Implementation of building information modelling in Vietnamese infrastructure construction: A case study of institutional influences on a bridge project

Completed Research Paper

Abstract

Many of today's building designs are created based on three-dimensional modeling technology. Architects and engineers use so-called building information modeling (BIM) systems to create digital representations of buildings. Inspired by the improvements in building construction projects, a Vietnamese construction project team decided to use the system to model a large-scale bridge crossing the Saigon River in Ho Chi Minh City, Vietnam. This paper provides an understanding of how the project team adopted BIM as the first BIM pilot project in Vietnamese infrastructure construction and analyzes the influence of institutional pressures. The findings reveal how the BIM champion of an international engineering consultancy led the project team to overcome challenges posed by local construction requirements and how the local partner adopted BIM technology under strict time and quality constraints. The case study presents an example for other infrastructure projects that involve BIM.

Keywords: Building information modeling, institutional pressures, infrastructure, developing country

Introduction

Building information modeling (BIM) systems are viewed as a technology capable of transforming design and construction processes, ultimately resulting in better buildings quality (Azhar, 2011; Bryde et al., 2013). A BIM system is a "shared knowledge resource for information about a facility forming a reliable basis for decisions during its life-cycle from the inception onward" (National BIM standard - United States, 2015). There is a broad consensus that BIM will be an essential cornerstone for digitalizing and modernizing the architecture, engineering, and construction industry. However, some scholars have commented on the challenges of implementation and limitations of the technology (Dainty et al., 2015; Vass & Gustavsson, 2017).

It has been argued that BIM practices are limited to large, highly information technology (IT)-literate firms capable of capitalizing on BIM technology (Hosseini et al., 2016). Other scholars find that BIM is primarily used in building construction projects, leaving behind other parts of the sector, such as transportation (Dongmo-Engeland & Merschbrock, 2016). Furthermore, most developing countries have considerable knowledge gaps and limited, occasional technological innovation, which has caused their construction sectors to miss out on BIM (Bui et al., 2016). This situation resembles what has been reported for healthcare systems, the internet, and e-procurement systems, which all prove difficult to implement in developing economies (Adams, 2004; Anaman & Osei-Amponsah, 2007).

In developing countries, building infrastructure is essential for economic growth (Giang & Pheng, 2011; Inderst & Stewart, 2014), and more research on technology adoption in project implementation is necessary to increase construction efficiency. Project owners have begun to demand visualization at a lower cost and better risk management (Ofori, 2007; Ogwueleka & Ikediashi, 2017). A potential solution to these problems is integrating BIM into the construction life cycle (Al-Btoush & Ahmad Tarmizi, 2017). There have been some encouraging recent developments in Asia, where several countries, including China, India, and Malaysia, have accumulated experience from work based on BIM

(Bui et al., 2016; Ismail et al., 2017). The application of BIM, and information and communication technology (ICT) in general, has reportedly brought benefits to the construction industry in developing countries. For example, ICT can improve the quality of quantity surveying services, facilitate decision making, and reduce costs on construction projects (Musa et al., 2010; Oladapo, 2006). However, as documented in the case of Vietnam, this requires specialists with technology infrastructure development skills and versatile IT professionals who can apply their ICT skills in other work domains (Khanh & Winley, 2018; Winley & Lau, 2012). In addition to the inherent challenges of ICT implementation in a developing country context, BIM implementations are typically complex. BIM involves shared information space technology used for collaborative digital design work across several organizations. This paper sets out to explore the challenges and opportunities of BIM implementation in a developing country construction context. Institutional theory is adopted to understand how BIM emerges, diffuses, and sometimes vanishes during the project (Colyvas & Jonsson, 2011; Mignerat & Rivard, 2009). The research focuses on how institutional effects shape organizational behavior in BIM implementation. The research question asked in this paper is *Which important factors explain the emergence and institutionalization of BIM in the construction context in a developing country?*

The research question is answered by conducting a case study of the Thu Thiem 2 Bridge project in Ho Chi Minh City, Vietnam. This project constitutes Vietnam's first BIM implementation in a transportation project. The project can be viewed as successful since the design team was awarded an international prize for its BIM work (Tekla, 2017) and provides an example for other project teams who want to implement BIM technology in their transportation projects. This paper also contributes to the information systems development literature by studying how BIM can be institutionalized and thereby increase construction firms' efficiency in a development context. Furthermore, the BIM work was achieved via collaboration among companies from both developed and developing countries, and mutual learning enabled the BIM work to be completed successfully. Data were collected through semi-structured interviews with eleven BIM subject matter experts working on the project and by assessing project documentation.

The next section explains the IT artefact at the core of our study and the local Vietnamese context, as well as how institutional theory was utilized in this paper, followed by a presentation of the research method. The following sections present and discuss the findings, which provide insights obtained from analyzing the data through the institutional lens and relate the research outcomes to previous studies. Finally, the conclusion section summarizes key findings and makes recommendations for further research.

Industrial context

In Vietnam, several major consultant companies have begun using BIM systems. For example, Hoa Binh Corporation, Contrexim, VNCC, Polysius Vietnam (Tran et al., 2014). However, it appears modeling is primarily used within individual disciplines, and few projects incorporate significant model-based interchanges between different firms and disciplines (ibid.). Thus, when assessed using the 'BIM capability stages', Vietnamese industries seem to have several firms operating at stage 1 maturity where only minor process changes have occurred, and traditional contractual relations, risk allocations, and organizational behavior persist (Succar, 2009).

Tran et al. (2014) state that BIM implementation in Vietnam is in its infancy and faces a range of challenges, including high investment costs and the lack of requirements from authorities, skilled personnel, and BIM training. The existence of these substantial challenges corroborates prior research, and it appears these types of challenges do not completely disappear even after a country advances its BIM work (Bosch-Sijtsema et al., 2017). To address some of the challenges and strengthen BIM implementation, the Institute for Construction Economics prepared a BIM roadmap for 2015–2020. This roadmap facilitates a review of BIM implementation practices worldwide to suggest an adoption plan for Vietnam (ibid).

The Vietnamese private sector and research institutes have been active in BIM implementation. For example, the Vietnamese software vendor Harmony Soft has made add-on packages for mainstream BIM software that include local Vietnamese building components in the models that reflect Vietnam's culture (Tran et al., 2014). In academia, local researchers from the National University of Construction and the

Institute of Construction Economics have begun focusing on BIM. These two institutions have collaborated on organizing several BIM seminars to increase BIM awareness in Vietnam. By participating in these seminars, government agencies, research institutes, universities, and construction practitioners in Vietnam update themselves on ongoing trends and good practices in BIM (Tran et al., 2014).

