Multi-sided Platforms: A Business Model for BIM Adoption in Built Environment SMEs

Saeed Banihashemi[1](✉), Hamed Sarbazhosseini[1], Sisira Adikari[1], Farshid Hosseini[1], and M. Reza Hosseini[2]

[1] University of Canberra, Bruce, ACT 2601, Australia
Saeed.Banihashemi@Canberra.edu.au
[2] Deakin University, Geelong, VIC 3220, Australia

Abstract. It has been cogently acknowledged that employing BIM in the built environment companies has delivered remarkable benefits such as enhanced HCI, superior visualization, precise documentation, integrated design, construction and project management processes. Yet, the Architecture, Engineering and Construction (AEC) enterprises involved are still lagging behind in embracing BIM into core practices of their projects. This is particularly evident in the case of Small and Medium Sized Enterprises (SMEs) where higher levels of BIM implementation need to be scrutinized. There is little evidence on how these SMEs perceive the role of BIM management, and to some extent, they apply this process in their projects. The limited financial and human resources of these SMEs make it difficult to keep up with such BIM adoption processes. Therefore, to address these challenges, this paper is to shed light on the potentials of applying the business strategy of Multi-Sided Platform (MSP) in the construction industry and adapting its conceptual model for managing BIM implementation in construction SMEs. Positioning BIM professional services in MSP model can enable these firms to focus on their core businesses while benefiting from the senior talents which offer immediate access to BIM industry best practices. The study contributes to the field by providing succinct information on MSP implementation and its adoption in AEC SMEs. The study contributes to the body of knowledge through positioning BIM management platform in a rather overlooked context namely SMEs. Practically, policy makers and stakeholders would also benefit from the findings in order to promote BIM adoption.

Keywords: BIM · SMEs · MSP · Construction · Built environment · Conceptual model

1 Introduction

One of the major responsibilities of a project management team in construction industry is to finish the project within the budget, time and quality stipulated in the contract documents [1]. As the time goes by, the construction process gets more complicated and requires superior Human-Computer Interaction (HCI), hence controlling all aspects of a project lies in a bird's eye view over its life cycle. Although the fundamental tenet in the success of this end is having an efficient and organized system of management, monitoring, implementation, collection and dissemination of

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information from the project to the parties involved, the dominance of the CAD as the traditional representative of HCI's in the built environment have overshadowed this momentum [2]. Such shortcoming is particularly intensified in Small and Medium-sized Enterprises (SMEs) where low productivity, high-level of waste, recurrent cost overruns and chronic delays in completion of construction projects are still major issues [3]. The common project management method applied in most construction firms today is document based approach in which individuals are assigned to obtain data from different parties involved in the construction stage [4]. As a consequence, a wide range of construction data is typically collected in the field and in a fragmented nature without taking their holistic implications into account toward managing the construction process efficiently [5].

In recent years, Building Information Modeling (BIM) has emerged as a comprehensive concept of process and tools which integrates all projects required data and information [6]. BIM supports new information workflows and integrates them more closely with existing simulation and analysis tools used by consultants and contractors [7]. It provides higher levels of user experience, better interaction with designers and drafters and greater HCI compared to outdated CAD. Since most processes in BIM are automated, and the involvement of human resources is minimized, it is claimed that by using BIM, the efficiency of monitoring, controlling and managing in construction projects life cycle is enhanced remarkably [8]. But, in spite of the proven advantages of BIM employment in the construction projects and observed trend in its adoption worldwide, the rate of BIM implementation is far below the current potentials in the construction industry and SMEs, particularly [9]. The reason for this fact might lie in the silence of literature on the studies toward the research and development on BIM management platforms in the Architecture. Engineering and Construction (AEC) SMEs and developing enhanced HCI for AEC users.

Lower BIM adoption is deemed as a challenge in small businesses [10], while studies on BIM adoption are mostly concentrated on large-sized companies and large-scale projects [11]. Therefore, the effective methods in better BIM adoption within SMEs have remained underrepresented in the existing literature [12]. Despite such scant attention devoted to BIM in SMEs, this area is of outmost importance for the construction industry in view of the fact that "…smaller firms will continue to dominate the construction industry landscape far into the future" [13].

