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Building Information Modeling (BIM) Implementation in Public–Private Partnership (PPP) Projects †

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Abstract: Studies about the challenges and lessons learned from Public–Private partnerships (PPPs) exist in construction all around the world, yet it is not certain how to use these challenges to improve the performance of projects. Building Information Modeling (BIM) has great potential to improve collaboration in PPPs. However, implementing this technology requires new steps rather than the traditional approaches. This study aims to resolve the implementation dilemma by proposing a BIM Implementation Plan. The methodology includes evaluating BIM adaptation at the company and project levels via PPP case studies. Results will show major drivers and barriers to utilizing BIM in PPPs.

Keywords: Building Information Modeling (BIM); Public–Private Partnerships (PPPs); enablers; barriers; construction industry

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1. Introduction

It has been common to use PPPs as a procurement method for projects that provide some type of public service and where government resources are not enough to finalize the project. The method establishes long-term partnerships between the private sector and the government while requiring extensive collaboration between public and private parties for successful project performance. The main features of PPPs are presented in the literature as follows [1]:

- A long-term contract established between a public and a private-sector party;
- Private sector providing the design, construction, financing, and operation;
- Payments processed over the life of the contract to the private-sector party for the use of the facility, either by the public-sector party or by the public as users of the facility;
- The facility remaining in public-sector ownership or reverting to the public sector;
- Change of ownership at the end of the PPP contract.

Technological developments have been on the rise in the construction industry with the introduction of BIM. The benefits of BIM were mentioned in the literature, such as decreasing project time and cost, improving production quality, decreasing design errors, and allowing for the use of an integrated project delivery (IPD) approach and better collaboration [2]. BIM has brought a different perspective on the traditional construction processes, such as PPP projects, due to being seen as the platform for IPD, where an established medium for collaboration and information sharing among the stakeholders is expected [3]. The benefits of providing a collaborative working environment were summarized as follows: (1) helping the owner better understand the nature and needs of the project; (2) improving the design, development, and analysis of the project;

(3) enhancing the management of the construction phase; and (4) developing the operations and the maintenance phase [4].

Many researchers worked on the factors slowing down BIM implementation. One study mentioned a variety of barriers, such as the industry's reluctance to change existing work practices, the lack of initiative and training, the fragmented nature of the industry, and varied market readiness across geographies [5]. Another study focused on the risk allocation in BIM due to a lack of clarity in roles and responsibilities among parties [6]. Yet, BIM, as a 3D modeling and digitalization tool, has great potential to improve collaboration in PPP projects, which would improve the overall project performance with benefits such as reduced cost and duration. The need is to focus on analyzing the drivers and barriers of BIM in PPP projects to offer solutions to common barriers and address challenges of PPP projects with regard to implementing BIM, which serves the aim of this study.

2. Methodology

The methodology includes a three-phase process to find enablers and barriers to BIM implementation in PPP projects (Figure 1). The first step in the process was to review previous literature on the drivers and barriers of BIM implementation. At this stage, the sources were not required to be specific to PPPs. The purpose was to create an organized list of drivers and barriers that could be applied to PPP projects. After the collection of drivers and barriers, they were organized into groups such as BIM technology-, project-, and company-related factors. The second step included a collection of international case studies of PPP projects where BIM was implemented. In the third step, the data collected regarding these projects were analyzed to find matches to the list of BIM implementation drivers and barriers from the literature review. The final stage included highlighting the major drivers and barriers to utilizing BIM in PPPs and discussing the suggestions from case studies. The BIM implementation plan is proposed to promote drivers and offer solutions to common barriers.

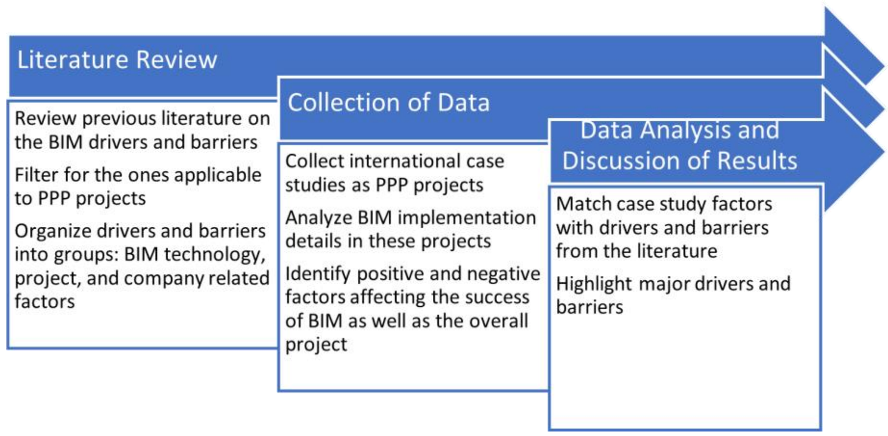

Figure 1. Research Flow.