The Vietnamese government has contributed to BIM adoption by preparing legal frameworks and promoting BIM use. In 2014, the updated construction law recognized BIM implementation as a construction management task. In December 2016, the Vietnamese government approved a BIM adoption plan that set a goal of completing at least 20 BIM pilot projects in 2018–2020. The outcomes of the pilot projects constitute the foundation for nation-wide BIM implementation, which will begin in 2021. Furthermore, the Ministry of Construction issued Circular 06/2016/TT-BXD, which allows including BIM implementation costs in construction budgets (Mui & Giang, 2018; Vietnam BIM Steering Committee, 2017). In 2017, a national BIM steering committee was formed to develop BIM implementation strategies and advocate BIM use. This committee's work includes introducing an online information portal, as well as coordinating and guiding government agencies in BIM implementation (Vietnam BIM Steering Committee, 2017). In 2018, the Vietnamese government launched its adoption plan by selecting 20 pilot projects to experiment with BIM implementation (Decision 362/QD-BXD). These projects include the following projects: residential and office buildings (11), transportation (5), hospitals (3), and a water reservoir (1). The project owners will apply BIM during the design, implementation, hand-over, and operation phases. The relevant government authorities, especially the BIM steering committee, will support these pilot projects to overcome BIM-related challenges in regulation, procedure, training, and procurement.

Theoretical lens

This paper aims to understand institutional effects on the success of the Thu Thiem 2 Bridge project, which included BIM implementation. In the IS literature, scholars have used institutional theory to examine innovation adoption phenomena in organizations. In 2009, Mignerat and Rivard (2009) identified and reviewed 53 articles published in 20 IS outlets, all of which used institutional theory. These articles focus on institutional effects and the institutionalization of innovation (Mignerat & Rivard, 2009). While the institutionalization literature mentions different formation stages of institutions, the term institutional effect refers to the external environment's influences on a specific organization (ibid.). In a similar review, Weerakkody et al. (2009) examined 210 peer-reviewed journals and found 511 articles published between 1978 and 2008 that address institutional theory. Among those scholarly works, 28 articles used institutional effects as a central analytic tool in IS studies. These IS articles were classified into three general themes related to IT: innovation (1), development and implementation (2), and adoption and use (3).

Table 1. Three pillars of institutions (Scott, 2014, p. 60)

	Regulative	*Normative*	*Cultural - cognitive*
Basis of compliance	Expedience	Social obligation	Taken for granted
Mechanism	Coercive	Normative	Mimetic
Logic	Instrumentality	Appropriateness	Orthodoxy
Indicators	Rules, laws, sanctions	Certification, accreditation	Prevalence, isomorphism
Basis of legitimacy	Legally sanctioned	Morally governed	Culturally supported, conceptually correct

Institutional theory helps researchers explain organizational change in the innovation adoption process (Colyvas & Jonsson, 2011). Organizational change happens because organizations seek acceptance within socially constructed systems (Scott, 2014). Institutionalists study an organization within its environment, which consists of its relationships with other organizations (ibid.). The analytic framework of institutional theory consists of three pillars as presented in Table 1 (ibid.). Regarding institutional effects, the three pillars present the mechanism forming institutions through institutional pressures, which are coercive, normative, or mimetic (ibid.). Coercive pressure relates to explicit regulatory processes that organizations must follow (Dimaggio & Powell, 1983). Normative pressures derive from professionalization, such as having interorganizational networks, similar educational backgrounds, and mimetic behaviors in a profession (ibid.). Mimetic pressure leads organizations to follow other organizations' practices that are perceived as being more successful (ibid.). Construction project teams work within a network of related organizations, such as clients, administrative agencies, and other teams working on similar projects. These related organizations exert different types of influences on project teams. The construction project environment is similar to what is described in institutional theory. Combined with the explanatory power of the theory, this similarity makes institutional theory an appropriate lens through which to understand a project team's behavior.

Regarding innovation adoption, Chan (2018) evaluate previous studies of how institutional pressures have made construction practitioners change their working habits to adopt innovative practices. For example, Kale and Arditi (2010) note that Turkish practitioners in their study applied CAD technology and ISO 9000 because they were afraid their competitors would gain a competitive advantage via these innovations. In a similar study, Dulaimi et al. (2003) found that Singaporean construction companies innovate because they tend to mimic others in their supply chain. Since BIM is an innovation in construction, construction researchers have focused on institutional pressures to examine BIM implementation phenomena. Studies of institutional effects on BIM implementation range from the national scale (Cao et al., 2014) to case studies (Edirisinghe et al., 2016). In these BIM implementation studies, the authors identified the key factors influencing innovation adoption in construction. The scholarly works described here document the explanatory power of institutional effects. Therefore, this paper focuses on institutional pressures to explain BIM implementation in the Thu Thiem 2 Bridge project case study.

Methodology

Since this paper aims to extend the understanding of BIM implementation in the developing economy context, the case study approach was selected. The case study approach fits the research purpose well because this approach can provide an in-depth description of social phenomena (Yin, 2017). In particular, this paper presents a case study of a construction project in Vietnam.

Case description

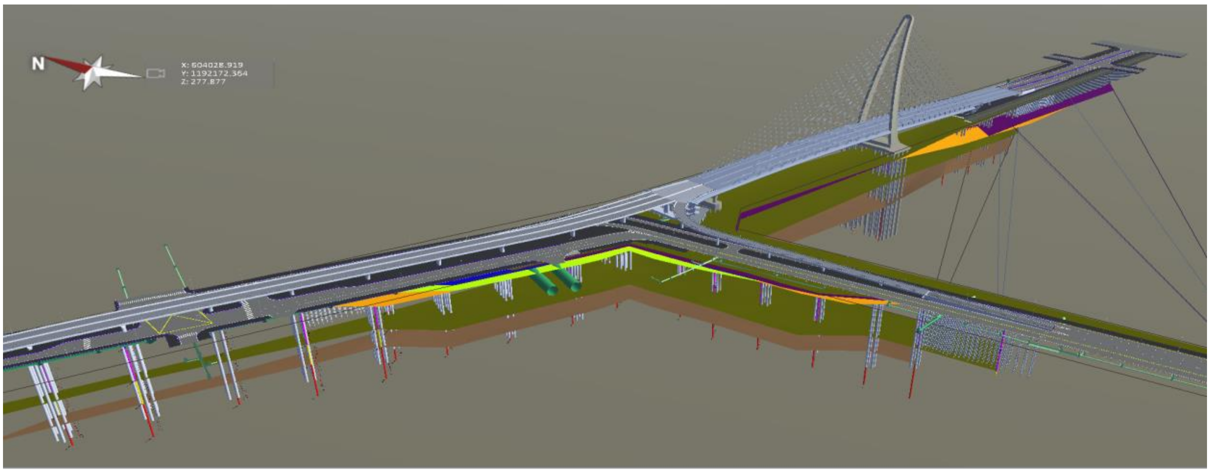

Figure 1. Thu Thiem 2 Bridge, Ho Chi Minh City, Vietnam [Courtesy TEDI South]

The setting of our case study is a large infrastructure construction project in Vietnam. The 1,473-meter-long bridge is one of five connections crossing the Saigon River in the center of Ho Chi Minh City. The cable-stayed bridge is set to become a landmark in the region with its pylon rising to 111 meters above water level. The bridge, linking the Thu Thiem district to the old city center, features six traffic lanes and two pedestrian walkways on either side of the bridge deck. In 2008, the Ho Chi Minh city council (HCMC) allocated €80 million to fund the project. Once enough land was acquired to begin construction in February 2015, a private corporation, Dai Quang Minh (DQMC), was appointed to oversee the bridge design and construction activities. The agreement included deploying BIM technology throughout the design and execution phases (Tuoi Tre Newspaper, 2015). DQMC has played the client role since the agreement was signed. The city's intention was to embrace BIM use following a wider national strategy seeking to increase digitalization in the Vietnamese construction industry. An example of the BIM models used in the project is depicted in Figure 1. In addition to requests from the city, DQMC must also comply with national construction regulations monitored by relevant authorities, such as the Department of Transportation, Ministry of Construction, Ministry of Transportation, and Institute of Construction Economics.