Progressively, AEC sectors have realized how important and productive it is to implement BIM and its managerial packages [14]. Developing the best and error-free design is what attracts customers and brings in new business. Even so, in the meanwhile, we cannot efficiently deliver the design and construction projects without solid BIM processes in place [15]. In fact, if valuable employees of the design teams are solely devoted to managing BIM, fewer human resources would be left to apply in the project [16]. On the other hand, if fundamental elements of BIM workflows such as BIM templates and guidelines or deployment of key software updates get ignored, the team will be hindered from working quickly and professionally [17].

This problem is certainly intensified where SMEs are to implement BIM in their digital design and construction workflows [18]. The limited financial and human resources of these SMEs make it difficult to keep up with such BIM adoption process [19]. Therefore, new business strategies should be analyzed and applied in order to facilitate BIM implementation activities in the meantime of minimizing the costs incurred and providing improved HCI experience for AEC experts. Multi-Sided Platforms (MSP) are among the emerging business strategies which have caught significant attention in recent years and remarkably changed the professional services methods. In fact, "professional service firms are moving away from pure vertically integrated models in which all client services are provided by their employees (e.g. traditional consulting firms), and towards the MSP model, in which they enable independent contractors or professionals to deal directly with clients" [20]. Developing an online and outsourced BIM management based on MSP can enable these firms to focus on their core businesses while benefiting from the senior talents which offer immediate access to BIM industry best practices. Through this achievement, the whole built environment industry can benefit from BIM adoption and application in a more efficient and easier integration. However, no research hitherto has been conducted on positioning BIM management in MSP and for AEC SMEs.

There is a conspicuous lack of studies on the identification of potential areas of MSP utilization in the construction industry and its associations with BIM management platforms. Against this backdrop, mathematical expression of the trade-offs among clients, consultants and third parties involved in BIM management and their interactions can be a significant achievement for construction project practitioners, policymakers and BIM advocates.

2 Background

2.1 Building Information Modelling (BIM)

Since the conventional 2D CAD system requires investing large amounts of time for construction projects operation, BIM expedites this process and provides the opportunity of testing and assessing different design and construction alternatives and their impacts on buildings [21]. "BIM is a digital representation of physical and functional characteristics of a facility" [7]. According to BS1192, "it is the management of information through the whole life cycle of a built asset, from initial design all the way through to construction, maintaining and finally de-commissioning, through the use of digital modelling" [22]. Thus, decisions that are made in the early stages of design play a significant role in the level of projects throughout the lifecycle of buildings. The ability to pinpoint the weaknesses of the design and implementing changes based on the available alternatives helps the construction industry mitigate the adversarial impact of construction errors and enhance the digital integration of buildings [23].

BIM involves collating, applying and maintaining an integral digital representation of all building information for different phases of the project life cycle in the form of a data repository [24]. It provides a comprehensive concept as an umbrella for the processes and tools, which integrate all projects required data through containing information needed in particular phases of a building's life-cycle (scheduling, analysis, cost evaluation, etc.) [7]. Yet, BIM is much more than a data container for the building model; it is an object-oriented building design and construction-specific model to assist the progress of the exchange and interoperability of data in the digital format [25].

A major benefit of utilizing BIM in the design and construction phase of a project is obviously coming through its ability to 'model' and test the constructability of the design within the model prior to setting foot on the project site.

As a management paradigm, BIM can be implemented through chains of ICT (Information and Communication Technologies) including BIM authoring tools such as Revit, ArchiCAD, Microstation and Navisworks [26]. Implementing BIM helps avoid errors alongside improving the productivity, scheduling, safety, cost and quality of construction projects [27]. BIM is a fast and effective process by which information pertaining to one project can be updated at any stage of the project from any department or unit (e.g. engineering department) [28]. Accordingly, because of its efficiency in adopting and propagating changes in the model, editing objects and reloading updated links, the entire project model will be updated based on the changes on one aspect of the project [15]. It is asserted that BIM is capable of enhancing the performance within the industry along with overcoming the problems stemmed from the fragmented structure dominating the industry [29]. Serving a catalyst of change for the construction industry, BIM encompasses a radical HCI reorientation of 2D to 3D modelling and a recent shift to 4D (project scheduling integrated), 5D (project cost integrated) and 6D (facility management integrated), exploiting more intelligent data analysis techniques in order to achieve a superior performance in delivering an As-Built BIM [16].

