded as the successful development and implementation of new and
significantly improved ideas, products, processes, practices and technologies related to their functionality and user characteristics, in order to increase effectiveness and efficiency in organisations. However, the construction industry is confronted with a complexity of project characteristics and technological constraints; therefore, there is a perception that this industry remains slow in adopting innovation, especially when compared to the manufacturing industry that is typically technology intensive, where innovations are rarely large scale or radical, and the adoption and implementation of innovations have been more extensive.

In contrast to manufacturing, construction is perceived as a service-based industry that is inherently labor intensive; thus, innovations in construction are small-scale incremental improvements in services or products. Also, they tend to be more ad hoc than in manufacturing firms as they are usually developed gradually from employee and manager ideas in response to challenges during the service delivery process [3]. Despite this perception, innovation in the construction industry does occur mostly in terms of physical processes and products, and particularly improvements in materials, such as new types of asphalt, concrete, or fiber composites, as well as new processes facilitated by information and communication technology (ICT) [4, 5]. Loosemore [3] developed a theoretical model of innovation in construction using the fifth-generation principles which described innovation in construction as a dynamic process of modification, starting with an organic approach in initial design and tender stages, and continuing to a more systematic approach during the delivery phase, in which tight budgets and programs demand focused discipline. Wipulanusat et al. [6] highlights the importance of organisations providing opportunities for their engineers to use a high degree of creativity and innovation for advancing their engineering expertise.

Innovation diffusion is defined as the process in which a new idea, concept, process or technology is disseminated by communication, relationships and the decision making processes involving acceptance or rejection across a social system over a time period [7]. The term ‘innovation diffusion’ is eclectically defined in this research as the process by which an innovation is adopted and implemented by firms in the construction industry until the expected users adopt and transfer the knowledge and experience of how to use the innovation. To achieve this process, it is imperative that firms understand how this action occurs within a complex social system of key stakeholders in the construction industry including, but not limited to: architects, engineers, contractors, subcontractors, academic research institutions and product development firms.

3. Study approach
Within the topic of innovation in the built environment, a literature review was performed in regard to the innovation diffusion fields that focus on the Australian construction industry. The examined papers consisted primarily of articles published by the largest world-wide specialists: Emerald, Science Direct (Elsevier), Springer, IEEE-Xplore. Search keywords were “innovation, innovation diffusion, innovation adoption, construction industry, and Australia.” The criteria for selecting studies were that the articles contributed to understanding of the factors influencing the innovation diffusion process, while ensuring the selected studies were of acceptable scientific quality. Once selected, the author then sorted the articles into two themes: innovation diffusion at organisational level and the innovation diffusion at project level. The aim of this study is to explore how innovations in the construction industry can be understood through diffusion of innovation theories and empirical works. To accomplish this aim, previously proposed theoretical frameworks and models were critically reviewed; then, empirical works were analyzed to interpret the innovation diffusion literature.

4. Innovation diffusion in the Australian construction industry
Construction scholars have conducted many studies investigating innovation diffusion in the Australian construction industry. For example, Peansupap and Walker [4] identified factors that were found to influence ICT diffusion and adoption in large Australian construction organisations, and grouped these into management, individual, technology and workplace environment categories.
4.1. Innovation diffusion at organisational level

In an attempt to provide a better understanding of the innovation diffusion phenomena from a social perspective, a study was conducted by Panuwatwanich et al. [8] to empirically investigate the impact of the socio-psychological process of innovation diffusion on business performance within architecture and engineering design (AED) firms. Panuwatwanich et al. [9] also investigated innovation diffusion in Australian design firms by studying 181 architectural and engineering design professionals and identified that socio-psychological factors, which might influence innovation diffusion within AED firms, could be divided into three factors: leadership, team climate, and organisational culture.

Each socio-psychological factor has a different role in innovation diffusion within an organisation. A leader plays an important role in inspiring creativity and challenging staff to promote the development of new ideas in the diffusion process which will lead to the innovation initiative in an organisation [9, 10]. When ideas are encouraged and challenged, staff are more likely to be aware of problems and think of new ways of working. A team climate where members actively support each other in developing innovative ideas is considered another requirement for innovation. This climate provides an important motive and determinant to achieve innovative behaviour of staff within the organisational context [8, 11]. The final socio-psychological factor which is an essential element for the successful diffusion of innovation is having an innovation culture within an organization [12]. Within such a culture, creative ideas are more likely to be transformed into innovative solutions, and the adopted innovation is more likely to be diffused because staff perceive encouragement and support from their firms [13].

![Figure 1. Empirical model for innovation diffusion at organisational level [8]](image)

Panuwatwanich et al. [9] also found that the socio-psychological factor of leadership and team climate influence perceptions of the third factor, an organisation’s culture for innovation, which this triad of factors subsequently impact on innovation diffusion as well as business performance as shown in Figure 1. Innovations such as innovative design solutions have a high impact on client satisfaction because the client can appreciate the benefits from the innovative design products when the value of the innovation has been made explicit [9]. As client satisfaction is a critical indicator of business performance, firms should strive for high levels of client satisfaction. This can be achieved by innovation in the firm. Evidence to support this link between socio-psychological factors and innovation diffusion was derived from quantitative and qualitative studies, with data collection methods including survey, documentation analysis, and case studies based on triangulation using multiple sources to ensure the validity of findings [9].