A Finnish consultancy (WSP Finland Øy) was appointed to work alongside the local consultant (TEDI South) to deliver the engineering design of the bridge. The Finnish engineers had a track record of working with BIM software in their projects. Finland is renowned for its highly digitalized construction sector, which delivered its first BIM projects nearly twenty years ago (Kam et al., 2003). However, BIM use in infrastructure projects is a relatively recent development in Finland (Bradley et al., 2016; Kivimäki & Heikkilä, 2015). Although TEDI South is a leading infrastructure consultancy in Vietnam, they had no prior experience working with BIM technology. Thus, the Finnish engineers supported their local counterpart in its BIM work. In turn, the Vietnamese consultant ensured local regulations were followed and that the project was delivered on time and within budget. The BIM vendors supplying the software and IT support were from Finland, Viasys VDC, and Tekla companies. All these project partners had to follow Vietnamese regulation enacted by relevant authorities.

The Thu Thiem 2 Bridge project was selected for several reasons. First, this case constitutes Vietnam's first BIM technology implementation in an infrastructure project, and the institutional context of BIM software implementation in Vietnam is poorly understood. Second, this project is viewed as internationally leading, signified by the team winning the international Tekla BIM Awards for the bridge design in 2017, which indicates that studying this advanced practice may yield important insight for companies elsewhere. Moreover, international collaborators on this project seem to have worked well together, with the Finish consultants being named 'creative company of the year' by the Embassy of Finland in Hanoi for their contribution to Finnish-Vietnamese relations. Finally, the knowledge and experience gained by the local engineers are likely to shape the development of Vietnam's national BIM standard for infrastructure.

Data collection

An interview guide was prepared based on institutional theory with a focus on the pillars of institutions, similar to what Scott suggested in his work on institutions and organizations (Scott, 2014). The interviewees answered seventeen open-ended questions, allowing them to share their experiences with the BIM-based work. The opening questions were aimed at learning about their professional background and role in the project. The next three thematic areas were designed to capture the regulative, normative, and cognitive elements experienced in BIM work (ibid.). The questions captured how institutional pressures manifested in day-to-day project activities (e.g., experience sharing and training), work materials (e.g., certificates, standards, models, and procedural guidance), and in the actors' documentation related to BIM. The interviews concluded by asking the engineers to identify the principal elements that inspired them to adopt BIM technology. In addition to the interviews, a range of BIM-related project documents informed this paper. This includes the written investment decision, BIM guidelines, training materials, meeting protocols, a simulation model of the project, and materials presented online.

Data collection began in May 2017 by contacting the director of Viasys VDC Vietnam, the software vendor that provided virtual design programs for the project. At this point, the design process had been underway for two years. Following this initial contact, a letter of intent was sent to the project director, who consented to the research being conducted. The first interview with WSP Finland's project manager took place at the end of June 2017. WSP's manager, who oversaw the design work on the project, identified the key actors performing managerial, coordination, and modeling tasks with BIM. From June to July 2017, a total of eleven interviews with the design team members responsible for implementing BIM were conducted and recorded. Then, the recorded interviews were transcribed and analyzed based on important concepts in institutional theory. An overview of the interviewees, their position, professional discipline, and construction work experience is presented in Table 2.

Table 2. List of informants

#	Position	Organization	Discipline	Experience (years)
1	Technical Manager	Dai Quang Minh Corp.	Structure	10–15
2	Project Director	Dai Quang Minh Corp.	Management	15–20
3	Project Manager 1*	TEDI South	Management	15–20
4	Bridge Engineer 1	TEDI South	Structure	5–10
5	Bridge engineer 2	TEDI South	Structure	0–5
6	Survey Engineer 1	TEDI South	Geology	+20
7	Survey Engineer 2	TEDI South	Geology	+20
8	BIM Coordinator 2	Viasys VDC	Structure	0–5
9	BIM Coordinator 3[f]	WSP Finland	Management	10–15
10	Technical Manager 2	WSP Finland	Structure	15–20
11	Project Manager 2**f	WSP Finland	Management	+20
* project-level BIM coordinator; ** project-level BIM manager; f: foreign engineer				

Notably, most interviewees had extensive experience in bridge construction. Only one bridge engineer and one BIM coordinator had less than five years of experience. However, these two engineers possessed strong BIM modeling skills. The other Vietnamese or local engineers had just begun exploring modeling programs a few months before the project was initiated. The interviewees consisted of two foreign and nine local engineers. While the foreign engineers only work for WSP Finland, the local or Vietnamese engineers represent the client, the WSP Finland office in Ho Chi Minh City, TEDI South, and Viasys VDC. The interviewees' strong professional backgrounds allowed them to reflect on both traditional practices and emergent BIM use.

Data analysis

All interview transcripts and collected documents were imported into NVivo 11 software and coded. The coding nodes follow Scott's three pillars of institutions, which allow classifying quotes into coercive, normative, and mimetic pressures. The quotes support the explanation of how institutional pressures influenced the project team.

Findings

Coercive pressures

The project members commented that they had to deal with three main barriers during the process. These barriers were traditional paper-based work practices, cost estimate regulation, and technological capacity. Without the support of the relevant authorities, it might seem impossible to use BIM in the project. Figure 2 presents keywords that were repeated the most from the interviewees. Some of the common keywords are BIM, project, construction, design, think, know. It indicates the data includes opinions and experience of the interviewees on applying BIM in construction projects.

The first barrier is that construction authorities only accept 2D paper-based drawings for approval. This requirement applies to all projects submitted for approval in Vietnam. The project director refused to make an exception and approve a 3D model: "*Everybody in Vietnam wants the 2D drawing and documents*." As stated by Survey Engineer 1, "*The Ministry of Transportation agencies always want to see physical* *signatures and stamps in all submissions*." The paper-based tradition also influenced TEDI South's design sequence during the project. Instead of beginning with a 3D model, the local consultant prepared the design on paper. Then, a 3D model was produced based on the 2D design to meet the requirements of the engineering contract with the client so that TEDI South could satisfy the local requirements and meet the deadline. Since this project was the first BIM experience of TEDI South, the project manager 1 was afraid that the local consultant would be unable to complete its assignment on time while learning to use the new technology. For WSP Finland, it was an unusual practice. After successfully creating the 3D model, the WSP Finland team had to prepare 2D drawings for submission. It seemed they had to "*go 100% back [to paper-based documents] to finalize the design*," as stated by BIM Coordinator 3. Since the drawings must comply with Vietnam's construction regulations, and the software was unable to export these accordingly, the WSP Finland team manually modified the drawings exported from the 3D model. This modification consumed a considerable amount of time. When the authorities requested changes, the WSP Finland team updated the 3D model and then produced the modified 2D drawings. The consultant team perceived the 3D model for TEDI South and the 2D drawings for WSP Finland as additional tasks they had to perform to incorporate BIM into the project: "*We [had] to prepare both the 2D drawings and the 3D model…, so it took a lot of time*" (BIM Coordinator 2).

