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COST-BENEFIT ANALYSIS OF USING BIM COMPARED TO TRADITIONAL METHODS IN IRAQ'S PUBLIC CONSTRUCTION PROJECTS

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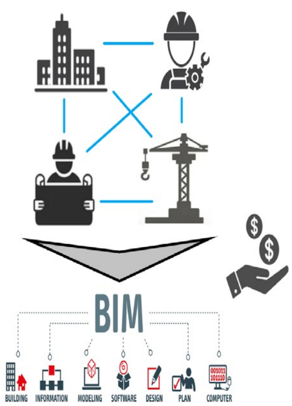
Graphical abstract



Abstract

The construction procurement process generates significant cost-related issues, such as project delivery delays, budget overruns, and poor quality. Public projects were suffering from bureaucracy and separation in work activities. Building Information Modeling (BIM) has demonstrated the potential for solving these issues. The study aims to investigate and analyze the cost-benefit analysis of using BIM compared to traditional methods in public construction projects in Iraq. Therefore, the study evaluated Multiple case studies of two projects quantitatively and conducted several interviews with 15 experts to determine the cost-benefit of adopting BIM compared to conventional methods. The study investigated the benefits of BIM in construction projects due to the remarkable difference between the two methods. The quantitative data of study findings revealed a significant cost improvement using BIM rather than the traditional method in public projects. To conclude, multi-cultural studies need to assess the projects' performance of large and small entities. Furthermore, this research suggested incorporating BIM adoption in government organizations in a wide range.

Keywords: BIM; Construction projects; Benefit-cost; Public projects

1.0 INTRODUCTION

The construction industry is historically associated with significant cost-related problems [1]. Building Information Modeling (BIM) is a developed method that claims to increase the ongoing progress and the required adaptation in the construction industry and transform its operational processes to achieve collaborative effort between project stakeholders and guarantee effective project performance [2]. Time, cost overruns, poor quality, and claims are the issues most found [3]. Recently, BIM use has increased worldwide [4]. The most common use of BIM is for visual analysis operations [5]; it can offer 3D renderings [6]. Moreover, it allows the project teams to have a take-off quantity in just a few minutes [5]. Also, an excellent capability to produce shop drawings [7].

Furthermore, BIM will handle project materials' distribution, schedule, and production [8]. BIM can display interference with sections and parts [9]. The use of this technique can cover repair and maintenance [10]. Immediate construction plans, benchmarking, and innovative solutions [11]. It reports Better data quality [12]. BIM efficiently provides the necessary data during the project life cycle [13].

Nevertheless, there seems to be an increasing awareness that more attention should be paid to building information modeling to predict and reduce the risk of implementing construction projects [6]. Construction players have a significant interest in managing the threats emerging in the construction industry, such as costs, time, efficiency, protection, and environmental sustainability [14]. It has implemented specialized technologies like BIM to solve recurrent problems in the construction industry [15]. Researchers expect that Future developments will help tackle these problems by introducing BIM in a wide range [16]. Since cost overruns can have serious consequences, it is imperative to understand better the relationship between BIM and construction risks in the on-site construction industry [17]. The scope of this empirical study involved the activities of two public projects in Iraq. The study aims to investigate how BIM can improve benefit-cost analysis compared to traditional methods in the construction projects of Iraq. the objective of the study is to explore how BIM can achieve benefits over cost compared to traditional methods. BIM is seen to be moving beyond the scene of conventional building construction [18]. According to [19], BIM has better designs than traditional design [20].

In BIM, the building information could be rigorously analyzed, quickly and performance benchmarked, enabling improvements and a more innovative solution [21]. A broad range of advanced design and visualization technologies can be used in BIM [22]. Stakeholders can access the model's different aspects and examine or add them. Therefore, it implies that professionals in various fields of study, if they are designers, engineering technicians, contractors, or construction managers, can all contribute their expert knowledge and input to the same framework [23]. Redraws and redesigns are also much faster and easier with digital modeling [24]. System restores and linkages to a project history are standard features in BIM technology, ensuring that adjustments and transformations are never wasted. Therefore, A removed or damaged file must not be a disaster [23]. BIM can develop more than just 2D drawings and 3D models [25]. Some processes could create models that include extra cost and time, resulting in integrative packs of data about the structure's functionalities.

