

THE INFLUENCE OF LEADERSHIP, RESOURCES AND ORGANISATIONAL STRUCTURE ON BIM ADOPTION

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Building Information Modelling (BIM) affects the construction processes and at the forefront of digital innovation. BIM allegedly carries benefits for better collaboration and less cost. BIM attracts the attention of numerous large and small firms that update their strategies to embrace this digital shift. However, construction firms face challenges to BIM adoption. There is a close relationship between BIM adoption efficiency and enterprise strategy, which is a key BIM adoption driver. After studying three Dutch and one Finnish firms to understand their BIM adoption history and strategies; enablers and barriers for business model innovation due to BIM were observed. Drawing upon empirical data and organisational, and innovation theories, this paper discusses points for BIM business model innovation. First, leadership commitment was decisive for attaining BIM adoption goals. Second, small firms did better than large firms in BIM adoption, as they met their financial goals and growth with less risk. Third, flexible organisational structures were resilient to meeting BIM changes. The study outlines implications for policy-makers and enterprises who have or plan to adopt BIM and adds to the knowledge base of BIM innovation adoption.

Keywords: BIM adoption, innovation, strategy, leadership, business models

INTRODUCTION

While there is no universally acceptable definition of Building Information Modelling, it can be defined as tools, processes, and technologies that are facilitated by digital, machine-readable, documentation about a building, its performance, its planning, its construction, and later its operation (Eastman *et al.*, 2008). BIM has been considered a solution to construction industry fragmentation, inefficiencies, poor project coordination and information management problems (Eastman *et al.*, 2008). In a BIM-based project delivery, input from the various design disciplines, contractor, suppliers and subcontractors can be sought early in the design process, visualised and the potential coordination problems could be detected and resolved. This process requires close and continuous collaboration among project actors. The promise of BIM and its associated technologies and processes, is that it can integrate the team and facilitate high-quality work. Despite the acclaimed benefits, the level and rate of adoption of BIM by construction actors vary across professional disciplines and countries. Generally, the implementation of any technology largely depends on issues such as change management within the organisations adopting it (Thong *et al.*, 1994). In this regard, Tornatzky and Fleischer (1990) suggested that enterprise management-related issues, e.g. organisation issues such as leadership, human resources management, corporate vision etc., would

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impact technology adoption rate and success by companies and the impact would be different for large and small-medium sized (SME) organizations (Prananto *et al.*, 2003). Kimberly (1976) argued that availability of specific resources is a better way of understanding adoption decision and progress instead of organizational size. The extent to which firm size would impact the capabilities to innovate has also been a subject of discussion in both construction management (Dainty *et al.*, 2017) and diffusion of innovation literature (Rogers, 2003, Barrett *et al.*, 2008).

In their critical review, Dainty *et al.* (2017) suggested that BIM uptake is 'likely to be more problematic for smaller firms without the resources and capacity to invest in the technology'. Arayici *et al.*, (2011) argue that SMEs have little to gain from BIM. For Jaradat and Sexton (2016) construction management research has favoured BIM adoption in large practices and megaprojects. It appears that BIM is only suitable for large organisations. However, there is little empirical evidence to support this. Meanwhile, the role of SMEs in diffusing BIM innovation is crucial for the integration of the supply chain and productivity across the industry as they are involved in every stage of facility life cycle including operations and maintenance. Given that SMEs account for a large proportion of the construction firms in many countries, the need to consider SME's perspective in BIM policy effort has been advanced by researchers (Dainty *et al.*, 2017).

From technology adoption theory, innovation diffusion theory and economics perspective, the role of SME in innovation is complex and needs further exploration especially in relation to BIM. This study will contribute to the debate in this area by examining enterprise management and organisational issues influencing widespread and best practice adoption and implementation of BIM, beyond organisational size. At the same time, the influence of the external environment on the enterprise management will be highlighted to provide context.