Figure 2. The common keywords repeated the most by the interviewees

Another barrier was the regulations for cost estimates include no items for applying new technologies, which meant individuals in charge of the state budget would refuse to reimburse for such items. Thus, the clients focused on the total cost more than innovation because they wanted to keep the construction costs as low as possible. Since the Thu Thiem 2 Bridge belongs to Ho Chi Minh City, the bridge was a state project, and the construction had to strictly follow the cost estimate regulations. According to the project director, it was difficult to get reimbursed for software license and computer purchases as cost items in the project's budget because the consultants could use these ICT tools on other projects. Thus, it was unreasonable to depreciate the whole investment amount on one project. Although the consultant could increase its fee a little if new technology was used, no extra points for innovation were given in the bidding process. According to the Technical Manager 2, consultants or contractors could use the project budget for software licenses and computers, but they had to transfer ownership of such items to the client after the project was completed. It was an asset management regulation. Unfortunately, a project might require several years to complete, at which point the software and computers might be outdated. Thus, the client would be unwilling to receive them. Even when BIM could show proven benefits, the Project Director insisted "*the cost has to be approved*." A decision from a higher level of authority is necessary in this case.

The technological capacity of Vietnamese construction companies was another barrier. The local consultant team recognized that its company had to invest in staff training, software licenses, and computer system upgrades, as well as implement new work processes to implement BIM, which could be a long process and require considerable effort. Thus, the management board seemed reluctant to adopt BIM and simply encouraged its staff members to upgrade their knowledge themselves. After the engineering contract was signed, TEDI South had more motivation, but it also had to deliver a 3D model. They used part of the contract money to buy software licenses, provide staff members with training by external lecturers and allow staff members to try different BIM programs during working hours. Before the contract was signed, interviewees from TEDI South commented that they were busy with other projects and did not have time to learn about BIM. From the client side, the Project Director noted that other parties, such as the contractors and government agencies, should also implement BIM to provide the greatest benefit to the project.

Furthermore, BIM implementation happened only after the HCMC officially approved it in the build-transfer agreement with DQMC. However, the decision to apply BIM seems to have been influenced by the Institute of Construction Economics' consent. In the beginning, not all authorities agreed with the proposal, but consent from the higher authority level was more important. In this case, the Department of Transportation, the HCMC agency for infrastructure, refused the proposed estimate for BIM, but the Institute of Construction Economics agreed. This consent was given approximately two years before the Vietnamese government officially approved the national BIM adoption plan in December 2016. It meant the Institute of Construction Economics perceived no coercive pressure for BIM at that time. The project owner, HCMC, made the decision based on the Institute of Construction Economics' comment. The reason, the Institute of Construction Economics recommended BIM use, will be further discussed in the mimetic pillar section.

Regarding the BIM expectations from the client side, the project members had different opinions. The WSP Finland team were surprised because the client indicated no desire include BIM in the project. Project Manager 2 understood that "*the client didn't know what to do [with BIM,] so they often agreed with what we [the consultant] proposed*." The Project Director explained that he considered cost as the most important criterion. In addition, the technical manager admitted that his team had no experience with BIM. Thus, the client team was unable to prepare requirements and monitor BIM implementation. Regarding BIM implementation, the consultant team felt the largest part of the coercive pressures were from the Institute of Construction Economics to showcase innovation benefits in the Vietnam context.

At the company level, the demand for BIM expertise was low. The members could join the project team without any advanced knowledge of BIM. No partners set formal recruitment requirements, such as BIM certificates or experience. Indeed, DQMC, WSP Finland, and TEDI South only encouraged their employees to explore software and BIM on a self-study basis. BIM implementation relied solely on the Finish consultant. From TEDI South's side, Survey Engineer 1 noted that "*the management board only requested us to master the program for which the company has licenses, and the board preferred [taking on] more projects to adopting new technologies*." DQMC considered the project to be temporary as members and technologies might vary from project to project. Moreover, HCMC would receive the bridge after the implementation in about three years. Thus, DQMC was unable benefit from BIM in the long-term. It led to the client being unmotivated to pursue BIM adoption. In this context, the local project members obtained BIM knowledge from seminars, conferences, and online channels. This environment, which provides knowledge of trends and the status of BIM applications, exposed them to normative pressures. The following section uncovers the effects of normative pressures on the Thu Thiem 2 Bridge project.

Normative pressures

The local project members from TEDI South and the WSP office in Ho Chi Minh City had the desire to follow modern trends in construction, resulting from normative pressures from information sources and the competitive environment. This desire became another motivation to implement BIM in their work without the management board's request. Thus, BIM implementation could remain in their companies in the long-term. "*Eventually, BIM, building information modeling, is a piece of digitalization progress in building industry*" (Project Manager 2).

In fact, the local project members knew about BIM through short courses, formal education, seminars, conferences, and online channels. The local modeling team prepared themselves in advance by attending short courses on modeling programs as illustrated by the following quotes: "*I studied some BIM tools myself and have tried to apply these new skills in practice*" (BIM Coordinator 2), and "*I think we have to study by ourselves to be ready for new demands at work*" (Project Manager 1). After the project began, TEDI South also organized similar courses for its employees, including the Thu Thiem 2 Bridge project team. The courses demonstrated new capacities of modeling programs and introduced new trends in BIM technology. However, Bridge Engineer 1 commented that those courses were ineffective because most of the tutors were from academic institutions and had little practical bridge modeling experience. The knowledge gained from these courses was unable to help them solve modeling issues encountered in the Thu Thiem 2 Bridge project. Thus, they had to search for solutions on online channels, such as YouTube and Autodesk Community. Conferences and seminars on BIM applications outside of the project were an additional information source. Furthermore, the WSP Finland project manager had completed his master's thesis on BIM in 2014. The fresh knowledge he gained during his degree program provided the latest trends to the local engineers through internal project training. The WSP Finland project manager also led the establishment of expectations for BIM use in the project. Referring to the BIM levels in the United Kingdom (British Standards Institute, 2013) as a measurement, he directed the Thu Thiem 2 Bridge project from level 0 to 3. In the later phases, he expected to combine all digitalized project information in the model. The short courses and these information sources provided an understanding of the new capacities of software and new trends in construction. The more the local project members knew about BIM, the more they wanted to update their knowledge. They wanted to match the level of BIM practitioners in other developed countries, such as the United Kingdom, the United States, Singapore, and Finland. This motivation encouraged them to implement BIM: "*If you are a consultant, you must lead the market in terms of technology*" (Survey Engineer 1).

