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BIM Adoption in MENA's Construction Industry: A Contractor's Perspective

Mohammad Sadeq Abdullah [1*], Mohamed Salem [2], Salah Omar Said [3], Mohamed Tantawy [3]

[1] *Department of Architecture, College of Architecture, Kuwait University, Kuwait City, Kuwait.*

[2] *Department of Civil Engineering, Collage of Engineering, Australian University, Safat, West Mishref 13015, Kuwait.*

[3] *Department of Civil Engineering, Faculty of Engineering, Mataria, Helwan University, Cairo 11718, Egypt.*

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Abstract

This study delves into the multifaceted landscape of Building Information Modeling (BIM) adoption and implementation across the Middle East and North Africa (MENA) region's construction industry. Employing an online survey methodology, the research scrutinizes the varied profiles of contractors. Through regression analysis, the study investigates the impact of institutional pressures on the contractors' BIM adoption, implementation, encountered barriers and challenges, expected benefits and outcomes, and related expertise and training. The analysis then extends to evaluate the interrelationships among such BIM variables. The key findings reveal significant influences of institutional pressures on BIM adoption and benefits as well as their expected benefits and outcomes but less impact on overcoming BIM barriers and challenges and enhancing expertise and training. The research highlights the limited role of BIM expertise and training in the adoption, implementation, and realization of its benefits and outcomes within the MENA construction sector. Furthermore, the study concludes that barriers, challenges, benefits, and outcomes don't have a significant effect on BIM's adoption and implementation. The study also evaluates the primary benefits and outcomes of BIM alongside the main barriers and challenges encountered. Crucially, the research identifies and dissects the salient barriers to BIM deployment, such as awareness and expertise deficiency, financial and human resource constraints, training shortages, and resistance to change. This study not only provides a detailed snapshot of the BIM landscape but also lays the groundwork for addressing the persistent challenges and harnessing the full potential of BIM in revolutionizing construction methodologies in the MENA region.

Keywords: MENA Region; Construction Industry; Contractors; Institutional Pressures; BIM Adoption and Implementation; BIM Expertise and Training; BIM Barriers and Challenges; BIM Benefits and Outcomes.

1. Introduction

Building Information Modeling (BIM) is a digital platform that provides a collaborative illustration and information of a building's physical and functional properties to assist in a project's procurement, design, construction, and facility management tasks [1]. The background of BIM in the construction industry reveals a global interest in its adoption and implementation based on the extensive provided literature. The potential of BIM to increase project sustainability and efficiency is becoming more widely acknowledged [2, 3]. The focus on using BIM in various settings, from large to small-scale construction projects, highlights its adaptability. However, the literature also shows that BIM adoption varies in scope and pace across various project scales and geographical areas [3-7]. A need for data precisely measuring BIM

* Corresponding author: dr.msadeq@ku.edu.kw

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adoption and implementation across the MENA construction industry exists despite studies such as in Mehran [8], which explored BIM adoption in certain parts of that region. This gap is substantial considering the opportunities and challenges this regional construction industry presents [8]. Furthermore, regional data—particularly in the context of the MENA—remains under-researched despite the wealth of literature on BIM technologies and practices worldwide.

The focus of the research problem is triggered by the requirement for a thorough grasp of BIM knowledge in the MENA construction sector. This entails examining the BIM technology and practice adoption level, recognizing the benefits and outcomes, and comprehending its particular obstacles and difficulties [3, 5-7, 9]. A region-specific study is necessary to fully understand the current state and the potential of BIM technology due to the unique characteristics of the MENA construction sector, including its regulatory environment, project scales, and technological maturity. Furthermore, it is critical to pinpoint the challenges and barriers impeding the MENA region's wider adoption of BIM [3, 4, 7]. Broad barriers to BIM deployment are highlighted by research, yet a targeted study of the MENA region would shed light on specific barriers, including cultural considerations, technological readiness, and regulatory frameworks [3, 10].

