Analysis of Challenges to BIM Adoption in Mega Construction Projects

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Abstract. Megaprojects are large-scale and complex investments, including a long construction period, as a result need efficient management skills during their life cycle. The success rate of the megaprojects is lower compared to the traditional projects due to their complex characteristics. By adopting new technologies, such as Building Information Modeling (BIM), more efficient project management can be performed for mega construction projects. Hence, the success of projects could be increased in terms of time, cost and quality. In this study, the challenges to BIM implementation in mega construction projects are investigated. To achieve this aim, the challenges for BIM adoption extracted through a literature review. Then, a questionnaire survey was designed to collect the data from practitioners. Furthermore, the challenges were analyzed using descriptive statistics.

Keywords: BIM, construction, megaproject, project management

1. Introduction
Mega construction projects can be described as “large-scale, complex ventures that typically cost US$1 billion or more, take many years to develop and build, involve multiple public and private stakeholders, are transformational, and impact millions of people” [1]. Some examples of the megaprojects include railways, airports, wastewater projects, power plants tunnels. They have an important role in meeting the diverse needs of people [2]. Rapid global urbanization has led to an increase in demand for megaprojects, especially in developing countries [3]. As a result, the number of megaprojects in the world has rapidly increased [4-5]. Although their numbers have increased so much, their success rates have remained low compared to traditional projects. The reason for having such low success rates is their uncertain and complex characteristics [6]. To reduce the impact of the complex and uncertain nature on the success of the project, more efficient project management needs to be performed. This can be achieved by adopting new technologies.

Building Information Modeling (BIM) is one of the most common information technology based approach that enables users to create virtual model of construction for the planning, design, construction and maintenance phases [7-8]. It allows engineers, constructors, and architects to recognize any problems associated with design, construction and operation stages [9]. In addition to these, using BIM helps projects achieve the desired targets in terms of time, quality and cost. It is clear that using BIM solves most of the problems encountered in projects, especially in megaprojects. It also increases the success rates of projects. Hence, its use in the AEC industry is also growing rapidly. Although it has many benefits and is widely used in many countries, it has not reached the desired level of use in some countries. Turkey is one of the country that the implementation of BIM has not reached the desired
levels especially in megaproductions. Therefore, the main objective of this research is to explore the barriers that hinder the implementation of BIM in megaproduction projects.

2. Literature Review

BIM technology has become one of the most important topics in construction management literature for the last two decades. There are large number of BIM studies that particularly focus on the challenges to the implementation of BIM technology in different countries. Al-Hammadi and Tian [10] analyzed the critical challenges to BIM technology adoption in the Saudi Arabian construction industry. “Lack of demand”, “lack of experts” and “poor awareness of BIM benefits” were listed as the major barriers. Farooq et al. [11] identified 12 barriers that hinder the BIM implementation in Pakistan. They also used an Interpretive Structural Modeling (ISM) to investigate the interrelationships between the barriers. Doan et al. [12] explored 14 potential barriers to the adoption of BIM technology in the New Zealand construction industry. According to this study, “a lack of BIM understanding”, “a lack of expertise”, “high economic investment”, “a lack of collaboration and coordination” and “legal issues” were listed as the major barriers. Roy and Firdaus [13] investigated the barriers for BIM implementation in Indonesia. They summarized the top five barriers to BIM adoption are “lack of BIM training”, “lack of BIM experience and capability”, “no client demand”, “high cost in software and hardware acquisition”, and “inadequate information technology (IT) facilities”. Chan et al. [14] examined the barriers to BIM implementation in Hong Kong. According to them, the major barriers impeding the adoption of BIM technology are “resistance to change”, “inadequate organizational support and structure to execute BIM” and “lack of BIM industry standards”. Charef et al. [15] highlighted the major barriers hindering the adoption of BIM technology in EU countries. Cao et al. [16] listed the barriers to BIM implementation in the Canadian construction industry. Hatem et al. [17] investigated the potential barriers impeding the BIM adoption in Iraq. “Weakness of the government’s efforts”, “poor knowledge about the benefits of BIM” and “resistance to change” were listed as the top three barriers hindering the BIM adoption. Sreelakshmi et al. [18] identified the major challenges faced by Indian construction companies in adopting BIM technology. Wu et al. [19] concluded from their study that the major barriers hindering the adoption of BIM technology for industrialized building in China are “capital-related factors” and “lack of support from owners”. In the light of the background research, this research aims to explore and analyze the barriers hindering the BIM technology adoption for megaproduction projects in Turkey.