Competition in the Vietnamese construction market was another pressure to apply BIM. The WSP Finland project manager noted that his company wanted BIM experience in Vietnam to compete with other international consultants in the future. Regarding the local companies, the TEDI South team knew that other companies were trying to adopt BIM. They mentioned Hung Nghiep, VTCO, and TEDI Hanoi as companies that are applying BIM. However, they had no discussion or information regarding the status of BIM implementation in these companies. Survey Engineer 1 insisted that "*an engineer needs both engineering and modeling skills*." With only an engineering background, an engineer needs other people to prepare the model. With only the modeling skills, he might not be confident in his work. Thus, if they had no BIM skills, they might be outdated soon. Besides, the local team understood that the Ministry of Construction would prepare regulations for BIM implementation based on pilot projects, including the Thu Thiem 2 Bridge. These regulations could be mandatory for the whole industry within a few years. They surmised that other companies were already preparing for this development and were afraid of losing their competitive advantage. Although all local members believed that Vietnam would adopt BIM, most of them presumed that the adoption would take five to ten years. This guess was much longer than that of the government plan, which set 2021 as the milestone to apply BIM throughout the country.

Mimetic pressures

In addition to coercive pressure from the authorities, mimetic pressure from the Finish consultant, who had the most extensive BIM experience on the project, played an important role in making the implementation successful. Since mimetic pressure influenced related parties and project members, the pressure assisted the project team in overcoming the strict regulation of construction costs and gradually changed from a paper-based to model-based design process.

Regarding cost regulation, the project director mentioned that the authorities had to approve the costs, but no one in Vietnam had prior experience with BIM in a bridge project. Thus, it was difficult to prepare and approve the estimated BIM-related expenses. In the Thu Thiem 2 Bridge project, WSP Finland was the only partner who had competence in and experience with BIM implementation. In 2012, the Finish Company began approaching the Ministry of Construction, Ministry of Transportation, Institute of Construction Economics, Department of Transportation, and other relevant authorities and began organizing BIM seminars. In these seminars, the WSP Finland project manager presented case studies from the United States and Finland to introduce the benefits of BIM: "*Our role would be bringing something new here, so I started to discuss with the ministries and many departments*" (Project Manager 2). The authorities perceived the potential and wanted to achieve such advances. Thus, the Ministry of Construction prepared a program for pilot BIM projects in Vietnam. In 2014, WSP Finland prepared the estimated cost for BIM as a design task in the Thu Thiem 2 Bridge project. The BIM implementation cost increased the total design fee by 10%. HCMC almost declined the proposal. Fortunately, the Institute of Construction Economics, the Ministry of Construction's agency in charge of construction economics, agreed with the proposal because it supported the Ministry of Construction's pilot program. The Institute of Construction Economics expected evidence of BIM's benefits in Vietnam on the Thu Thiem 2 Bridge project. With consent from the Institute of Construction Economics, HCMC formally requested that the client apply BIM in the project, leading to implementing BIM in the project at the beginning of 2015. It is noted that the government approved the pilot program in the BIM adoption plan in 2016 (The Prime Minister Office, 2016). In this process, WSP Finland placed mimetic pressures on the relevant authorities to remove the traditional barrier of the cost estimate. In particular, WSP Finland obtained approval for BIM implementation by presenting the benefits of BIM to the relevant authorities, which indicates that the mimetic pressure became coercive. During the design phase, the project team showcased BIM use in the Thu Thiem 2 Bridge project through seminars. In these seminars, the project team invited a representative from the Institute of Construction Economics, the Department of Transportation, and other relevant authorities. This communication channel maintained mimetic pressure on the authorities, who held coercive power in the project.

Mimetic pressure also encouraged the local team to gradually change the local consultant's design process. Through its partnership with WSP Finland, TEDI South received on-the-job training and seminars. This cooperation helped increase BIM knowledge and skills among the Vietnamese engineers. In this project, the experts from WSP Finland guided TEDI South's engineers in following the BIM execution plan, as well as preparing the model. WSP Finland also introduced typical BIM projects to the local consultant team. Since the project had a tight deadline, TEDI South decided to prepare the traditional 2D drawings for submission. Then, they created the 3D model from the 2D design and used it for reference. They felt that they were not ready for BIM in the Thu Thiem 2 Bridge project. Their purpose for using BIM in the project was to study how to use BIM rather than make the best use of the new technology. However, because TEDI South knew how to use BIM, they were able to utilize the 3D model to identify problems in the paper drawings. When the 3D modeling team found problems, they checked and modified the drawings: "*The 3D model helped us to identify so many mistakes and clashes in the drawings, especially complicated structures*" (Bridge Engineer 2). As can be seen in Figure 3, the steel bar placement, pipes, anchors, and other structural components were merged in the 3D model. The design team used a BIM software tool to prepare this simulation and automatically detect conflicts between the components and then adjust the design accordingly. Before they prepared the 3D model properly, traditional 2D drawings of related components in Figure 3 were submitted to meet the tight deadline. The conflicts identified from the 3D model were transferred to the later design step. Since the relevant authorities still demand traditional drawings, the BIM technology was not leveraged to its full capacity. In the traditional procedure, a senior engineer would review all papers based on his experience. However, many conflicts remained until the implementation. Bridge Engineer 1 added that "*sometimes we don't know how the contractor can build from the paper drawings, some parts are almost impossible to imagine*." With the 3D model, the local design team seemed more confident with their product and decided to adopt 3D designs in the future. "*The company* [TEDI South] *is looking for big projects to implement BIM*"," according to Survey Engineer 1. The experience of the local design team in the Thu Thiem 2 Bridge project was important in this process. It implies there were mimetic effects that made TEDI South modify their design process.

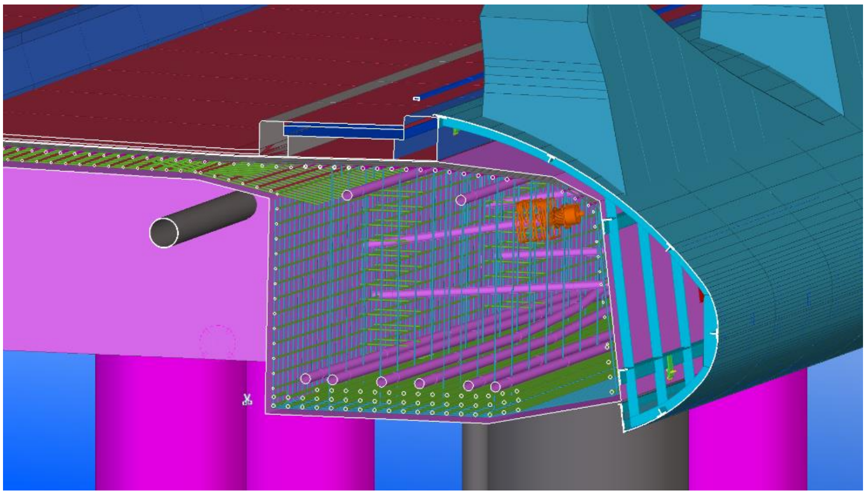

Figure 3. A 3D simulation of complicated structures to identify conflicts [Courtesy WSP Finland Øy]