To maintain no development disputes, BIM may be used to organize used technologies [26]. The ability of BIM to avoid project delays and keep construction costs stable has improved the performance of construction projects. Most development issues, such as engineering conflicts and data loss, were resolved in the pre-construction stage, allowing the project to succeed during construction [27]. BIM retrieves models and other details from various devices and sites, whether the user is on the road, planning to visit investors in their offices, or stationed on the ground using cloud services [28]. Digital models could also be used to develop amplified visual representations that use the virtual world to bring design elements to life, enabling anybody to see the final product on-site [29]. Even though it is a commonly accepted technique in the construction sector, many small businesses are hesitant to adopt it, believing it is only appropriate for megaprojects, elevated architects, public projects, or environmental-focused organizations [30].

As per the results of a poll performed by (National Building 2016), There are five significant issues that the construction sector faces when incorporating BIM technologies. This high technology head's primary issue is inadequate knowledge and false information about it. Experts assisted in carrying out this study in these fields based on their opinions on using BIM to achieve desirable goals. Thus, the researchers investigated and analyzed multiple case studies for two projects. In addition, a qualitative method was performed with expert assistance and construction industry players, collecting their responsiveness towards the variance of the cost of project items during construction and their understanding of using BIM to solve all these issues. The arising question is; how can the use of BIM improve the performance of the project? This study tested the hypothesis that BIM adoption can improve the performance of construction projects experiencing lower costs compared to traditional methods. The researchers investigated previous studies for all the information and data needed for adopting BIM in the construction industry. Previous studies focused on crucial and frequent factors facing construction projects such as clash detection, safety, cost estimation, cash flow generation, lifecycle assessment, waste reduction and sustainability, and construction and design integration. The significance of the study is to adopt BIM in Iraq's public and private sectors in a wide range. Moreover, it emphasized the financial advantage and the importance of using BIM in the construction sector. The literature investigation is illustrated in table 1.

2.0 METHODOLOGY

Table 1 Previous studies on BIM in the construction industry

Empirical findings	Source
Clash Detection	[31][32][33]
Clash Categorization	[34]
Clash Stakeholder	[35]
Clash application	[36]
Clash Resolution	[37]
Cash Flow Generation	[38][39]
Productivity, quality	[40]
Sustainability, LCA	[41][42]
and Waste Reduction	[43][44]
Visualization	[45]
Collaboration	[46]
Automation	[47]
Integration and Communication	[48]
Building Design	[49]
Decrease Design Errors	[50]
Construction and Design Integration	[51][52]
Process Standardization	[53]
Problem-solving	[54]
Information Sharing	[55][56]
Stakeholders' involvement	[57]
construction safety	[58][59]
Risk Management	[60]
cost estimation	[61][62]
refurbishment	[63]
planning efficiency	[64]
Fast modeling and documentation	[65]
Prefabrication advancement	[66]

This section will focus on the design and methods used to accomplish this research. A quantitative research methodology was obtained by analyzing data and statistics of two construction projects. Furthermore, this study implements a qualitative grounded theory method to support this research. A project cost summary shows the differences between adopting BIM and traditional techniques. Quantitative data collection takes the most time and is time-consuming as the example measure is usually more prominently contrasted with qualitative. The researchers discussed the collected data to respond to the research objectives. Besides, this sample would have to include individual participants in an interview who may contribute to the research. Given the small number of people with relevant experience, the researchers randomly assigned interview experts for this study. It is not easy to cover the whole project. Therefore, the researchers delegating a good sample reflects the significance of this research to entire projects and then conducting a discussion on the results. This research followed a specific structural process as shown in figure 1.