THEORETICAL FRAMEWORK

Adoption Trends of BIM as an Innovation

BIM is an innovation for construction industry (Arayici *et al.*, 2011) and various scholars are problematizing around its diffusion across countries (Wong *et al.*, 2010, Dainty *et al.*, 2017). There is anecdotal evidence that BIM adoption is still rather patchy despite the growing public sector mandate in many countries. Ramilo and Embi (2014) identified technological, financial, organizational, governmental, psychological and process barriers to BIM-related innovation in firms. Although, BIM brings a promise of a new way of doing things effectively, it could expose the firms adopting it to risk of business failure, as they would need to change their processes (Ramilo and Embi, 2014). Through this process of change, the firms' capabilities are challenged and tend to be below expectations. Apparently, BIM adoption would not immediately translate into more business (Khemplani, 2004). In the absence of large enough immediate gains, adoption attitude and investment would depend on long term corporate strategy and vision, which could in turn influence commitment, and investment in- and development of- BIM capabilities. BIM visions may entail BIM use to achieve automational, informational or transformational effects (Fox and Hietanen, 2007). Automational effect is the substitution of digital technology for labour to improve productivity, whereas informational effect is the capacity of BIM to collect, store, process and transmit information (Ibid.). Transformational effect is strategic and is the use of BIM to innovate and transform business and the supply chain to gain competitive advantage (Ibid.). For the reasons above, BIM adoption decisions may vary between large and small firms.

Scholars linked the differences between BIM adoption by large and SMEs to the notion of '*digital divide*' in which Information Technology (IT) implementation is seen to be hindered by motivation, material access to technology, lack of skills, and lack of usage access in terms of getting opportunity to work with the technology and these are seen to be creating a gap in adoption rate between the SMEs and large firms (Dainty et al., 2017). The gap can also be explained by resource-based theory which suggests that when compared to large firms, small firms are constrained by resources to innovate but this could be compensated for by the agility and flexibility of small firms which promotes innovation due to the ability to identify and meet customer needs in a difficult business environment (Chen and Chen, 2013).

However, if such innovation is incremental - that is through small improvements (Abernathy and Clark, 1985) - it may not give SMEs any competitive advantage and may be costly, inefficient and short lived. Using current firm resources may be risky and lead to failure. Nevertheless, Chen and Chen (2013) discovered that small firms that continuously utilize and invest in innovation resources, can gain competitive advantage and in turn secure further external resources (investment) to mobilise next into differentiating their product or services. In the context of BIM, it would appear that only a strategic and transformational BIM agenda can benefit small firms on the long run and may be a determinant of significant investment in BIM. However, Acar *et al.*, (2005) concluded that attitude towards IT is not different between large and small construction firms because IT is often not considered as strategic. For these reasons, it is likely that BIM adoption would be influenced by interaction between leadership, innovation resources, and organisational structure.

Drivers of Innovation Adoption

Diffusion of Innovation (DOI) theory (Rogers, 2003) and Technology-Organization-Environment (TOE) framework (Tornatzky and Fleischer, 1990) are two relevant and developed for explaining the drivers and dynamics of innovation at the organisational level. Rogers (2003) DOI theory identified four elements of innovation: (1) the innovation itself, (2) communication channels, (3) time, and (4) social system. Considering innovation as an idea, practice, or project that is perceived as new to the organisation there is need for knowledge and persuasion about the innovation before it can be adopted. Diffusion is the process by which an innovation is communicated through certain channels over time among the members of a social system (Rogers, 2003).

When looking at BIM as innovation, communication channels within and across firms and organizational structure would influence its adoption. The DOI theory further identified five forces that influence the rate of innovation adoption (1) relative advantage (2) compatibility (3) complexity (4) trial ability (5) observability. During diffusion process these forces decrease uncertainty about the innovation. Relative advantage is the extent to which an 'innovation is seen as being better than the idea it supersedes'. Complexity is 'the degree to which an innovation is perceived as relatively difficult to understand and use'. Compatibility is the 'the degree to which an innovation is perceived as consistent with the existing values, past experiences, and needs of adopters. For example, the compatibility of a firm's existing and innovative software and BIM software may influence BIM adoption decisions and rate. Trial ability is the 'degree to which an innovation may be experimented with on a limited basis'. For example, firms that implement BIM on pilot projects, learn over time and BIM adoption rate increases. The

trials may also lead to reinvention or modification of organisational processes and technology.