A great deal of academic and practical value can be gained from existing BIM research. This research closes a significant gap in the literature by gauging the impact of institutional pressures on several variables related to BIM adoption and implementation in the MENA construction industry and comprehending the obstacles and difficulties within such a context. Additionally, by examining the advantages and benefits of BIM technology adoption and implementation in this area [7], the research offers industry stakeholders insightful information to help them plan for increased BIM adoption and make well-informed decisions [3, 4]. This thorough examination shall advance scholarly knowledge of BIM in MENA and provide industry experts and decision-makers with helpful advice on using BIM to enhance productivity, sustainability, and teamwork in building projects. Finally, investigating the advantages and benefits of BIM technology in the MENA construction sector is essential to completing the research scope. Even though the literature from around the world points to many benefits, such as improved efficiency, collaboration, and waste reduction [11], knowing how these advantages are related to the MENA context helps stakeholders and policymakers to encourage further BIM adoption in the construction industry.

The literature shows significant BIM adoption and implementation gaps in various regions and sectors, particularly in MENA. Sodangi et al. [1] discuss Saudi subcontractors' awareness and adoption, but institutional pressures are unexplored. Merschbrock & Munkvold [2] discuss BIM-based digital collaboration in a hospital project, but MENA SMEs' challenges are understudied [10]. The MENA region's institutional and cultural factors may differ from Malaysia's, but Waqar et al. [3] identify BIM deployment barriers in small construction projects. Saka et al. [10] present a framework for MENA BIM adoption based on institutional isomorphism in Nigerian SMEs, but data and analysis are lacking. While Manzoor et al. [5] and Maraqa et al. [7] examine the effects of digital technologies and BIM on sustainability and process flows, they need to address the role of BIM expertise and training in overcoming adoption barriers and maximizing BIM's potential. Mehran [8] examines UAE BIM adoption, but he doesn't discuss how improved skills and knowledge help. This gap is essential because BIM expertise can boost implementation strategies. Akinade et al. [11] and McConnell [12] discuss stakeholders' expectations and construction claim fundamentals, but further research is needed to determine how BIM training affects project efficiency, collaboration, and sustainability, particularly in the MENA region.

The role of contractors in the MENA construction industry is increasingly crucial, given their direct impact on project execution and deliverables. Contractors, with their specialized expertise and resources, are pivotal in navigating the complexities of modern construction projects. Recognizing their significance, this study delves into the BIM adoption landscape from the perspective of contractors within the MENA region [12]. This focus is driven by the understanding that contractors not only contribute to the tangible aspects of construction projects but also play a key role in the integration and utilization of innovative technologies like BIM. Their unique position, coupled with the challenges and opportunities they face, such as financial constraints, technological adaptation, and collaboration dynamics, underscores the necessity of examining BIM adoption through their lens. By doing so, the research aims to uncover nuanced insights into how BIM can be more effectively adopted and implemented by contractors, thereby enhancing project efficiency, quality, and sustainability.

This study endeavors to deepen the understanding of BIM adoption within the MENA construction industry from a contractor's viewpoint. The research is structured to address the following objectives:

- To assess the impact of institutional pressures on the adoption and implementation of BIM in the MENA region. This assessment is inclusive of the impact on BIM expertise and training, barriers to adoption, and the outcomes and benefits of BIM usage.
- To investigate the role of BIM expertise and training in the adoption and effective implementation of BIM. This objective is aimed at understanding how enhanced skills and knowledge contribute to overcoming adoption barriers and leveraging BIM's full potential.

- To identify and analyze the principal barriers and challenges to BIM adoption in the region. This involves exploring how these obstacles affects the willingness and capacity of the industry to integrate BIM into their operations.
- To explore the primary benefits and outcomes of BIM technology in improving project efficiency, collaboration, and sustainability. This objective seeks to understand the tangible and intangible gains from BIM implementation in the MENA context.
- To examine the influence of BIM expertise and training on the benefits and outcomes realized from BIM adoption. This focuses on how education and professional development in BIM can enhance the value derived from its use in construction projects.

Each of these objectives is designed to contribute to a comprehensive understanding of BIM's status, challenges, and opportunities in the MENA construction sector, providing valuable insights for stakeholders and policymakers.

2. Literature Review and Conceptual Framework

2.1. Institutional Pressure Influence on BIM Adoption and Implementation, BIM Barriers and Challenges, BIM Benefits and Outcomes, and BIM Expertise and Training

BIM adoption and implementation in the construction industry are diverse globally. The findings of Saka et al. [10] and DiMaggio and Powell [13] provide strong evidence that institutional pressure affects BIM adoption and implementation. According to DiMaggio and Powell's theory of institutional isomorphism, organizations change in response to outside influences, which results in shared procedures and frameworks [13]. The theory is confirmed by a study that looks at how institutional isomorphism influences BIM adoption in SMEs in the Nigerian construction industry [10]. These studies show that external pressures, as evidenced by the alignment of BIM practices with institutional norms and regulations across different countries heavily influence BIM adoption and implementation decisions.