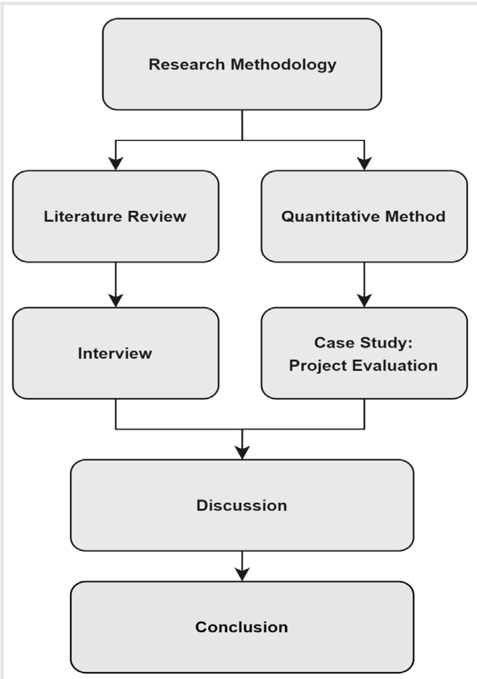


Figure 1. Research Flow Chart

2.1 Qualitative Approach: A Grounded Theory

The Grounded theory design is a way of developing a basis for understanding a speculative topic's broader theoretical process. Because it is sensitive to participants in the environment rather than employing "off-the-shelf" materials, grounded theory could have an interpretation that matches the problems. Furthermore, it is the most outstanding choice if a particular action needs to be investigated or when a human activity or relationship needs to be discussed [67]. Researchers must be aware of assertions and biases introduced into the study process while using qualitative research. Although the grounded theory has established checks to manage assumptions and preferences, such assessments may not remove the negative preconceptions [68]. As a result, the current study required first to collect stakeholders' opinions on the implications of using BIM compared to the conventional method and how it can improve the project performance considering the time and cost to meet the study's objectives. The authors used the grounded theory to gather enough complicated and extensive data on the subject to gain a nuanced and deep grasp of it. To supplement what was discussed in the literature, the researchers communicated personally with participants and enabled them to express their tales in an interactional form.

2.2 Data collection

In this study, the researchers investigate the performance of BIM and conventional methods related to the time and cost through the lifecycle of construction projects. The researchers communicate to collect their qualitative data from the experts in the construction projects. The data collected by the researchers from 15 project experts (engineers, consultants) and the interviewees contributed to the study effectively. The contributors were required to be informed about or get enough expertise with the central phenomenon; therefore, the method and criteria for selecting these initiatives were critical [69]. This research employed a practical sort of purposeful sampling called "Snowball Sampling" to contact the most skilled professionals in a project. The researchers invited respondents or interviewees with contact details to use their social networking sites to suggest the researcher to the best knowledgeable individual who can guide this study using this strategy [70]. Data analysis and Data collection were two processes that were intertwined. The research group sent the round 1 form of questions and evaluated the data. Participants' responses led to more data collection and more extensive questions until convergence was reached. Moreover, the researchers performed a total number of 10 interviews with 15 relevant experts; every attempt was made to keep the discussions consistent. All of the meetings were recorded and documented.

2.3 Data Analysis

As previously described, the coding process and data gathering might happen simultaneously in a grounded theory method. When it comes to data collecting, this can assist interviewers in getting more detailed responses. There are three types of coding [67].1) Open coding: within that step, data is segmented, and data are grouped under the conceptual headings to generate basic categories. 2) Axial coding: inside the discussion transcripts, recognized open codes are joined to create categories. This step in the axial coding process aids in the identification of causal conditions, tactics, and intermediate categories. 3) Selective code: the core group and other categories formed in the axial coding stage give a beginning structure for a theory, which is then completed in more detail by the attributes of each group. QDA Miner lite was used to analyze the data and take the interviewees' great words to form the coding.

2.4 Verification Strategies: Validity And Reliability

Verification is a distinctive element of qualitative research because of the extensive time spent in the field, the detailed description, and the closeness of interviewees to the investigation. The term "reliability" is frequently used in qualitative research to refer to the consistency of numerous coders' customer replies in databases [71]. As a result, the interview protocol's dependability was tested in a focus group before beginning the data collection. The study team used a procedure named inter-coder agreements, which involves three separate coders who are competent in the procurement area analyzing a transcript independently and discussing it continuously to assess the consistency of different coders' replies in databases. Each independent coder for this research had over ten years of experience using the best-value technique in their projects. According to the axial and selecting code findings, the inter-coder agreement method produced a codebook. Instead of forming an entire list of all information extraction outcomes, this codebook specified the primary categories identified and served as a standard guide for coding measures across the study. This study utilized three tactics to improve the validity and reliability of the results [72]. The first way is triangulation. It is the most reliable method for determining the correctness of the results [71]. The study looks for matching information from various sources (e.g., interviewing many participants in each project and collecting data from four distinct types of building classifications). Second, the authors use published research to bridge the codes, categories, and contexts. Finally, the interviewers were shown the grounded theory and visualizations and requested their opinions. All the interviewees had previously worked on best-value projects, giving the emergent grounded theory credibility as an integrated framework of views for explaining the phenomenon of teamwork in best-value projects.