The Technology-Organization-Environment (TOE) (Tornatzky and Fleischer, 1990) identifies three contextual aspects that could affect technology adoption process and decision-making: technology, organization, and environment. Technology entails internal and external technologies available to the firm. Technology itself is merely a physical tool, humans have to interact with it to know the purpose of using it, how to operate the tool, and the impact of using it (Arpaci *et al.*, 2012).

Internal technology is already natural to the firm, while external technology is available in the market. Technology availability as well as the features of the technology themselves can influence its innovation adoption process. External technology could provide the organization a vision about what is possible and could impact the adoption process. There may be external technological innovations that could produce incremental or disruptive changes (Tushman and Nadler, 1986). Incremental innovations (small improvements) are least risky as they present little change for the firm. For example, the change from paper-based designing to AutoCAD was incremental as it did not disrupt the existing processes. With BIM, adapting to both new BIM tools and workflows is needed.

Disruptive change leads to fundamental change in the organizational processes, workflow and culture. The 'organizational' context of TOE framework refers to the characteristics, resources and descriptive measures of an organization such as firm size, organizational structure (complexity of managerial structure of the top management), the quality of its human resources, and the amount of slack resources. It also includes informal decision making and communication process between employees. Formal and informal mechanisms that link units within an organization would facilitate the communication and knowledge sharing about new innovation.

It is reasonable to expect that smaller organization may find it easier to adapt to change process when compared to larger organizations. Of course they may be constrained by other factors such as lack of resources. Larger organizations would require more formal links to facilitate the communication and knowledge sharing about the new technology. It is also likely that organic and decentralized organizational structure (with least hierarchy) would progress more quickly in the adoption process (Lam, 2011), as there is lateral communication across such firms. This means that the role of top management in creating an organizational context to support adoption is critical for success.

Top management has to support change; communicate the need for change as well as motivate the entire organization into change and define the organization's vision for the change. They need to make resources available for implementing change including the building executive team to support the change at all levels. In the literature, there is inconclusive evidence to suggest that organizational size and availability of slack resources (unutilized resources) influence adoption (Rogers 2003). Kimberly (1976) argued that availability of specific resources is a better way of understanding adoption decision and progress instead of organizational size. The external 'E' 'environment' context of TOE framework assumes that to adopt a new technology an organization needs to interact with other external elements including business partners, clients, the industry, competitors, regulations, and relationships with the government. Drawing upon the afore-described forces for diffusion of BIM innovation and the TOE framework, this study used empirical data from firms engaging in BIM innovation to respond the question: How do enterprise management aspects, such as leadership, resources, and organisational structure influence BIM adoption by firms?

METHOD

The study followed an interpretive approach to understand how firms adopt BIM. The line of reasoning was inductive, by gathering and analysing a number of data sources to make sense of the relation between enterprise management and BIM adoption. Primary data were obtained from face-to-face interviews of eight individuals from four firms in the Netherlands and Finland about BIM adoption history and experience. Secondary data were collected about the firms' history and identity. The firms were part of a larger pool of twenty construction industry firms in North-west Europe, recruited from a snowballing technique, which were studied for the same objectives. Thus, the case selection was purposeful and these four cases were selected for having a push approach towards innovation, and for evidencing various elements of leadership, resources, and organisational structure. These firms (cases) were diverse in size, services offered, and context. Table 1 shows their key features and research settings:

Table 1: Firm characteristics, interviewees, and context of the study.

	Firm A	Firm B	Firm C	Firm D
Country	Finland	The Netherlands	The Netherlands	The Netherlands
Type of services	Architectural	Contractor firm	BIM Consultants	Lifecycle Consultants
Size of firm	SME - 15 staff	Large	SME - 50 staff	SME - 50 staff
Age of firm	10 years	230 years	9 years	23 years
Interviewee 1	Founder	BIM Specialist	BIM Architect	Director/owner
Interviewee 2	Founder	BIM Manager	-	BIM Consultant

The primary data were collected through semi structured interviews of 90-120 minutes, which were later transcribed verbatim. The interview questions were about the identity of the firms, their history, challenges and strategy of BIM adoption, progress and future vision for BIM. The secondary data included observations of the firms' work practice, firm policy documents, company websites, press, and slides by the companies. The analysis of the interviews was based on thematic analysis (coding) of the transcripts. The content of the interviews was examined for meaning and themes were identified through interaction between data and theoretical framework.