Ahmed et al. [14] emphasize the importance of interoperability in Malaysian BIM adoption and the need for institutional support. El Hajj et al. [15] discuss MENA BIM adoption barriers and how institutional pressures increase or decrease them. Hall et al. [16] outline institutional pressures as significant barriers to BIM adoption for New Zealand SMEs. In addition, Yılmaz et al. [17] and Zhang et al. [18] examine BIM implementation barriers in the HVAC industry, emphasizing the importance of institutional pressures for overcoming obstacles and enhancing expertise and training. Datta et al. [19] highlight the benefits and drawbacks of BIM for sustainable practices, showing that institutional pressures encourage BIM adoption and implementation.

In addition, the hypothesis is supported by findings that identify obstacles to BIM deployment in Malaysian small construction projects, suggesting that organizations may encounter challenges due to external institutional pressures such as industry standards and regulatory frameworks. As demonstrated in the Malaysian context, these challenges often arise from the need to integrate BIM practices with existing institutional policies or due to a lack of support from these institutions [3].

Institutional pressure can lead to improved BIM outcomes and benefits, such as increased sustainability and efficiency in building projects, by driving the adoption of cutting-edge technologies like BIM for more environmentally friendly and productive building methods Tulenheimo [20] and Wong et al. [21]. Furthermore, the notion that institutional pressures necessitate and facilitate the development of BIM knowledge and training within organizations is supported by additional research. This occurs as organizations advocating for BIM use create a demand for skilled personnel, thereby encouraging training and progress in the field Saka and Chan [22] and Won et al. [23]. Drawing on the discussions presented in the literature, this study posits four research hypotheses, all of which are considered from the perspective of general contractors as follows:

H1. *Institutional pressure positively affects BIM adoption and implementation.*

H2. *Institutional pressure positively affects BIM barriers and challenges.*

H3. *Institutional pressure positively affects BIM benefits and outcomes.*

H4. *Institutional pressure positively affects BIM expertise and training.*

2.2. Influence of BIM Expertise and Training on BIM Adoption and Implementation

Projects in developed countries like the Norwegian hospital studied by Akinade et al. [11] demonstrate BIM advanced technological integration and efficiency. The UK, aligning with the global trend, demonstrates high adoption and advanced implementation with Industry 4.0 integration [24]. Table 1 shows the varied BIM adoption and implementation landscape across different countries. It shows that while countries like Norway and the UK, with advanced BIM implementation, are reaping the benefits of effective digital collaboration [2], others like Malaysia face significant barriers, leading to limited adoption [3]. With moderate BIM adoption, UAE and Pakistan are in different stages of evolution and emergence, reflecting a gradual recognition of BIM benefits and mixed progress, respectively Masood et al. [25] and Mehran [8]. Collectively, these findings underline the transformative impact of BIM in the construction industry while highlighting the diverse challenges and stages of implementation across different regions. Accordingly, our study aims to examine the following research hypothesis:

H5. *BIM expertise and training positively affects BIM adoption and implementation*

Table 1. BIM adoption and implementation

BIM Adoption	BIM Implementation	Country	Findings	References
High	Advanced	Norway	Effective digital collaboration.	Merschbrock & Munkvold (2015) [2]
Low	Limited	Malaysia	Significant barriers present.	Waqar et al. (2023) [3]
Moderate	Evolving	UAE	Gradual recognition of benefits	Mehran (2016) [8]
Moderate	Emerging	Pakistan	Mixed progress.	Masood et al. (2014) [25]
High	Advanced	UK	Industry 4.0 integration.	Newman et al. (2021) [24]

2.3. Influence of BIM Barriers and Challenges on BIM Adoption and Implementation

The variation of literature offers perceptive viewpoints on the obstacles and difficulties encountered in implementing BIM in various nations. Several researchers how BIM is successfully implemented in Norway, suggesting fewer barriers in a developed setting [4, 5, 7]. Several significant challenges have been noted as well in Malaysia, especially with small construction projects where the lack of expertise and financial constraints make BIM deployment difficult [3].