3.0 RESULTS AND DISCUSSION

The results shown below were achieved by analyzing two sample projects in Iraq. The data was collected for the whole project's lifecycle at different stages.

Table 2 Estimation of labor and costs in the process for BIM project 1/ stage1

Level	Person-hour	No. of labor	Daily fee	Estimates	Sum
BIM Manager	30	1	$873	$3,274	
BIM Coordinator	60	1	$729	$5,468	
BIM Modeler	120	1	$551	$8,265	$22,356
Professional	26	1	$977	$3,175	
Intermediate	26	1	$669	$2,174	

Table 3 Estimation of labor and costs in the process for BIM Project1/ stage 2

Level	Person-hour	No. of labor	Daily fee	Estimates	Sum
BIM Coordinator	60	1	$729	$5,468	$7,642
Intermediate	26	1	$669	$2,174	

Table 4 Estimation of labor and costs in the process of conventional Project2/stage1

Level	Man-hour	No. of labor	Daily fee	Estimates	Sum
Manager	40	1	$650	$3,250	
Coordinator	160	2	$420	$16,800	$22,250
CAD operator	80	1	$220	$2,200	

Table 5 process of labor and cost estimates for conventional Project2/ stage 2

Level	Man-hour	No. of labor	Daily fee	Estimates	Sum
Manager	40	1	$650	$3,250	
Coordinator	160	1	$420	$8,400	$13,850
CAD operator	80	1	$220	$2,200	

Tables 2,3,4, and 5 above, demonstrate the cost estimates of the working staff for both projects divided into two stages for each project. The first stage for each project representing BIM and conventional methods shows almost no difference between these two methods (22,356$), and the BIM method (22,250$), for traditional methods. On the other hand, the researcher can find considerable variance in stage 2 of each project. To summarize, the total cost estimates of both sets for each method can be accounted for as shown:

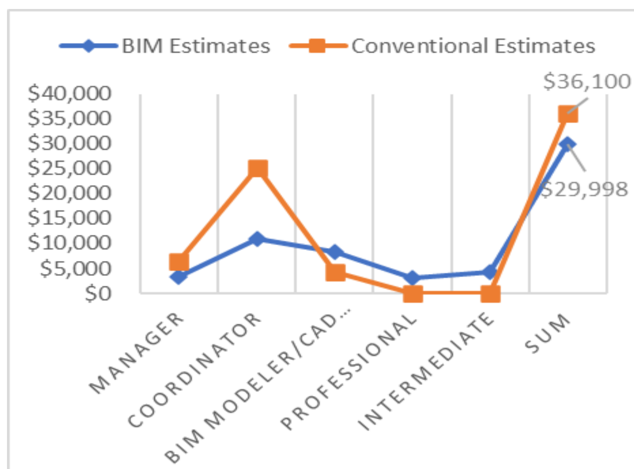


Figure 2. A Comparison of total estimates between BIM and conventional methods

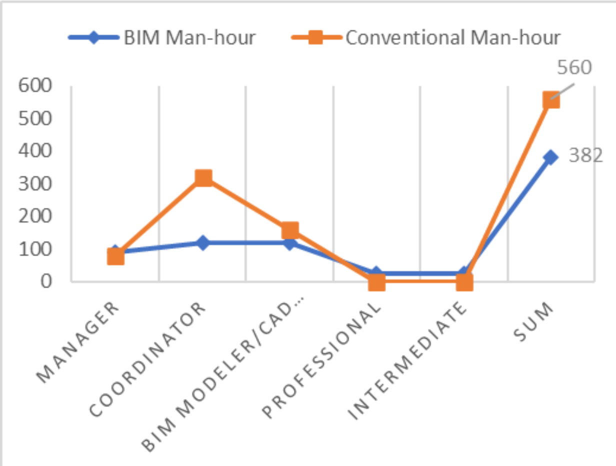


Figure 3. A Comparison of the total time required for the BIM and conventional method