In order to evaluate the innovation diffusion maturity levels within the AED firms, Innovation Diffusion Readiness (IDR) was conceptualized on the basis of three socio-psychological factors; namely, leadership for innovation, team climate for innovation and organisational culture for innovation [14]. The key findings showed that the overall level of IDR among the sampled firms was
moderate to high. Using cluster analysis, three main clusters were uncovered: Very High, High, and Moderate IDR. Further analysis indicated that the higher IDR clusters appeared to perform significantly better in diffusing innovative design practices. This finding highlighted that when the firms shifting to a higher IDR cluster, they could achieve a significant improvement in the diffusion of innovation [14].

4.2. Innovation diffusion at project level

Another important factor regarding innovation diffusion highlighted by Rose and Manley [5] is the vital role of governments in promoting the steady flow of product innovations relevant to the Australian construction industry across the supply chain. Despite this strong supply of product innovations, adoption rates in the Australian construction industry remain low, due to six key obstacles that hinder the adoption of innovative products: project goal misalignment; client pressures; weak contractual relations; lack of product trialing; inflexible product specifications; and product liability concerns [5]. Thus, construction firms need to overcome these major barriers to innovation diffusion if they are to be successful.

Rose and Manley [7] also investigated innovation diffusion in the Australian construction industry, drawing on an innovation diffusion model and developing a tailored conceptual framework to guide future empirical work aimed at assessing innovation diffusion in the project-based context. One important aspect of the framework is that the design and operation of innovation diffusion should be dependent upon its intended audience, as what is suitable for innovation diffusion for large firms may be unsuitable for small firms. Hence, input from these studies on how innovation diffuses within an organisation, can assist firms to overcome the complex challenges of innovation diffusion in construction. The conceptual framework consists of five stages: knowledge and idea generation; persuasion and evaluation; decision to adopt; integration and implementation; and confirmation as shown in Figure 2.

![Figure 2. Conceptual framework of innovation diffusion at project level [7]](image)

In the first stage, staff acquire an understanding of an innovation. From a construction innovation perspective, Winch [15] explained that innovation derives from two approach; in the top-down approach, new ideas are adopted by organisational executives; in a bottom-up approach new ideas are generated by team members who have solved the problems during a construction project and gained lessons later in the procurement process. At the second stage, staff determine the advantages or disadvantages of an innovation depending on three measures [7]: the relative advantage in which an innovation might be better than existing practices; compatibility, which considers whether an innovation is perceived to be consistent with the existing values and objectives of the potential adopters; and complexity, the degree to which an innovation is perceived as difficult to understand and apply. The choice for construction firms to adopt innovations can be determined by these three measures.

At the third stage, the decision to adopt, companies decide to adopt or reject an innovation according to the consequences of the selection [7]. Subsequently, an innovation is implemented, and then, the benefits are considered in regard to expanding on a wider scale but its application may be discontinued if poor performance is experienced. It is expected that this framework is expected to improve
understanding of innovation diffusion processes on construction projects. Each stage of the conceptual framework is influenced by two elements which are, the internal capacity of team members to consider and implement an innovation according to their past experience and practice, as well as the relationships between organisations which impact the efficiency of knowledge sharing among firms [7]. As a result, these two elements will impact the effectiveness and efficiency of the innovation diffusion process in an organisation.

To assess the effectiveness and efficiency of the innovation diffusion process in the context of construction, Rose and Manley [7] also proposed three measurement constructs to modify their tailored framework for the built environment. The first measurement construct is the innovation characteristics which affect the capability of team members to adopt and understand the innovation. The second measurement construct is capacity of adoption, which refers to the learning performance of organisations. The third measurement construct is speed of adoption, which measures the pace of the implementation of innovation activity in construction firms. Data obtained from these measurement constructs will enable informed policy advice to assist in maximizing the potential for innovation diffusion in construction firms.

In order to interpret their framework, Rose and Manley [16] conducted a quantitative survey to rank the relative importance of the obstacles constraining the adoption of innovative products in Australian road infrastructure projects. The three most important obstacles to address are: overemphasis on upfront project costs during the tender stage; disagreement over who carries the risk of new product failure; and adversarial contract relations. It is important, therefore, for construction firms to focus on procurement systems and industry relationships in order to overcome these obstacles and shape the opportunities for innovation diffusion.

To analyse the support role of clients for improving innovation diffusion in the procurement process, Loosemore and Richard [17] conducted research based on 46 interviews with Australia’s leading construction clients, contractors and consultants. The research revealed that many clients were unwilling and unable to employ strategies to foster more innovation because of internal governance constraints, a lack of tools and insight to evaluate innovation in tenders, a poor understanding of how built assets contribute to core business objectives, and a narrow understanding of their central role in driving innovation. The importance of client leadership in driving, encouraging, and facilitating more innovation should be more valued in the construction sector. This can be achieved by clients deploying an integrated project strategy that allows scope and time for innovation to occur, encourages collaboration and early involvement, and distributes risk and opportunity in a balanced and transparent manner [17].