Resolving interoperability issues is crucial to BIM adoption in Malaysia [14]. El Hajj et al. [15] discuss MENA BIM adoption barriers and how they hinder BIM technology adoption and use. Hall et al. [16] examine various BIM adoption barriers in New Zealand SMEs and how they prevent BIM integration. Yılmaz et al. [17] examine the HVAC industry's BIM implementation barriers, emphasizing the need to address sector-specific challenges for wider adoption. Zhang et al. [18] discuss how institutional pressures can reduce these barriers, improving BIM's sustainability. Datta et al. [19] discuss BIM's benefits and drawbacks for sustainable practices and emphasize the importance of recognizing and overcoming these drawbacks to maximize BIM potential.

This implies that resource constraints present barriers that are more significant and challenging for smaller projects in developing nations when implementing BIM [26, 27]. A gradual but progressive adoption of BIM in the Middle East, particularly in the UAE, has been described [8]. Although BIM awareness is rising, some of the main challenges include the need for standardized practices and proper training [27, 28]. The integration of BIM with the Internet of Things (IoT) has been further emphasized, recognizing the difficulties in integrating these cutting-edge technologies with conventional construction methods [29].

Furthermore, the difficulty of integrating BIM with the new Industry 4.0 technologies in developed countries like the UK has been highlighted, where despite the enthusiasm for such integration, the modern systems can be prohibitively expensive and complex [30]. The necessity of standardizing BIM practices to overcome these obstacles has also been emphasized [31].

Table 2 shows some challenges and barriers faced in adopting BIM across various countries. In Malaysia, for example, the significant barriers in small construction projects are predominantly due to resource limitations [3]. Based on such a literature review, our study examines the following research hypothesis:

H6. *BIM barriers and challenges positively affect BIM adoption and implementation*.

Table 2. BIM Barriers and Challenges

BIM Barriers and Challenges	Country	Findings	References
Resource Limitations	Malaysia	Significant barriers in small projects	Maturana et al. (2007); Manzoor et al. (2021); Maraqa et al. (2021); Waqar et al. (2023) [3-5, 7]
Lack of Standardized Practices	UAE	Gradual adoption, need for standardization	Mehran (2026); Olanrewaju et al. (2021, 2022) [8, 26, 27]
Infrastructural Deficits	Pakistan	Hindered by infrastructure, skill shortage	Masood et al. (2014) [25]
Resistance to Change	Global	Challenges in adapting to new practices.	Akinade et al. (2011) [11]
Aligning BIM with Advanced Technologies	Various	Integration complexities with IoT	Shahinmoghadam & Motamedi (2019) [29]
Complexity and Cost	UK	High cost and complexity in Industry 4.0	Newman et al. (2021) [24]

2.4. Influence of BIM Benefits and Outcomes on BIM Adoption and Implementation

The body of research on BIM from different nations highlights various advantages and benefits, demonstrating the technological influence on the building sector. The value of BIM in enhancing digital collaboration, especially in intricate projects like hospital construction, has been highlighted [22, 32, 33]. BIM significantly improves coordination and project management, resulting in more effective and error-free construction [10, 34]. The use of BIM in Architecture, Engineering, and Construction (AEC) firms in the UAE has been investigated, pointing out its benefits in improving planning, shortening project delivery times, and saving money, while also highlighting the technology's role in streamlining construction procedures [1, 8].

These studies show that BIM completely transforms several construction-related processes, from waste management to initial planning [23, 35, 36]. In addition, it is contended that adopting BIM is beneficial for the construction sector mainly because it lowers construction time and costs and enhances overall project quality [37]. Furthermore, insights into the UK's experience with implementing Industry 4.0 in the construction sector are offered, indicating that BIM is essential to this shift and to creating more innovative, sustainable built environments [24]. Based on such literature, our study investigates the following research hypothesis:

H7. *BIM benefits and outcomes positively affect BIM adoption and implementation*.

2.5. Influence of BIM Expertise and Training on BIM Benefits and Outcomes

In contrast, the difficulties encountered in Malaysian projects due to low technological proficiency have been emphasized [3]. Studies have indicated that BIM is gradually becoming more widely used in the Middle East, but there is still a need for improved infrastructure and training [8, 38]. Research by Chan [39] indicates that BIM plays a constructive role in improving the efficiency of building projects globally, pointing towards a global trend of digitalization in construction with varying local adoption rates and challenges.