Moreover, the data reveals the influence of members who had more advanced modeling skills and BIM knowledge. In the Thu Thiem 2 Bridge project, the design team relied on BIM coordinators from WSP Finland and the software vendor to solve modeling issues. These coordinators mastered the modeling programs and had engineering backgrounds. Since this was the first bridge project with BIM built in Vietnam, the project members found many required components, for example, the handrail, to be difficult to model. In this case, the BIM coordinators searched the available solutions and solved the problems with them. This support was useful for the local consultant since it worked with the modeling programs for the first time. When the local engineers had gained more experience with the software, they began to write some add-ins that were tailored to their work. An add-in is a piece of code or mini-program that can be used as a function in specific software to provide extra features. Most of the add-ins were created to input data or visualize the components. For example, Survey Engineer 1 wrote a Revit add-in to input the displayed values for the boreholes in the model. This add-in could enter the data from the geological survey into the model. It saved considerable time compared to entering the data manually. Survey Engineer 1 commented that "*It took much time to familiarize with the software in this project, but we could do it faster in future projects when we have libraries and tailored add-ins*." In this learning process, the local engineers not only familiarized themselves with the modeling programs but also customized these for their own sake. The customization helped the design team meet local requirements. Although the customized add-ins only supported survey information in the Thu Thiem 2 Bridge project, these mini-programs might be the key to removing the traditional barriers and meeting the local requirements on other BIM projects in Vietnam.

Discussion

This paper has described how the effects of institutional pressures lead to successful BIM implementation in the Thu Thiem 2 Bridge project. The main factors were support from the relevant authorities and guidance from the BIM champion on the project. A BIM champion is a person with the required technical skills and motivation to lead the organization' implementation of BIM (Messner & Anumba, 2013) who, in this case, was the WSP Finland project manager. Also, the project team had to overcome three barriers that hindered innovation on the project. These barriers derived from mandatory construction regulations regarding paper-based submissions, cost estimate regulations, and the technological capacity of Vietnamese companies. However, the project team managed to implement BIM successfully. Through the institutional lens, this effort represented a mutual effect of institutional pressures, which are summarized in Table 3. In the case study, the mimetic pressure became coercive. After the relevant authorities acknowledged BIM's benefits from presentations they had attended at workshops and seminars, they recommended the project owner formally request BIM. Since the local members had to apply BIM, they had stronger motivation to seek related knowledge. They collected knowledge not only from other project members but also from outside sources, such as short courses, workshops, seminars, conferences, and online channels. This environment provided them an overview of BIM's implementation status worldwide. During this information seeking process, they exposed themselves to normative pressures. Thus, they felt it necessary to obtain new BIM skills. Otherwise, their skills could be outdated soon. The case study also explains how companies gradually change their working processes during innovation adoption, with the local consultant team shifting from paper-based to 3D modeling design.

Table 3. Overview of the findings classified based on the three pillars of institutions

Regulative pillar	Normative pillar	Cultural-cognitive pillar
• Project owner demand • Relevant authorities' consent/decision • Construction regulations • National BIM pilot plan • BIM execution plan	• Participation in seminars, workshops, conferences, and short courses • Online channels • Competitive construction market • Government initiatives	• Mimicking others' processes at work • Receiving training from others • Mimicking examples from online communities

Furthermore, the interviewees referred to the existing paper-based tradition as the most time-consuming issue in implementing BIM. Since the software was unable to generate 2D drawings that could meet the local requirements, the project team had to modify them manually after they were exported from the 3D model. This indicates a gap between the local requirements and the software's capacity. In the Thu Thiem 2 Bridge project, project members used add-ins to reduce the number of manual tasks. These customized mini programs might decrease the gap. However, it seems difficult to resolve this issue without the involvement of authorities and software vendors. These agencies define the local requirements and develop the software. How local requirements might be harmonized with software capacity might be an interesting topic for further research.

In the case study, coercive pressure from government authorities, the project owner, and the client were low. They requested BIM in the project only because the consultant presented good practices through various seminars and had no specific expectations for BIM. In contrast, coercive pressure from clients and government authorities have been reported as the major reasons for BIM in Hong Kong (Chan, 2014) and China (Cao et al., 2014). However, none of these studies reveal why government authorities and clients request BIM. Since these organizations have decision-making power on construction projects, identifying what influences the BIM adoption decisions of government authorities and clients requires further study.

The Thu Thiem 2 Bridge project confirms the importance of a BIM champion. The WSP Finland project manager acted as the major change agent to implement the BIM innovation in the project. The importance of a BIM champion has also been documented in other studies in Norway (Bui et al., 2018) and Sweden (Lindblad, 2016). In a similar vein, Bosch-Sijtsema et al. (2017) found that clients need solid knowledge to enforce BIM implementation in their projects. Unlike these studies, the BIM champion on the Thu Thiem 2 Bridge project worked for the consultant's team. This position provided the Finish manager with less coercive power than a BIM champion on the client's team. Thus, coercive pressure might be important, but it is not necessarily the root of the innovation adoption initiative. Moreover, the client teams of public projects in Vietnam have low salaries compared to the consultant or contractor teams because these salaries have to follow the national scale for state officers. Thus, it might be difficult to recruit competent BIM champions to the client team. This context raises the question of how BIM champions from the consultant team influence BIM implementation on public projects. The answer to this question might reveal practical contributions to public projects not only in Vietnam but also in other developing countries that have a similar situation. Furthermore, studies addressing this question could contribute to a better understanding of institutional effects on BIM implementation in construction projects that have a low level of coercive pressure.

In a BIM implementation study conducted in China, Cao et al. (2014) found normative pressure had no influence on BIM implementation. However, the interviewees in the case study provided a different perspective. Through seminars, workshops, conferences, and online channels, project members perceived innovative trends in the construction industry. The trends made the project members want to learn new BIM skills for their own sake; otherwise, their skills could become outdated. This is the result of normative pressure on the project team. Most of the project members knew about BIM trends through discussions in professional communities. Thus, how construction communities support BIM implementation in infrastructure projects deserves further study.

This paper provides practical contributions to BIM implementation in infrastructure projects where BIM applications are still in the early stage. By describing the responses of different partners under institutional pressures in the Thu Thiem 2 Bridge project, the paper explains how the project partners overcame various barriers to make BIM implementation possible. The practical contributions can be useful for innovation adoption in infrastructure projects for government agencies, project owners, design consultants, and contractors: (1) Government agencies and project owners can create discussion channels for innovations in construction, coordinate inter-project experience sharing, prepare frameworks for testing new technologies, and may want to consider changing building regulations for BIM; (2) Project design teams can staff their projects with BIM experts in key roles, create environments where novice BIM users learn from experts, and employ recent university graduates with strong IT/BIM skills; (3) Contractors can participate in professional forums and seminars to remain abreast of the latest technology and can collaborate with partners who have a greater technological capacity. The first contribution mentions about generating discussions among policy-makers and BIM experts. In this way, the policy-makers have better understanding of BIM technology, while BIM experts are aware of local requirements. As a result, updated regulations to leverage BIM capacity and customized BIM implementation processes will be available for construction practitioners. The second and third contributions present suggestions to address the technological capacity of local construction companies. Better technological capacity and better regulations can benefit BIM implementation in a developing context.