2.2 Small and Medium-Sized Enterprises (SMEs)

SMEs as the backbone of projects implementation in the construction industry are usually characterized by the number of employees in the business world [30]. Henceforth, a summary of available definitions is given in Table 1 to put it into the context of various countries. In the US, a small business is defined by having less than 99 staff, and a medium business ranges from 100 to 499 people. However, in Australia, SME Association of Australia [31] defines a micro business as having less than 4 employees and labels companies between 5 and 20 employees as a small business. In addition, a medium-sized business is determined to have staff between 20 up to 200 people. In the case of Canada, financial turnover is also considered in addition to the number of employees. In terms of the number, Canadian SMEs are featured as the same as American ones but, as to the financial index, companies are "small" subject to the less than \$1 million and "medium" if ranging up to \$5 million. In line with these definitions, SMEs represent more than 90% of the construction sector with similar percentages applicable to countries, e.g. the US, the UK, Australia, Asia [10] and Canada [12].

SMEs play a key role in developing prosperous economic and social structures around the world [31]. However, these companies are disadvantaged in preserving their competitiveness due to the dearth of benefitting from sufficient human resources; which is the mainstay of the built environment industry [32]. It is generally contended in construction literature that SMEs are typically lagging behind large-sized firms in embracing innovation and technological advancements [13, 30]. This is the BIM scenario as well [10, 12, 33] due to the number of issues such as the lack of knowledge and awareness, initial costs and lack of skilled personnel.

Table 1. SMEs definitions in various countries (Adapted from [19])

Country	Number of employees	Annual turnover	Source
Australia	0 < Micro < 4	N/A	[31]
	5 < Small < 20		
	21 < Medium < 200		
USA	Small < 99	N/A	[34]
	100 < Medium < 499		
Canada	Small < 99	Small < $1 million	[35, 36]
	100 < Medium < 499	$1 million < Medium < $5 million	

2.3 Multi-sided Platform (MSP)

The two-sided market is an intermediary platform which includes at least two specific user groups providing network benefits for them. The organization, association or firm that develops such platform via facilitating direct interactions between two (or more) specific types of affiliated users is regarded as the MSP [20]. This is grounded upon the notion of linking both sides of customers who are in need of each other. MSP exists because there is a need of intermediary in order to match both parts of the platform in a more efficient way. In fact, this intermediary will minimize the overall cost by avoiding duplication and minimizing transaction costs. It will further create possible exchanges that could be impossible without the platform and bring value for both sides. These platforms, by playing an intermediary role, generate values for all parties involved that are interconnected through it, and hence, those sides (parties) could be considered as customers.

In general, MSPs are recognized by three key elements [37]:

- A multi-product business exists including a platform to provide specific services to two or more sides of the market.
- Cross-network effects are facilitated. Experts benefit from mutual participation on both sides of the market.
- Platforms are financially tweaked by bilateral price setters on both sides of the market.

In light of the network effects, prosperous platforms benefit from rising returns to scale. Users are inclined to pay more for access to a bigger network, and as a result, margins increase because user bases grow. So, network platforms are differentiated from traditional service businesses. In traditional businesses, growth beyond some point generally causes a decrease in returns since new customers' acquisition gets harder as fewer people find it competitive. Furthermore, the idea of increasing returns makes the competition fierce in MSPs. Therefore, platform leaders should invest more in research and development in order to improve their competitive edge, reduce the prices and leverage their higher margins to defeat weaker rivals. As a result, mature MSPs are often run by larger platforms [38].

3 Research Method

The methodology adopted for this study is based on Design Thinking (DT) process integrated with qualitative method and inductive analysis of literature. Design Thinking is a human-centered creative problem-solving approach to come up with feasible solutions that meet customer needs with added business value. The integration of DT processes into qualitative research delivers new and deeper levels of insights. The DT process employed in this research is shown in Fig. 1 [39]. It includes five iterative activities with specific deliverables highlighted in yellow.