Table 3 illustrates various phases of BIM practices in several nations, with differing degrees of maturity and emphasis. Norway's construction industry is setting the bar with its highly integrated use of BIM, while the Malaysian experience is still emerging. In its nascent stage, the construction sector in the UAE is progressively embracing BIM as AEC firms become more cognizant of its advantages [8]. Pakistan has adopted BIM moderately and is progressing slowly, with an emphasis on the need for improved technology infrastructure [25].

Table 3. BIM Technologies and Applications

BIM Technologies	BIM Practices	Country	Findings	References
Advanced	Highly Integrated	Norway	Effective in complex projects.	Bui et al. (2019) [40]
Basic	Emerging	Malaysia	Barriers in small projects.	Waqar et al. (2023) [3]
Developing	Gradually Adopting	UAE	Growing awareness in AEC firms.	Mehran (2016) [8]
Moderate	Slow Progress	Pakistan	Moderate level, needs infrastructure and training.	Masood et al. (2014) [25]
Advanced	Sustainability Focused	Global	Enhancing efficiency and sustainability.	Akinade et al. (2016) [11]

Most developed countries and some developing countries have advanced digitally and integrated BIM applications and tools thoroughly in their construction markets for their proven benefits and outcomes. The application of BIM in small construction projects in Malaysia significantly increased construction efficiency and quality [3]. The results of Saka et al. [41], who addressed the value of BIM in designing out construction waste and thereby supporting more environmentally friendly and sustainable building practices globally. The recurring theme in these studies is how beneficial BIM can be to the construction sector, despite the various obstacles to its adoption and application. Based on the outcome of these studies, our research also tries to investigate the following research hypothesis:

H8. *BIM expertise and training positively affect BIM benefits and outcomes*.

The review of all previous literature has led to the development of the study's conceptual framework (see Figure 1) to tackle all generated research hypotheses.