3. Research Methodology

This study aims to investigate the barriers for megaproduction projects in Turkey in three steps such as survey design, data collection, and data analysis. In the first step, a questionnaire was designed to evaluate the impact of the barriers. To design the questionnaire, a set of barriers was identified through a literature survey (Table 1). It should be noted the published papers (both in journals and conferences) related to BIM technology barriers were collected using Scopus and Web of Science databases for this identification stage.

| Barriers                        | References |
|---------------------------------|------------|
| B1.Lack of knowledge about BIM  | 10, 20, 21, 22 |
| B2.High cost of BIM software    | 13, 15, 22, 23, 24 |
| B3.Lack of experience in using BIM| 16, 17, 19,25 |
| B4.Lack of standards and government regulations | 11,15,16,25,30 |
| B5.Lack of skilled personnel    | 11, 13, 21, 26 |
| B6.BIM Licensing problems       | 13, 22, 27 |
| B7.Lack of demand               | 10, 11, 15, 25, 28 |
| B8.Interoperability problems    | 14, 20, 24, 28 |
| B9Resistance to change          | 21, 22, 26, 28 |
The questionnaire includes two parts. First part includes questions asking the demographic information about the participants, whereas the second part covers the barriers to BIM technology adaption. In this part, a five-point Likert scale was adopted to assess the impact of each barrier. After the questionnaire was designed, it was distributed to the participants via e-mail. As it is important to determine the proper respondents, the population of this research includes consultants, contractors and clients who have been involved at least one mega construction project in Turkey.

In the last step, the collected data were statistically analyzed to elicit the ranking of each barrier. For this purpose, the mean score method was adopted. In this method, the ranking of each barrier was found using the following formula:

\[ MS = \frac{\sum (f \times s)}{N} \]  

Where MS is the mean score for each factor; f is the frequency of response to each rating for each factor; s is the score of each factor; N is the total number of responses.

4. Results

4.1. Profiles of Respondents

A total number of 73 questionnaires have been distributed. 52 responses were received, which shows a response rate of 71.2%.

- 48% of the respondents were contractors having a majority, 29% were consultants, and 23% were clients.
- 77% of the respondents had bachelor’s degree, 19% had master’s degree, and 4% had doctorate degree.
- 67% of the respondents were civil engineers, 13% of the respondents were architect, 12% of the respondents were mechanical engineers, and 8% of the respondents were electrical engineers.
- 21% of the respondents have 0-10 years of working experience, 62% of the respondents have 10-20 years of working experience, and 17% of the respondents have more than 20 years working experience.
- 61% of the respondents have 0-5 year experience in BIM technology, 33% of the respondents have 5-10 years experience in BIM technology, and 6% of the respondents have more than 10 years experience in BIM technology.