FINDINGS

Corporate Vision and Strategy

The four firms had varying visions and strategies for BIM adoption. Firm A was an architectural SME, established in 2007, only working in BIM. All projects are in BIM whether or not it is required by the client. Although the founders have worked in other firms using 2D, they envisioned BIM as the future of design tool and process. To them, BIM does not change the time for completing a project but changes the way the time is used on various activities over project life cycle. According to the founder, "we started our company and made BIM part of how we work. For us we wanted to make sure that we take into account future of design as process and tool and our objective is also to improve our process". Because they were proactive of clients' request, their vision could be characterised as transformational, informational and automational. Firm B, a large company with 25 subsidiaries, specialising in various projects, had a vision to use BIM on only large and especially integrated projects. As subcontracting had become an important aspect of their projects, they envisioned that information management would become their core business. In their vision statement BIM is an object-oriented communication

and information platform. The BIM specialist stated: “we wanted a good platform for information sharing”, which relates to informational and automational BIM vision. Firm B focused on small and incremental changes enabled by IT with no significant change to existing inter-organisational roles.

Firm C, an Architectural and Structural design SME, started using BIM by accident while helping another firm to prepare drawings for a project. Their client (another architectural firm) demanded for it and during the exploration process they discovered the benefit and made BIM their mainstream practice. A BIM vision was articulated and written down. They used BIM to capture information from the client and throughout the project lifecycle. They wanted BIM to improve the design quality delivered to clients and they had an unintentional and transformational BIM vision.

Firm D, a lifecycle consultant SME, envisioned BIM as an approach for transforming the building process and their business. They wanted to make a difference by using BIM for integrating their modelling with their cost management expertise. The intention was to develop a more efficient building process and get ahead of other players in the market. They envisioned the use of BIM collaboration to satisfy client’s needs and secure business. They have trialled a new business model with BIM. The Director said: “We wanted to do things differently and be ahead. We wanted to marry our modelling knowledge and cost knowledge together. We wanted to share knowledge through 3D models instead through people’s head”. This was a transformational, informational and automational BIM vision.

Leadership commitment

The two founders of Firm A started using BIM in late 1990s and early 2000s. While the company was not built around BIM, they committed to using BIM as the only way of working right from the outset of the new firm. BIM knowledge is the major criterion for all new recruits. The founder stated:

...we employ only those who are BIM ready. We engage those who have used it on projects and it paid off. Although, we have a few who have not used it a lot but we put them in the midst of large number of people who are very proficient with it and so we don’t have to worry

The BIM vision of Firm B was written by the Board of Directors. Despite being hit by recession; they were committed to making BIM a culture among 2500 employees. The Board set up a BIM Centre - the only initiative within the company centrally funded by the board. Firm B also established a steering group with directors from the 25 subsidiaries. The group develops yearly plans, then consolidated in one by the BIM Centre. Prior to that, BIM implementation was decentralised across 5 locations, which was proven inefficient.

For Firm C, although BIM use was unintentional, in 2007/2008, they committed to its full adoption. Disregarding staff resistance, a top down approach was adopted whereby all employees were required to use BIM within 3 months. Upon realising this was utopic, the management focused on those that are willing to work (10%) with BIM and progressively expanded BIM adoption to other employees.

The director and owner of Firm D has been working in construction for 45 years as cost manager. Originally, the core business of the firm was cost estimation and management. In 2006, to differentiate their business, 3D modelling expertise was added to its core business which is then used to extract quantities for cost estimation.

Investment in innovation resources

The firms had varying approaches to investing in BIM. Firm A only hired employees with BIM experience in real-world projects. They did not charge clients extra fees for BIM use on projects. They were also proactive in green building certifications. They partnered with another firm, collocated in the same building, on virtual reality to enable concurrent design and communicate it to the clients via 3D glasses.