2.1. Phase 1: Literature Review

Many researchers have studied the applicability and feasibility of BIM implementation in PPP projects from various perspectives. As an example, BIM was mentioned as a way to measure life cycle performance [7]. Management platforms were proposed for life cycle information exchange and measuring and monitoring sustainability [8]. Previous studies identifying the motivation factors to implement BIM in PPP projects were used to create the drivers in this study. Similarly, the literature also included studies to state the challenges of BIM implementation in PPP projects. For example, the lack of guidance for the transition to BIM and the inadequate number of industry-based studies were mentioned as barriers to BIM adoption [6]. Previous studies identifying the motivation factors to implement BIM in PPP projects were used to create the drivers in this study.

For a successful BIM application in PPP contracts, the drivers and barriers from the literature sources were organized, and the wording was updated to obtain the factors in Table 1.

Table 1. BIM implementation barriers and drivers obtained in this study.

	Barriers	Drivers
BIM Technology	Lack of BIM definition	Ability to monitor and evaluate the asset's life cycle performance
	Lack of easy access to BIM software	Ability to measure and monitor sustainability
	Lack of ease-of-use of BIM technology	Real-time information for accurate assessment of Value for Money (VfM)
	Lack of BIM knowledge	Management platform for a life cycle information exchange
	Lack of time to learn BIM	Design advantages such as information exchange, visualization information formatting
	Frequent changes in BIM requirements	Improving PPP-integrated information management
	BIM ownership challenges	
	Initial investment cost of BIM training and specialists	
	Cost of BIM software and hardware	
	Shortage of BIM experts	
	Insufficient BIM standards and protocols	
	Interoperability of BIM software applications	
	Inadequate opportunity for BIM implementation	
Company-related	Lack of flexible collaboration models	Improving collaboration
	Weak support from senior management	Support both qualitative and quantitative assessment
	Organizations' internal resistance to BIM	Helping obtain more future projects
	Fragmented nature of stakeholders to BIM	Enabling more sustainable and informed decision making
	Unfamiliarity with BIM use	Predicting the cost in the supply chain and procurement
	Reluctance to initiate new workflows	
	Lack of demands from the clients	
Project-related	Tight project schedule	Reducing rework, risk, liability and contingency fees
	Contract type (fixed-price contracts)	Improved cost management
	Unavailability of information	Improved quality management

2.2. Phase 2: Collection of Data—Case Studies

A set of international PPP projects where BIM was implemented were collected to be analyzed with respect to the barriers and drivers obtained in this study. Considering the length limitation, only three of these case studies will be presented here.

2.2.1. Case Study 1

The first project is a hospital project located in Australia. The project used BIM with an integrated third-party system to manage the hospital's facility management (FM) system and ensure patient satisfaction. Among the factors affecting BIM implementation, the project utilized PPP payment mechanism management and reported it as a driver for the accurate assessment of VfM. Advanced technologies such as Tag Tracking/RFID and

Automated guided vehicles (AGV) improved the PPP integrated information management. Although the integrated software used with it had many drivers to support BIM implementation, two major barriers were encountered: the Building Management System (BMS) could not fulfill the needs of all parties, and the lack of flexible collaboration models was experienced. The integration of various systems was mostly evaluated as an advantage, yet there were some interoperability issues with using different BIM software applications. In the cases of barriers, it was emphasized that the transfer of knowledge should be sustained among PPP projects when implementing BIM. A centralized system to integrate and share data would also help with the project scope changes as well as specifics of healthcare projects, such as medical support services, where the private partner also provides the medical equipment like Magnetic Resonance Imaging (MRI) machines or other equipment in the laboratories.

2.2.2. Case Study 2

The second project is an 86,000-SF school building located in Sweden. The public party awarded this project to a contractor to develop a 3D BIM model, where the model and data were used for the production of as-built plans, and afterward, it was planned to be used as a design reference for the renovation and extension of the school. As the plan was to utilize the BIM model for future use, one of the drivers was improving PPP integrated information management and using it for design advantages in the next phases of the project. The architect was given a complete Autodesk Revit model to start working and, in this way, did not need to take additional measurements on-site or produce new data. Including the information in the 3D BIM model beforehand helped with information exchange, visualization information, and formatting. Although the process seemed seamless at first, it brought in its own barriers in the implementation and shared use of BIM. Involved parties had an inadequate opportunity for BIM implementation, as one party created the model, and the others inherited and followed up their steps. Some parties complained about the lack of ease of use of BIM technology and the cost of BIM software and hardware. Considering that it is costly to start the initial investment in BIM training, one way to prevent this issue in the future is to ensure the BIM knowledge and software association of included parties. For the public party, the PPP-BIM model brought advantages such as providing a management platform for life cycle information exchange and the ability to measure and monitor sustainability, which is promising for the future of the city and its sustainability goals.