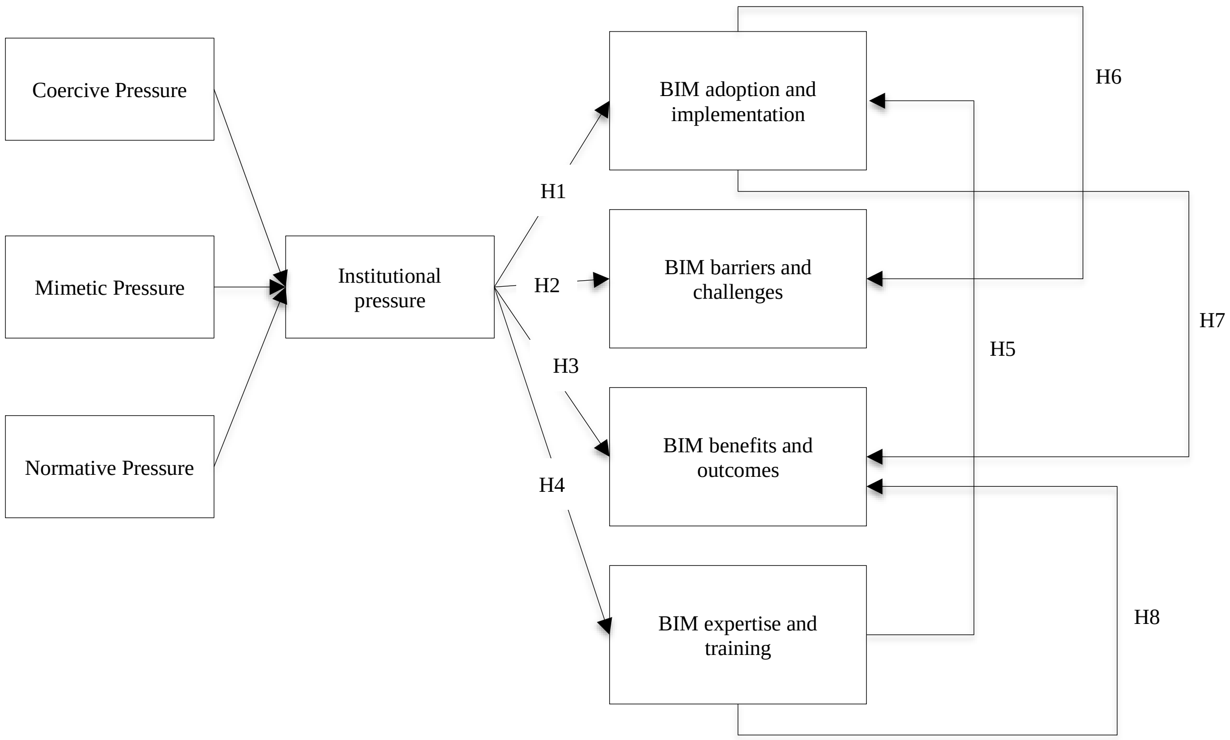

Figure 1. Conceptual Framework

3. Research Methodology

3.1. Research Design

The selection of survey questionnaires as a quantitative research method is supported by well-established business research methodologies. Quantitative methods play a pivotal role in acquiring extensive empirical data, which is imperative for an in-depth awareness of business practices, as stated by Bell et al. [42]. Aligning with the tenets of Dillman [43], provides additional support for the selected methodology, emphasizing the importance of tailoring surveys to fit the target population of general contractors in the MENA construction industry.

3.2. Data Collection Procedures

The methods and strategies used in this study to collect data, especially convenience sampling and online surveys to obtain information from general contractors in the MENA region, align with common and accepted research practices. The effectiveness of online surveys in modern business research is underscored, stressing their ability to effectively reach a broad and heterogeneous audience [42]. This strategy is beneficial for targeting particular groups, like contractors, since it makes it possible to distribute the survey quickly and collect data on time. Furthermore, the practicality and effectiveness of the convenience sampling technique in rapidly reaching a large number of respondents justify its use in this situation, despite occasional criticism for possible biases. The use of online surveys is further supported by the promotion of respondent-friendly designs that encourage participation and truthful responses [43]. To ensure that the survey is both relevant and accessible to the intended audience, the study followed this methodology, which involved collecting personal information from websites and contacting contractors directly via email. Because this method customizes the survey experience to the respondent's needs and preferences, it increases the possibility of a higher response rate and more accurate data.

In addition, Dillman [43] offers a thorough analysis of survey methodology that highlights the significance of ethical issues in data gathering. The collection of personal data to distribute surveys must adhere to the principles of consent and privacy, which align with the current research ethics guidelines. Direct communication with contractors facilitated a clear understanding of the research's purpose, which was crucial for preserving openness and confidence between the participants and the researchers. Finally, Sekaran and Bougie [44] and Saunders et al. [45] emphasized the significance of a systematic approach to research methods. Online surveys provide an organized method for gathering data that guarantees systematic, repeatable, and verifiable information. This methodical approach is essential in business research, where data validity and reliability are critical. In the end of data collection, the study concluded with forty-nine (49) valid and fully completed survey questionnaires from contractors among MENA regions.

3.3. Instrument Development

The development of the survey instrument for this study, focusing on various aspects of BIM, such as adoption, implementation, technologies, barriers, and benefits, was rooted in a methodical approach that aligns with the principles outlined in the referenced academic literature. This survey design covers various topics, from BIM adoption to its outcomes. It follows the guidelines suggested by Bell et al. [42], who emphasize the importance of constructing a survey that thoroughly addresses the research questions and objectives. The inclusion of a wide array of topics within the survey aligns with the recommendations of Saunders et al. [45], who advocate for a thorough approach to survey design, particularly in business research where the complexity of practices and technologies, such as BIM, require detailed investigation. Furthermore, two subject specialists and a language professional, a process that resonates with the methodologies endorsed by Sekaran and Bougie [44], rigorously established the validity of the survey instrument through a review.

4. Data Analysis

4.1. Demographics, BIM Expertise, BIM Clients and Related Delivery Methods

Tables 4 and 5 provide a snapshot of the demographics and BIM expertise of the research population as well as the preferred type of clients and delivery methods that is more responsive to the application of BIM. Table 4 highlights the diverse geographical representation, with a significant 25% of participants hailing from Kuwait, alongside contributions from various MENA regions, including United Arab Emeritus (22%), Kingdom of Saudi Arabia (12.5%), Qatar, Egypt, Bahrain and other MENA countries. These diverse geographical spread underscores the widespread interest and variability in BIM adoption across the region. Resultantly, nearly half of the respondents (46%) identified as part of the management team, showing that decision-makers are significantly engaged in BIM processes. The distribution of BIM experience among respondents was varied, with a quarter (35%) having 5-10 years of experience, indicating a mature user base. The presence of individuals with less than 5 years of experience (33%), suggests an ongoing inflow of newcomers to BIM.