Firm B invested €650,000 yearly on their BIM Centre for coordinating BIM company-wide. With 8 staff, the centre focused on R&D, methods, manuals, guidelines, developing information exchange protocols, and discussions about information structure such as standardization company-wide, and staff training across her 25 subsidiaries. They also invested in laptops and connecting all sites to firm's network. The BIM Centre is involved in national and international BIM initiatives. They have collaborated with major software developers to drive the development of new BIM applications. They led 40 other firms (private and public) to work on object library together with industry and public government.

Firm C replaced their existing software and invested in BIM tools. They invested in research and training of staff using external trainers for design and early-stage cost estimation. An innovation team of 5 people was established to drive the BIM vision. At the outset of BIM adoption, temps were employed on contract basis to work on traditional projects, while permanent staff were working on BIM. In Firm D, an innovation manager eased the adoption process. An in-house BIM manager was hired to manage the BIM process. They also developed and now sell their own online tool for linking 3D models to cost to other BIM authoring software in a less complex way. Cost libraries, and databases as well as methodologies for modelling and work requirements were developed. Staff were trained in-house. To facilitate the subcontracting process, an integrated online platform was created so that each sub-contractor can upload their models online. Because of their vision to transform the building process free workshops were organised to train clients and business partners about BIM. The firm leads industry initiatives on BIM.

Organisational structure for innovation diffusion and Informal Aspects

Firm A consciously retained a small firm size, as they believed that it facilitates BIM adoption. It was easy for them as an SME to find knowledgeable staff to train others. Firm B has 25 subsidiaries in various locations. Decentralising BIM adoption into five branches was found to be inefficient. Thereafter, a centralized approach was adopted by establishing the BIM Centre to cater for the BIM adoption needs of all subsidiaries. Firm C unsuccessfully adopted a top down BIM adoption structure at the outset. Then, they adopted a flexible and organic approach whereby staff are first trained in BIM and then embedded within the firm. The BIM Architect stated:

If management does not support it, don't do it and even if management order it and want it and staff don't want it, don't do it. You must have a good mix. Some people must be ready to use it

Prior to BIM era, Firm D had a top down management structure and while introducing BIM, they introduced a lean organizational structure. To them, BIM adoption work best with a flat structure that inspires proactive behaviour.

The influence of context

Firm A is situated in Finland while firms B, C, and D are located in the Netherlands. Finland has a deeply entrenched collaborative culture as opposed to Netherlands which is both collaborative and competitive because of the financial crisis. While BIM has been

largely mandated by the public sector in the Finland with a lot of BIM development and cross-organisational knowledge exchange initiatives, BIM mandate in Netherlands is not as forceful. Organisations in Netherlands actively seek BIM knowledge exchange beyond their firm (Firm B and D). In Finland, knowledge exchange became cultural because of their collaborative culture and the aggressive nature of the governmental BIM mandate. The Dutch building agency responsible for managing government assets has mandated BIM but in a slow, measured and non-aggressive fashion when compared with the Finnish authority which actively promotes and coordinate all BIM adoption efforts across the industry. The downturn in the Netherlands had mixed effects on BIM adoption depending on firms' views, corporate vision and strategy. The transformational BIM vision by Firm D is purposely to stay ahead, transform the building production process and offer clients new way of producing better buildings, cheaper and faster in the face of the downturn whereas BIM was not conceived by Firm B and C as a means of navigating the downturn.

BIM Implementation outcomes

Firm A is rather successful with BIM, as all projects are now done with it, but at various levels depending on clients' needs and requirements. Firm B has not been so successful, despite the leadership commitment and funding available for BIM adoption company-wide. The firm size appeared to have hindered adoption effort. Although Firm B has some characteristics that should enable in-house learning of integrated BIM and to transform the industry they only managed incremental and small change with BIM despite their financial commitment to it perhaps because of their large size, rigid organisational structure and deeply entrenched organisational culture. Meanwhile, Firm B became insolvent and was restructured. Firm C now uses BIM on all projects but at different levels. They have been transformed to a BIM consultancy. They have seen failure cost reduced by 10%-20% and ahead-of-time project completion because of BIM. Firm D now works with BIM on all projects. With their current BIM capability tested on projects, they foresee a future where they will be able to manage projects with a limited contractor role. They have developed a new commercially available BIM methodology and online software tool.