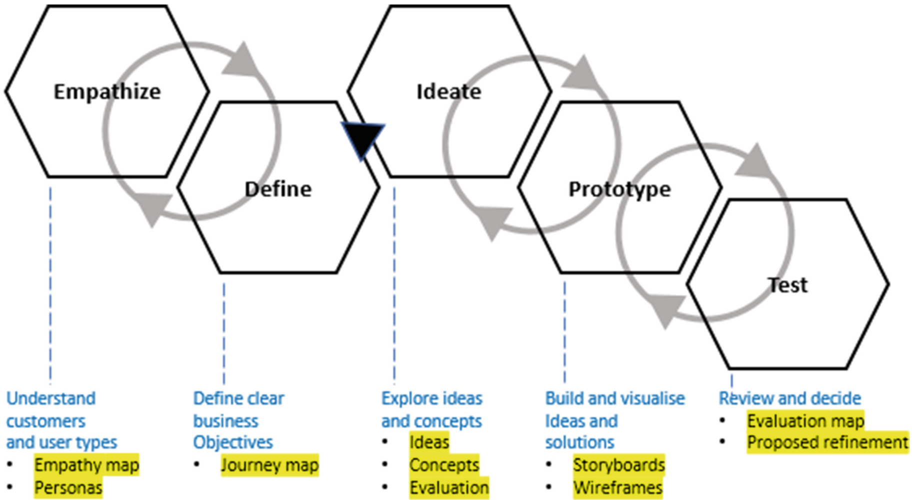

Fig. 1. Design thinking process with main activities and deliverables [39] (Color figure online)

Specifically, empathy maps, personas, and journey maps were extensively used to develop ideas and concepts which were represented in storyboards and wireframes for evaluations. The integrated method is recommended for all stages of research including the case of this paper. By applying the integrated qualitative method, the design emerges as the study unfolds in which the data is in the form of words, ideas, concepts, pictures or objects. Subsequently, the inductive logic is used to deduce patterns and frameworks from observations to know the variables and constraints and hypothetical relationships. This leads to developing a conceptual model to represents the researcher's synthesis of literature on how to explain a phenomenon. It illustrates what is expected to find through the research, including how the variables might relate to each other and how the characteristics of the model are mapped [40].

4 Conceptual Model

In view of the arguments on the lower adoption of BIM in SMEs and the emergence of MSP as the pioneering business strategy, a theoretical model is developed to conceptualize the interactions between AEC SMEs, BIM adopters and the role of platform amongst (see Fig. 2). The platform here hosts BIM adopters and SMEs as two distinct sides of the business in which they directly interact together and are affiliated with the platform. Direct interaction means that these two sides maintain the control on the key terms of their interactions rather being fully controlled via the intermediary. As evident, the nature of the interaction is to provide BIM adoption services to AEC SMEs. However, the key terms of the interaction involve marketing, pricing and the delivery of the traded services and its quality assurance and control. Affiliation in this model denotes the conscious efforts of each side to invest in platform-specific actions which are essential to provide direct interaction with each other. Using resources, spending money on developing required APIs to connect and subscription fees can be the items of investment to affiliate. Such elements differentiate MSPs from traditional business models.

Providing the direct interaction between BIM adopters and SMEs distinguishes this model from the traditional type in which SMEs need to recruit a full-time BIM manager or procure a BIM consultant and spend large overheads on that. Furthermore, affiliation by all relevant customer types (sides) helps distinguish MSPs from input suppliers who are not “adopted” by all sides. Because of the small size of projects run by SMEs, implementing BIM in SMEs could be greatly effective which leads to the remarkable return on investment and productivity [11, 12, 41]. The bottom line is that smaller groups of project participants and shorter project duration make it simpler to achieve the benefits of BIM, its adoption in higher levels [42] and possible swift organizational changes [43]. It is revealed that different organizational structures of SMEs require different skills, training and equipment for BIM implementation [44]. It is further identified that the cost of BIM implementation in SMEs are higher than that of in large counterparts due to the demerits of software acquisitions. In fact, due to the limited resources available for SMEs, implementing BIM takes considerable risk [41] (Fig. 2).

Hosseini et al. [19] theorized the barriers of BIM adoption in SMEs into three main clusters of the supply chain, organizational and project barriers. Supply chain barriers comprise industry and institutional issues in which the former group indicates the barriers stemmed from the location, market and lack of demand from stakeholders and proximity to markets where BIM is flourishing, and the latter denotes the policies, practices, knowledge and procedures implemented by the various parties involved in the construction supply chain surrounding the organization [45]. Organization context covers intentions, support and commitments of management and personnel with regard to BIM adoption, strategic objectives, resource allocation and addressing training needs. In light of adapting MSP to overcome these challenges, there are three key factors including innovate, offering and consume which are internalized in MSP and linked to the sides of the business. The service providers, BIM managers and adopters, in this case, should strive for creating innovative solutions in order to offer their BIM services through the platform and make it available and accessible.