Table 4. Demographics and BIM Expertise Demographics and BIM Expertise

Company Location	N	%
Egypt	3	9.38%
Kuwait	8	25.00%
Qatar	2	6.25%
Saudi Arabia	4	12.50%
The United Arab Emirates (UAE)	7	21.88%
Other	7	21.88%
Company Role		
Digital Transformation Manager	5	10.20%
Senior BIM Manager	6	12.24%
BIM Manager	11	22.45%
Years of Personal Experience in BIM		
Less than 5 years.	16	32.65%
5 to 10 years.	17	34.69%
11 to 15 years.	11	22.45%
16 to 20 years.	3	6.12%
More than 20 years.	2	4.08%

Table 5. BIM Clients and Related Delivery Methods

Company Location	N	%
Public Sector	16	50%
Private Sector	11	34.38%
Public Private Partnership (PPP)	4	12.50%
Other	1	3.13%
No answer	17	
Project Delivery Method		
Design-Bid-Build (DBB)	8	25%
Design-Build (DB)	12	37.50%
Phased construction	4	12.50%
Integrated Project Delivery (IPD)	1	3.13%
Fast Track	3	9.38%
Construction Management	1	3.13%
Other	3	9.38%
No answer	17	

Table 5 demonstrates that public clients' projects are leading in terms of BIM adoption (50%) over private clients' projects (35%), suggesting an increase of public awareness of the value of BIM implementation. BIM is an applicable platform for the traditional Design-Bid-Build (DBB) delivery method (25%) but is used more (37.50%) to align with the rapid pace of the Design-Build (DB) delivery method.

4.2. Regression Analysis

Through this regression analysis, the study looked at the effect of institutional pressures on four different factors: BIM adoption and implementation, BIM barriers and challenges, BIM benefits and outcomes, and BIM expertise and training (Table 6). For the first model, institutional pressures significantly affect BIM adoption and implementation (β=0.367, t-value=2.086, p-value=0.049). This indicates that the adoption and implementation of BIM increases with more institutional pressures. The model shows a moderate effect, with an R^2 value of 40.6%, suggesting that institutional pressures can justify 40.6% of the variance in BIM adoption and implementation. In the second model, the results show that institutional pressures have no effect on BIM barriers and challenges (β=-0.219, t-value=-1.203, p-value=0.236), as the p-value is above the 5% threshold. The low R^2 value (18.3%) indicates a weak effect of institutional pressures on the variance of BIM barriers and challenges. For the third model, institutional pressures significantly affect BIM benefits and outcomes (β=0.612, t-value=4.580, p-value=0.000). This suggests that BIM benefits and outcomes can be enhanced by the influence of institutional pressures. With an R^2 value of 58.7%, this model indicates a moderate effect and suggests that institutional pressures explain a substantial amount of the variance in BIM benefits and outcomes. The fourth model presents a non-significant effect of institutional pressures on BIM expertise and training (β=0.291, t-value=1.961, p-value=0.056), as the p-value is slightly above the 5% threshold. The R^2 value of 28.7% indicates a weak effect and suggests that institutional pressures influence is limited on the variance of BIM expertise and training. This regression analysis finally concluded that institutional pressures significantly influence the adoption and implementation of BIM, as well as its benefits and outcomes, but do not significantly affect BIM barriers and challenges, nor BIM expertise and training.

Table 6. Regression Analysis (Effect of Institutional Pressures)

Independent variable = (Institutional pressures)				
Dependent variables	**Model 1**	**Model 2**	**Model 3**	**Model 4**
H1. BIM adoption and implementation	0.367*			
	p-value = 0.049			
H2. BIM barriers and challenges		-0.219n.s		
		p-value = 0.236		
H3. BIM benefits and outcomes			0.612***	
			p-value = 0.000	
H4. BIM expertise and training				0.291n.s
				p-value = 0.056
F-statistics	4.352	1.448	20.979	3.846
t-value	2.086	-1.203	4.580	1.961
R-square	40.6%	18.3%	58.7%	28.7%

The regression analysis in Table 7 examined the effect of BIM expertise and training, BIM barriers and challenges, and BIM benefits and outcomes on the adoption and implementation of BIM (H5, H6, H7). Additionally, it targeted to measuring the effect of BIM expertise and training on the expected benefits and outcomes of BIM technology (H8).