4.2. Ranking of Barriers

Table 2 shows the respondents’ perceptions for 12 barriers that hindering the implementation of BIM. The results showed that respondents ranked “B5. Lack of skilled personnel” as the most important barrier with a mean value of 4.38. It is one of the biggest barrier to BIM technology implementation, especially for developing countries. Although the number of BIM professionals in Turkey has rapidly increased in the last decade, it is still limited. As the need for skilled personnel in megaprojects is higher than traditional projects, this barrier takes the priority among all respondents. The second most highly
rated barrier was “B1. Lack of knowledge about BIM” with a mean value of 4.25. This is another major barrier that hinder the BIM implementation. Most people working in the construction industry do not have enough knowledge about BIM. This barrier has also been reported as one of the most important barriers in many studies [12,13,17]. “B4. Lack of standards and government regulations” was ranked third with a mean value of 4.19. Another barrier to overcome to reach the desired level of BIM technology use is the preparation of the necessary standards and legal regulations. “B3. Lack of experience in using BIM” is another important barrier that was ranked fourth with a mean value of 4.08. The fifth most important barrier hindering the BIM technology adoption is “B9. Resistance to change” with a mean value of 3.96. “B6. BIM Licensing problems” is the least important barrier with a mean value of 2.29. Contrary to similar studies, financial barriers (B11. High cost of training and B2. High cost of BIM software) remained at the bottom of the ranking. This can be explained by the fact that the megaprojects have a larger budget compared to the traditional projects. Clients group and contractors group ranked “B9. Resistance to change” as the most important barrier, whereas contractors group ranked it eighth. Contractors group ranked “B5. Lack of skilled personnel” as the first priority whereas clients group ranked it third an consultants group ranked it second. According to the clients, the top three barriers are as follows: B9. Resistance to change (MS = 4.58, Rank = 1), B1. Lack of knowledge about BIM (MS = 4.42, Rank = 2), and B5. Lack of skilled personnel (MS = 4.33, Rank = 3). According to the contractors, the priority of barriers are as follows: B5. Lack of skilled personnel (MS = 4.44, Rank = 1), B4. Lack of standards and government regulations (MS = 4.28, Rank = 2), and B1. Lack of knowledge about BIM (MS = 4.33, Rank = 3). According to the consultants, the priority of barriers are as follows: B9. Resistance to change (MS = 4.40, Rank = 1), B5. Lack of skilled personnel (MS = 4.33, Rank = 2), and B1. Lack of knowledge about BIM (MS = 4.27, Rank = 3).

Table 2. Ranking of Barriers

| Overall | Client | Contractor | Consultant |
|---------|--------|------------|------------|
|         | MS     | Rank       | MS         | Rank |
| B1. Lack of knowledge about BIM | 4.25  | 2          | 4.16       | 3    | 4.27 | 3 |
| B2. High cost of BIM software | 2.65  | 11         | 2.24       | 12   | 2.40 | 11 |
| B3. Lack of experience in using BIM | 4.08  | 4          | 4.12       | 4    | 4.13 | 4 |
| B4. Lack of standards and government regulations | 4.19  | 3          | 4.08       | 4    | 4.28 | 2 |
| B5. Lack of skilled personnel | 4.38  | 1          | 4.44       | 1    | 4.33 | 2 |
| B6. BIM Licensing problems | 2.29  | 12         | 2.56       | 11   | 2.33 | 12 |
| B7. Lack of demand | 3.69  | 7          | 3.80       | 7    | 3.73 | 7 |
| B8. Interoperability problems | 2.96  | 10         | 2.92       | 10   | 3.20 | 10 |
| B9. Resistance to change | 3.96  | 5          | 3.40       | 8    | 4.40 | 1 |
| B10. Inadequate studies on BIM | 3.23  | 9          | 3.24       | 9    | 3.27 | 9 |
| B11. High cost of training | 3.69  | 7          | 4.04       | 5    | 3.47 | 8 |
| B12. Lack of tangible BIM benefits | 3.87  | 6          | 4.04       | 5    | 4.00 | 6 |

5. Conclusion
This study reports the results of a survey questionnaire investigating barriers that hinder the BIM technology implementation in megaprojects. Potential barriers to BIM implementation were initially identified through a literature survey. Using these barriers, a questionnaire was prepared and applied to the clients, contractors and consultants. The results were analyzed by adopting a mean score method. The findings of this research show that the top five most important barriers are lack of skilled personnel, lack of knowledge about BIM, lack of standards and government regulations, lack of experience in using
BIM, and resistance to change. Based on the findings of this study, future work can develop some strategies to overcome the identified barriers that hinder the BIM technology implementation. The sample size of the respondents is the limitation of this study. As the number of megaprojects is limited in Turkey, it is difficult to find suitable respondents, have experience in megaprojects, for the questionnaire survey. Future studies can be performed by increasing the sample size.

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