DISCUSSION

Leadership - It appears that BIM vision and strategy have mixed impact on the success of BIM adoption depending on other issues. Although firms with no clear vision for BIM appear to struggle (Firm C), leadership and commitment rectifies the lack of clear vision. Firms with a transformational vision exhibit stronger leadership and commitment (Firm D) than those who see BIM only as an information exchange tool (Firm B), which is in accordance with (Fox and Hietanen, 2007). Firms with transformational vision tended to be proactive in investing in long-term BIM prospects rather than just immediate gains (Firm A and D). They seek new services to meet clients' needs (Firm A and D) and are committed to redefining construction business (Firm D). Having a transformational strategy is compatible with informational and automational strategies. Others appear to be more focused only on in-house development of BIM rather than seeking new offerings to clients (Firm B and C).

Resources - Whereas firm size can influence the ability to invest in innovation resources (Firm B), it might also be a liability. Large firms face the dilemma of choosing between top-down and bottom-up as well as centralised and decentralised approaches to adopt BIM (Lam, 2011). While a decentralised approach can facilitate organisational culture change (Lam, 2011), it makes change effort cumbersome and inefficient (Firm B). On

the other hand, centralised approach is counterproductive when seeking change in organisational culture; it is slow and rarely company-wide. The findings confound some existing concern about BIM adoption and small firms (Acar et al., 2005, Dainty et al., 2017). It appears that the difficulties faced and success of BIM adoption by small firms depends on corporate vision, leadership support, and commitment rather than limitations of resources. After all, the risk and impact of failure of BIM adoption is less for smaller than large firms. The adoption history and the outcomes of BIM implementation across the 4 firms perhaps show that disruption and new business models to change construction production process might come from SMEs with transformational vision and leadership commitment (e.g. Firm D). After all, SMEs are generally more competitive in the supply chain and able to utilize their resources in an agile manner. Firm D continued to invest in BIM innovation and the firm commitment has yielded new innovation (a software firm).

Structure - Large firms with established clientele may resist change especially when BIM is not required. While they have the slack resources to implement change, they may have inflexible organisational structure to maintain their market position amidst disruptive change and are exposed to risk (Chen and Chen, 2013). Any gains from disruptive change are not immediate to offset the initial investment of large firms. When BIM is not required, firms can implement change in a non-disruptive fashion to improve internally (Firm B). Small and flexible firms require less slack resources to implement change and subsequently carry less risk than large firms.

Firms with flexible structures can later upscale rather quickly and in turn induce greater change. With transformational BIM vision and continuous investment in BIM resources, the likelihood of SMEs, start-ups, and flexible firms disrupting the industry depends on their ability to find large clients who are attractive to their newly discovered business model (Firm A and D). They may be able to implement BIM with great success on the long run when compared with large and established firms (Firm B and C). We expect the interaction between size, resources and leadership to be similar in industries such as manufacturing. However, there might be some differences depending project type specialisation. Firms specialising in prefabricated buildings might be able to implement BIM quickly with greater success since the supply chain is standardised, whereas those specialising in unique projects might find it challenging because of the ever changing nature of the supply chain they have to engage across projects.

CONCLUSIONS

This study examined how organisational management aspects influence the adoption of BIM innovation. Drawing upon empirical data from four construction firms in North-western Europe and innovation and organisation theories, several key aspects were identified, namely leadership, resources and organisational structure were found critical for successful BIM innovation adoption. The study adds to research and knowledge base on BIM adoption from an intra-organisational perspective and offers new insights into the discourse about which firm size better supports BIM adoption. The data and the reflection of these four firms who adopted BIM a few years back should be of interest to practitioners who have or plan to adopt BIM and transform their practices. The paper outlines implications for policy-makers as numerous features apart from firm size might influence BIM adoption. Correspondingly, varying incentives schemes could support BIM adoption and macroscopically its diffusion in the industry. Future research will revisit the study of these firms (and the larger sample) in a longitudinal study to reflect on the strengths of leadership, resource availability and organisational structures for successful BIM innovation adoption.

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