5. Conclusion

Innovation is a dynamic activity that can develop the value of ideas, practices, and technologies through the generation and implementation of new knowledge. Innovation is a significant element for the Australian construction industry to remain competitive in today’s changing business environment. Despite a perception that the construction industry is not innovative, there is an evidence of innovation diffusion across construction organisations. Greater attention is required to better understand the role and characteristics of innovation diffusion as elements of firm-level strategies within the complex and interdependent construction industry. Effective diffusion of innovation is essential for construction companies to obtain competitive and operational benefit which can be achieved by completely comprehending the innovation diffusion process. Within this process, there are potential drivers and obstacles to recognize and address. Emphasizing these drivers of and obstacles to innovation diffusion is important in order to effectively develop a conceptual framework of innovation diffusion which starts with knowledge and idea generation and ends in implementation and confirmation. Achieving successful innovation diffusion outcome and business performance is dependent on leadership, team climate and organisational culture. Thus, the adaptation of a conceptual framework of innovation diffusion to the construction context can enable construction companies to integrate information,
knowledge, and technology to respond to the emerging demands of the Australian construction industry in the future.

References
[1] Aouad, G., Ozorhon, B., and Abbott, C., "Facilitating innovation in construction: Directions and implications for research and policy," *Construction Innovation*, vol. 10, pp. 374-394, 2010.
[2] Stewart, I. and Fenn, P., "Strategy: the motivation for innovation," *Construction Innovation*, vol. 6, pp. 173-185, 2006.
[3] Loosemore, M., "Construction innovation: Fifth generation perspective," *Journal of Management in Engineering*, vol. 31, pp. 1-9, 2015.
[4] Peansupap, V. and Walker, D., "Exploratory factors influencing information and communication technology diffusion and adoption within Australian construction organizations: a micro analysis," *Construction Innovation*, vol. 5, pp. 135-157, 2005.
[5] Rose, T. and Manley, K., "Adoption of innovative products on Australian road infrastructure projects," *Construction Management and Economics*, vol. 30, pp. 277-298, 2012.
[6] Wipulanusat, W., Panuwatwanich, K., and Stewart, R. A., "Pathways to workplace innovation and career satisfaction in the public service: The role of leadership and culture," *International Journal of Organizational Analysis*, vol. 26, pp. 890-914, 2018.
[7] Rose, T. and Manley, K., "Measurement constructs to explore innovation diffusion in construction," in *Proceedings of the Construction, Building and Real Estate Conference*, 2012, pp. 354-362.
[8] Panuwatwanich, K., Stewart, R. A., and Mohamed, S., "The role of climate for innovation in enhancing business performance: The case of design firms," *Engineering, Construction and Architectural Management*, vol. 15, pp. 407-422, 2008.
[9] Panuwatwanich, K., Stewart, R. A., and Mohamed, S., "Critical pathways to enhanced innovation diffusion and business performance in Australian design firms," *Automation in Construction*, vol. 18, pp. 790-797, 2009.
[10] Wipulanusat, W., Panuwatwanich, K., and Stewart, R. A., "Exploring leadership styles for innovation: an exploratory factor analysis," *Engineering Management in Production and Services*, vol. 9, pp. 7-17, 2017.
[11] Wipulanusat, W., Panuwatwanich, K., and Stewart, R. A., "Workplace innovation: Exploratory and confirmatory factor analysis for construct validation," *Management and Production Engineering Review*, vol. 8, pp. 57-68, 2017.
[12] Wipulanusat, W., Panuwatwanich, K., and Stewart, R. A., "Statistical data analysis of culture for innovation using an open data set from the Australian Public Service," in *Lecture Notes in Computer Science* vol. 10365, ed. Cham: Springer 2017, pp. 78-89.
[13] Panuwatwanich, K., Stewart, R. A., and Mohamed, S., "Validation of an empirical model for innovation diffusion in Australian design firms," *Construction Innovation*, vol. 9, pp. 449-467, 2009.
[14] Panuwatwanich, K. and Stewart, R. A., "Evaluating innovation diffusion readiness among architectural and engineering design firms: Empirical evidence from Australia," *Automation in Construction*, vol. 27, pp. 50-59, 2012.
[15] Winch, G., "Zephyrs of creative destruction: understanding the management of innovation in construction," *Building Research & Information*, vol. 26, pp. 268-279, 1998.
[16] Rose, T. and Manley, K., "Revisiting the adoption of innovative products on Australian road infrastructure projects," *Construction Management and Economics*, vol. 32, pp. 904-917, 2014.
[17] Loosemore, M. and Richard, J., "Valuing innovation in construction and infrastructure: Getting clients past a lowest price mentality," *Engineering, Construction and Architectural Management*, vol. 22, pp. 38-53, 2015.