2.2.3. Case Study 3

The third project is a sports center project in Sweden. First, the existing project was 3D scanned and processed by using a point cloud. The existing plans of the building were digitalized and added to the BIM model. Per the client’s request, a Level of Development (LOD) of 200 was used in this stage. A third-party software application was used to combine all plans and share them with associated parties. Using multiple software applications caused some interoperability of BIM software applications and required familiarity with BIM use. The drivers, in this case, were having design advantages such as information exchange, visualization information, and formatting, and the availability of a management platform for life cycle information exchange. When used during the operations phase, all employees could access the 3D images and information, which were encountered as improving PPP integration, collaboration, and quality management.

2.3. Phase 3: Data Analysis and Discussion of Results

Considering the literature review information and inputs from the case studies, it was observed that companies utilizing PPP and BIM together tend to emerge for higher-end software systems. This approach eliminated many of the first-level barriers retrieved from the literature in this study, such as the lack of BIM definition, lack of easy access to BIM software, lack of ease-of-use of BIM technology, and lack of BIM knowledge. It was mentioned that the private parties did not have issues obtaining or knowing the background information regarding BIM. As many of these companies already have a BIM or Virtual Design and Construction (VDC) department set up, the cost of BIM software or hardware was not an issue for them. On the other hand, the subcontractors might not have been familiar with the BIM software or other related applications such as laser scanning devices, and therefore, it was suggested to select the PPP-BIM project team based on the use of technology in the project.

With the involvement of various technology applications, the interoperability of BIM software applications and the lack of flexible collaboration models were highlighted as more important barriers to BIM implementation. In the cases where subcontractors with less familiarity with technology applications were involved, their unfamiliarity with BIM use and the lack of time to learn BIM became issues.

When the drivers obtained from the literature vs. the case studies were considered, design advantages, such as information exchange, visualization information, and formatting, were frequently mentioned. Improving PPP-integrated information management worked well for owner parties, as they utilized the PPP-BIM pair to improve their FM services in the future. The ability to monitor and evaluate an asset's life cycle performance and real-time information for the accurate assessment of VfM were the top monetary benefits for owners in selecting BIM implementation in their PPP projects. It was not surprising to see improving collaboration among parties as a driver. The surprising drivers were related to sustainability, as the literature has emphasized sustainability-related barriers repeatedly, whereas the ability to measure and monitor sustainability and the management platform for a life cycle information exchange were limitedly mentioned in case studies.

Overall, the BIM-technology-related BIM implementation barriers from the literature in particular need to be filtered to include the relevant ones for the project using multiple technologies, as it seems to be the norm in this new construction era. The typical drivers coming from the literature are still valid, yet the PPP projects need to have a broader vision of sustainability to include certain commonly cited drivers.

3. Conclusions and Future Work

This study focused on BIM implementation in PPP projects by analyzing the drivers and barriers of BIM. The systematic analysis of PPP journal articles published revealed information on the most common drivers and barriers of BIM. The re-organization and re-wording process provided the key factors in implementing BIM, whether they motivate parties as in the case of drivers or whether they challenge parties as in the case of barriers. Barriers and drivers were grouped into BIM technology, company-related, and project-related factors. Global case studies helped further to analyze these factors from the perspectives of practitioners.

The major findings showed that many of the first-level barriers retrieved from the literature no longer apply to the new age projects where private parties have the BIM technology knowledge needed to implement and run BIM in PPP projects. This was a surprising outcome, as the majority of the previous studies regarding BIM barriers repeatedly emphasized BIM technology-related factors, such as the lack of easy access to BIM software and the lack of BIM knowledge as negative influencers of BIM implementation.

As an expected outcome, the lack of flexible collaboration models was repeated in both the literature and case studies as a crucial barrier to planning for when to implement BIM in PPP projects. With the team-based nature of PPP projects and technological innovation and integration with BIM, successful collaboration is needed among all public and private parties involved. When any of these parties show a lack of technological skills or are unable to contribute effectively to the project's success, this situation creates a crucial barrier for the BIM-PPP combination.

The involvement of emerging technologies has also resulted in new barriers, such as the interoperability of BIM software applications. When planning the new BIM implementation plans, companies should evaluate both the BIM knowledge and the required software products of the parties involved. This was reviewed as a solution for both the collaboration issues as well as potential technical issues that can arise from BIM implementation.

This study revealed that major drivers obtained from case studies are in line with the ones in the literature. Both sources valued the design advantages of BIM coupled with information exchange and visualization advantages. These are very important BIM drivers for most construction projects as well as PPP projects. Specifically, in PPP projects, owners emphasized the positive impact of FM services and the ability to monitor and evaluate an asset's life cycle performance. The ability to measure and monitor sustainability can be encountered as a new-age driver for the BIM-PPP pair.

When the major findings of this study are considered, it is suggested that the previously used BIM implementation plans should be revised according to the recent changes in BIM technology and PPP team setup. The new age BIM implementation plan should focus on the skills of the parties as well as the specific technology needs of each project for full success. Future studies can focus on the role of public and private sectors in various companies to create an effective framework that can be applied globally in BIM-PPP projects.

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