Regarding institutional effects, the consultant team exerted mimetic pressure by presenting the benefits of BIM to the relevant authorities. The main actor was the BIM champion, the Project manager from Finland. The Finish BIM champion showed BIM benefits to relevant authorities in various seminars and workshops. This effort motivated decision-makers in these agencies to support the project team to implement BIM in the Thu Thiem 2 Bridge project. Since the authorities acknowledged the benefits, they decided to allow BIM use in the case study. Furthermore, the project team not only adopted BIM but also customized modeling programs to make these programs fit the local regulations. The findings might also be valuable to other projects in similar contexts.

The case study presents an example of how construction companies in a developing context collaborate with their counterparts from developed regions for BIM implementation. The experience of the local consultant might be useful for other developing countries which want to increase the uptake of BIM. In the Thu Thiem 2 Bridge project, the main barriers for implementing BIM, as a new technology, in Vietnam infrastructure projects derived from the local regulations. These barriers were the paper-based approval and the cost estimate regulations. To overcome these barriers, the supports from relevant government authorities are essential. For successful implementation, the local consultant connected the Finish consultant to relevant authorities. In this way, the project team could present the benefits of BIM to these authorities and have their consents for BIM implementation.

Regarding the IS discipline, IS scholars have studied response strategies to institutional pressures for many years (Mignerat & Rivard, 2009). Thus, strategic responses of construction organizations to institutional pressures on BIM implementation is a relevant topic for IS scholars. The paper also makes a theoretical contribution by providing an understanding of institutional pressure on BIM implementation in an infrastructure project within the context of a developing country. Since knowledge from developed countries might be invalid in developing ones (Khanna, 2015), more studies in developing contexts are necessary to improve our understanding of institutional theory. The findings illustrate how different institutional pressures combined to ensure the implementation of innovation in the case study.

The major limitations of this work lie in the context of the case study. The Thu Thiem 2 Bridge project is the first BIM pilot project in an infrastructure context in Vietnam. In this context, the influence of similar projects or companies were limited. Furthermore, the interviewees included the managers, coordinators, and 3D modelers. This combination helped to provide data on the managerial and collaboration processes, which are the key focus of this paper. However, the data does not include the local 2D bridge designers' opinions. Thus, a part of the BIM implementation in the Thu Thiem 2 Bridge project might remain uncovered. Furthermore, the case study identified the influence of the consultant team on the decision of the project owner, but the data include no interviews with the project owner or the relevant authorities. Therefore, the data might only reflect the opinions of the consultant. Despite these possible limitations, this paper documents relevant findings regarding BIM implementation in the Thu Thiem 2 Bridge project.

Conclusion

In summary, this paper presents a case study of the first BIM pilot project in the Vietnamese infrastructure domain. Analyzed through the institutional theory lens, the collected data reveal important factors for successful BIM technology adoption. Although the project team faced barriers in the local traditional working process and context, the experienced partner from Finland supported the team in successfully implementing BIM. The description of institutional effects in this paper contributes to the understanding of BIM implementation in the IS discipline. The experience of the project team reported in this study might be transferable to other projects in similar contexts. Also, this paper suggests some suitable topics for further study, such as the gap between local requirements and software capacity, the influence of relevant authorities, the role of BIM champions on the consultant team, and last but not least, the role of the construction community in adopting new technologies in the local context.

References

Adams, R. H. (2004). Economic growth, inequality and poverty: estimating the growth elasticity of poverty. *World Development, 32*(12), 1989-2014.

Al-Btoush, M. A., & Ahmad Tarmizi, H. (2017). Barriers and Challenges of Building Information Modelling Implementation in Jordanian Construction Industry. *Global Journal of Engineering Science and Research Management, 4*(9), 9-20.

Anaman, K. A., & Osei-Amponsah, C. (2007). Analysis of the causality links between the growth of the construction industry and the growth of the macro-economy in Ghana. *Construction Management and Economics, 25*(9), 951-961. doi:10.1080/01446190701411208

Azhar, S. (2011). Building information modeling (BIM): Trends, benefits, risks, and challenges for the AEC industry. *Leadership and Management in Engineering, 11*(3), 241-252. doi:10.1061/(ASCE)LM.1943-5630.0000127

Barbosa, F., Woetzel, J., Mischke, J., Ribeirinho, M. J., Sridhar, M., Parsons, M., Bertram, N., & Brown, S. (2017). Reinventing construction: A route to higher productivity. *McKinsey Global Institute*.

Bosch-Sijtsema, P., Isaksson, A., Lennartsson, M., & Linderoth, H. C. (2017). Barriers and facilitators for BIM use among Swedish medium-sized contractors-"We wait until someone tells us to use it". *Visualization in engineering, 5*(1), 3. doi:10.1186/s40327-017-0040-7

Bradley, A., Li, H., Lark, R., & Dunn, S. (2016). BIM for infrastructure: An overall review and constructor perspective. *Automation in Construction, 71*, 139-152. doi:10.1016/j.autcon.2016.08.019

British Standards Institute. (2013). B/555 Roadmap (June 2013 Update). Retrieved from https://shop.bsigroup.com/upload/Construction_downloads/B555_Roadmap_JUNE_2013.pdf

Bryde, D., Broquetas, M., & Volm, J. M. (2013). The project benefits of building information modelling (BIM). *International Journal of Project Management, 31*(7), 971-980. doi:j.ijproman.2012.12.001

Bui, N., Merschbrock, C., & Munkvold, B. E. (2016). A Review of Building Information Modelling for Construction in Developing Countries. *Procedia Engineering, 164*, 487-494. doi:10.1016/j.proeng.2016.11.649

Bui, N., Merschbrock, C., Munkvold, B. E., & Lassen, A. K. (2018). *An institutional perspective on BIM implementation – a case study of an intercity railway project in Norway*. Paper presented at the Submitted to the 27th International Conference on Information Systems Development (ISD2018), Lund, Sweden.

Cao, D., Li, H., & Wang, G. (2014). Impacts of isomorphic pressures on BIM adoption in construction projects. *Journal of Construction Engineering and Management, 140*(12). doi:10.1061/(Asce)Co.1943-7862.0000903

Chan, C. T. (2014). Barriers of implementing BIM in construction industry from the designers' perspective: a Hong Kong experience. *Journal of System and Management Sciences, 4*(2), 24-40.

Chan, P. (2018). Change and Continuity: What Can Construction Tell Us About Institutional Theory? In *Societies under Construction* (pp. 151-184): Springer.