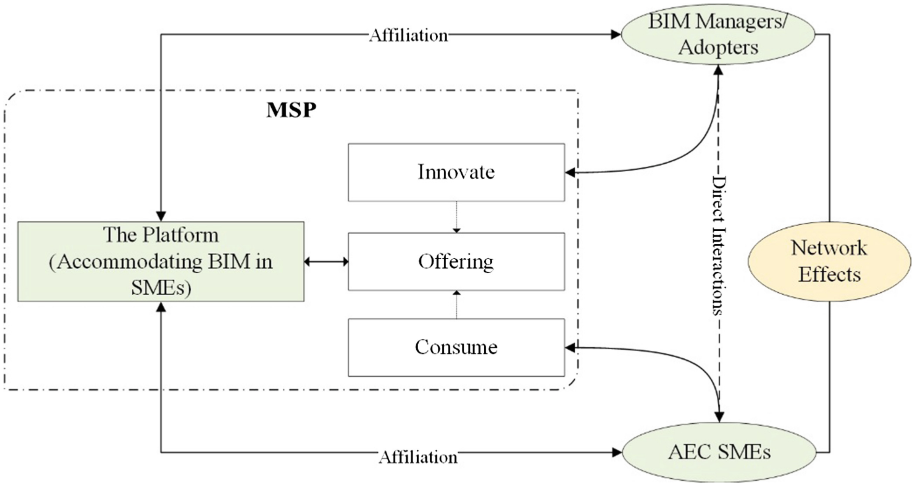

Fig. 2. Conceptual business model of MSP for BIM adoption in AEC SMEs

The innovation campaign, handled by service providers, could focus on alleviating the industry-based barriers by getting stakeholders familiar with BIM adoption benefits, sharing knowledge and expertise, lowering the adoption costs and providing accessible and affordable BIM services. According to the model, consume is another internalized factor of MSP which is bilaterally linked to the customer side; AEC SMEs. This connection could be exerted to resolve the organizational barriers by facilitating the connection of management and staff of SMEs with the service providers and platform and motivate them to invest in the affiliation. The offering is the third internal factor of MSP which is exclusively managed by the platform and refers to the regulatory role of MSP in balancing the model. Among the BIM adoption barriers discussed, it is in the equivalence relation with the institutional barriers and its policy and procedure elements. In fact, the platform is responsible for regulating and tweaking how the model works in order to maximize its efficiency and competitiveness. Eventually, the whole model is positively influenced by the network effect. This is the virtue which affects the model on two levels. In the lower level, the number of AEC SMEs and BIM adopters as customers and service providers increase in light of the network-based function of the platform leading to a more prosperous market for BIM adoption in the construction industry. Likewise, in the upper level, this effect enhances the platform popularity, value and its competitive edge resulting in expanding MSPs in the built environment.

5 Conclusion

This study is a point of departure for putting forward remedial solutions for BIM implementation in SMEs by outlining the insight toward the application of MSP as a cutting-edge approach in business and marketing. As the first study in its kind, BIM adoption in AEC SMEs was grounded upon the business model and the MSP was conceptualized as the platform to get BIM adopters and AEC SMEs onboard and link them together. The barriers of BIM adoption in SMEs including industrial, institutional and organizational were correlated with three key elements of MSP as innovate, offering and consume. As the main contribution of this study, theorizing BIM adoption and management services in MSP empowers AEC SMEs to expand their competitive edge on and enhance their core businesses in the meantime of achieving benefits from the best service providers which offer immediate access to BIM implementation. This advantage could lower the adoption overheads and maximize BIM diffusion into the construction industry.

However, the findings should be considered with caution due to a number of limitations in conducting the present study. That is, the model is conceptual and still in its preliminary stage and so, it may not be directly applicable to the practice. It needs further improvement and refinement by collecting empirical evidence and model validation. Moreover, other business models can be also investigated in order to identify their similarity and discrepancy and feasibility in application to the research issue.

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