The experiences and views of various stakeholders with considerable construction project delivery expertise indicated multiple ways the best-value strategy influences participants' behavior. Stakeholders reported that early decisions and team interactions affected the project's performance during the interviews. The results of the grounded theory interview captured some expected benefits that lead to time and cost improvement through the lifecycle of the construction project, categorized as below:

3.1 Stakeholders' Early Involvement

the building sector is highly fragmented Because of poor communication between the design and construction phases. Traditional delivery methods such as design-bid-build promote the separation of design and construction processes. Because of the hard decision to officially invite the contractors to design decisions, such a separation limits the flow of design and construction knowledge. As a result, the innovation potential is decreased. Many stakeholders want to adopt integrated delivery platforms that support overlapping design and construction to alleviate these restrictions and incorporate construction information into the design phase [73].

"Most projects suffered from inaccurate documents, and the blame is on the nature of conventional contractual form and project delivery system."

When BIM is incorporated into a project's design and planning phases at the demand stage, the likelihood of switching to a different method of delivering the project is minimized because of the digitalization of the data involved.

"Promoting the organizational structure by innovative systems (e.g., BIM) greatly reduces discrepancies in projects and construction defects."

3.2 Collaboration

Effective teamwork is possible if the project members believe in BIM as a platform for collaborative work – where such validating norms will determine actions across the team. BIM can resolve most of the issues raised in the project efficiently without the need for a routine, which consumes time waiting for approval and can be neglected.

"We worked closely with the field personnel and were able to resolve the majority of the concerns. However, everything became a problem when obligations were allocated to this authority. It is quite difficult getting done when people have that attitude."

3.3 On-site Best Practices

- *Visualization*

The most common use of BIM is for visual analysis operations[7, 72]; it can offer 3D renderings[6].

- *Cost estimation*

It allows the project teams to have a take-off quantity in just a few minutes[75].

- *Shop drawings*

The capability to produce shop drawings [76].

- *Concurrent project activities*

BIM will handle project materials' distribution, schedule, and production [77].

- *Detection of interference*

BIM can display interference with sections and parts [78].

- *Management of the facilities*

can be used for repair and maintenance [79].

- *Better design skills*

Immediate construction plans, benchmarking, and innovative solutions [80].

- *Documentation*

Reporting Better quality of data [81].

- *Project log-life data*

It efficiently provides the necessary data during the project life cycle [13].

4.0 CONCLUSION

BIM has brought significant advantages to the construction sector. Building Information Modeling (BIM) is a technique for performing construction activities. It is a breakthrough that improves the delivery of construction domains across the project's lifecycle. Concurrent construction is aided by using BIM throughout the project's lifetime. It can certainly help with the various stages of a project's lifecycle, from initiation to design, implementation, operation, and finally, demolition. Several studies have demonstrated the significant benefits of BIM deployment in increasing productivity and efficiency. The government is the driving force behind Implementing BIM.

Furthermore, BIM significantly impacts current practices, contractual policies, and business strategies. Therefore, the use of BIM concerning the cost and time can be shown more clearly in the long term. Moreover, it will improve the performance of the workforce and enhance fluent implementation of project work activities. It controls the quality of achieved work, reduces cost and short work, safety and risk avoidance, assists in the documentation work and reports preparation, and easy and fast transferrable data, accessible and pre-work complex projects. In this study, the researchers collected data from multiple case studies of two projects and compared the data with all the information obtained from the literature review. This study emphasized that the wide use of BIM in the construction site will alleviate risks in many stages. In addition, it uncovered the unique feature of the construction site in Iraq. The intrusion of BIM will be extraordinarily beneficial, improve the cost and time of projects, and increase project performance effectively. For future research, the researchers proposed to study the technical advantages of adopting BIM in public procurement organizations for process integrity.

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