Colyvas, J. A., & Jonsson, S. (2011). Ubiquity and legitimacy: Disentangling diffusion and institutionalization. *Sociological theory, 29*(1), 27-53. doi:10.1111/j.1467-9558.2010.01386.x

Dainty, A., Leiringer, R., Fernie, S., & Harty, C. (2015). *Don't believe the (BIM) hype: the unexpected corollaries of the UK'BIM revolution'.* Paper presented at the Engineering Project Organizations Conference.

Dimaggio, P., & Powell, W. (1983). The iron cage revisited: Institutional isomorphism and collective rationality in organizational fields. *American Sociological Review, 48*(2), 147-160. doi:10.2307/2095101

Dongmo-Engeland, B., & Merschbrock, C. (2016). *A research review on Building Information Modelling in Infrastructure projects.* Paper presented at the Life-Cycle of Engineering Systems: Emphasis on Sustainable Civil Infrastructure: Proceedings of the Fifth International Symposium on Life-Cycle Civil Engineering (IALCCE 2016), Delft, Netherlands.

Dulaimi, M. F., Ling, F. Y., & Bajracharya, A. (2003). Organizational motivation and inter-organizational interaction in construction innovation in Singapore. *Construction Management and Economics, 21*(3), 307-318.

Edirisinghe, R., Kalutara, P., & London, K. (2016). *An investigation of BIM adoption of owners and facility managers in Australia: institutional case study.* Paper presented at the COBRA 2016.

Giang, D. T., & Pheng, L. S. (2011). Role of construction in economic development: Review of key concepts in the past 40 years. *Habitat International, 35*(1), 118-125. doi:10.1016/j.habitatint.2010.06.003

Hosseini, M. R., Banihashemi, S., Chileshe, N., Namzadi, M. O., Udaeja, C., Rameezdeen, R., & McCuen, T. (2016). BIM adoption within Australian Small and Medium-sized Enterprises (SMEs): an innovation diffusion model. *Construction Economics and Building, 16*(3), 71-86. doi:10.5130/AJCEB.v16i3.5159

Inderst, G., & Stewart, F. (2014). *Institutional investment in infrastructure in developing countries: introduction to potential models*: The World Bank.

Ismail, N. A. A., Chiozzi, M., & Drogemuller, R. (2017). *An overview of BIM uptake in Asian developing countries.* Paper presented at the AIP Conference Proceedings.

Kale, S., & Arditi, D. (2010). Innovation diffusion modeling in the construction industry. *Journal of Construction Engineering Management, 136*(3), 329-340.

Kam, C., Fischer, M., Hänninen, R., Karjalainen, A., & Laitinen, J. (2003). The product model and Fourth Dimension project. *Journal of Information Technology in Construction (ITcon), 8*(12), 137-166.

Khanh, T. N. N., & Winley, G. K. (2018). An investigation of ICT knowledge and skills in Vietnam. *The Electronic Journal of Information Systems in Developing Countries, 84*(3). doi:10.1002/isd2.12023

Khanna, T. (2015). A case for contextual intelligence. *Management International Review, 55*(2), 181-190.

Kivimäki, T., & Heikkilä, R. (2015). *Infra BIM based real-time quality control of infrastructure construction projects.* Paper presented at the ISARC. Proceedings of the International Symposium on Automation and Robotics in Construction.

Lindblad, H. (2016). Organising the Implementation of BIM: A Study of a Large Swedish Client Organisation. *Building up business operations and their logic Shaping materials and technologies, 3*, 356.

Messner, J., & Anumba, C. (2013). BIM planning guide for facility owners. *Pennsylvania State Univ., University Park, PA*.

Mignerat, M., & Rivard, S. (2009). Positioning the institutional perspective in information systems research. *Journal of information Technology, 24*(4), 369-391. doi:10.1057/jit.2009.13

Mui, T. V., & Giang, H. V. (2018). Promote the application of BIM to construction investment projects apartment buildings in Vietnam. *Journal of Science and Technology in Civil Engineering (STCE) - NUCE, 12*(1), 22-28. doi:https://doi.org/10.31814/stce.nuce2018-12(1)-03

Musa, N. A., Oyebisi, T., & Babalola, M. (2010). A study of the impact of information and communications technology (ICT) on the quality of quantity surveying services in Nigeria. *The Electronic Journal of Information Systems in Developing Countries, 42*(1), 1-9. doi:10.1002/j.1681-4835.2010.tb00303.x

National BIM standard - United States. (2015). The National BIM Standard-United States® Version 3. Retrieved from https://www.nationalbimstandard.org/nbims-us

Ofori, G. (2007). Construction in developing countries. *Construction Management and Economics, 25*(1), 1-6. doi:10.1080/01446190601114134

Ogwueleka, A. C., & Ikediashi, D. I. (2017). The Future of BIM Technologies in Africa: Prospects and Challenges. *Integrated Building Information Modelling*, 307. doi:10.2174/9781681084572117010016

Oladapo, A. A. (2006). The impact of ICT on professional practice in the Nigerian construction industry. *The Electronic Journal of Information Systems in Developing Countries, 24*(1), 1-19. doi:10.1002/j.1681-4835.2006.tb00157.x

Scott, W. R. (2014). *Institutions and organizations: Ideas, interests, and identities*: Sage Publications.

Succar, B. (2009). Building information modelling maturity matrix. In *Handbook of Research on Building Information Modeling and Construction Informatics: Concepts and Technologies: Concepts and Technologies*: Information Science Reference.

Tekla. (2017). Infrastructure project leads the way towards BIM in Vietnam. Retrieved from https://www.tekla.com/baltic/bim-awards/thu-thiem-2-bridge

The Prime Minister Office. (2016). Decision 2500/QD-TTg: The Approval of Building information modelling adoption plan in construction implentation and operation.

Tran, H. M., Nguyen, V. H., Ta, N. B., & Le, T. H. A. (2014). BIM implementation worldwide and the status of BIM adoption in Vietnam construction industry. *Vietnam Construction Economics Megazine*(2).

Tuoi Tre Newspaper. (2015). Ho Chi Minh City build Thu Thiem 2 bridge. Retrieved from https://tuoitre.vn/tphcm-xay-cau-thu-thiem-2-705378.htm

Vass, S., & Gustavsson, T. K. (2017). Challenges when implementing BIM for industry change. *Construction Management and Economics, 35*(10), 597-610. doi:10.1080/01446193.2017.1314519

Vietnam BIM Steering Committee. (2017). BIM implementation in Vietnam. Retrieved from http://bim.gov.vn/tin-tuc/

Weerakkody, V., Dwivedi, Y. K., & Irani, Z. (2009). The diffusion and use of institutional theory: a cross-disciplinary longitudinal literature survey. *Journal of information Technology, 24*(4), 354-368. doi:10.1057/jit.2009.16

Winley, G. K., & Lau, S. K. (2012). The adoption and use of ICT in Thailand and Vietnam. *The Electronic Journal of Information Systems in Developing Countries, 54*(1), 1-29. doi:10.1002/j.1681-4835.2012.tb00386.x

Yin, R. K. (2017). *Case Study Research and Applications: Design and Methods*: SAGE Publications.