The first model tested the effect of BIM expertise and training on the adoption and implementation of BIM (H5). However, the effect is non-significant (β=0.304, t-value=1.861, p-value=0.076), meaning that BIM expertise and training do not significantly influence BIM adoption and implementation at the 5% significance level. The R-squared value of 36.2% indicates a weak effect, showing that the variance in BIM adoption and implementation explained by BIM expertise and training is limited. The second model tested the impact of BIM barriers and challenges on BIM adoption and implementation (H6). The effect is also non-significant (β=-0.431, t-value=-1.498, p-value=0.149), indicating that the extent of BIM barriers and challenges does not significantly affect BIM adoption and implementation at the 5% significance level. With an R^2 of 31.1%, the model suggests a weak effect as well. The third model examined the effect of BIM benefits and outcomes on the adoption and implementation of BIM (H7). This model also shows a non-significant effect (β=0.369, t-value=1.672, p-value=0.109), implying that benefits and outcomes derived from BIM do not significantly influence BIM adoption and implementation at the 5% significance level. The R-squared value of 34.3% also suggests a weak effect. Lastly, the fourth model tested the effect of BIM expertise and training on BIM-gained benefits and outcomes (H8). Again, the effect is non-significant (β=0.040, t-value=0.245, p-value=0.808), meaning that BIM expertise and training do not significantly affect the benefits and outcomes derived from BIM at the 5% significance level. Moreover, the R-squared value is only 3.9%, indicating a very weak effect.

Table 7. Regression Analysis (Other Factors)

	Dependent variables			
Independent variables	**BIM adoption and implementation**	**BIM adoption and implementation**	**BIM adoption and implementation**	**BIM benefits and outcomes**
H5. BIM expertise and training	0.304n.s			
	p-value = 0.076			
H6. BIM barriers and challenges		-0.431n.s		
		p-value = 0.149		
H7. BIM benefits and outcomes			0.369n.s	
			p-value = 0.109	
H8. BIM expertise and training				0.040n.s
				p-value = 0.808
F-statistics	3.463	2.244	2.796	0.060
t-value	1.861	-1.498	1.672	0.245
R-square	36.2%	31.1%	34.3%	3.9%

Therefore, none of the models presented significant effects at the 5% level, suggesting that BIM expertise and training, BIM barriers and challenges, and BIM benefits and outcomes all have no significant influence on the adoption and implementation of BIM. Similarly, BIM expertise and training have no significant impact on the gained benefits and outcomes of BIM.

4.3. BIM-Related Barriers and Challenges

The findings of our study revealed major barriers and challenges related to BIM adoption and implementation (Table 8). One significant obstacle highlighted by the respondents is the lack of financial resources. Half of the participants (43%) agreed, and an additional (17%) strongly agreed that the scarcity of funds poses a challenge. This suggests that additional financial backing can help in adopting and implementing BIM technologies and processes in construction projects. Another prominent barrier identified by the respondents is the lack of human resources. Most participants (41%) agreed, and an additional 15% strongly agreed that the scarcity of skilled personnel and adequate staffing levels present a challenge. The need for extra human resources with the necessary BIM expertise can impede the successful implementation and effective use of BIM. To address this challenge, it is essential to invest in attracting and developing skilled professionals who can support and drive BIM adoption in the construction industry.

Table 8. BIM-Related Barriers and Challenges

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
Lack of financial resources	6.90%	12.07%	20.69%	43.10%	17.24%
Lack of human resources	8.62%	10.34%	24.14%	41.38%	15.52%
Lack of training	5.17%	6.90%	13.79%	43.11%	31.03%
Lack of awareness	6.34%	10.91%	10.34%	37.93%	34.48%
Lack of expertise	7.26%	9.99%	13.79%	37.93%	31.03%
Resistance to change	12.24%	8.81%	10.53%	33.33%	35.09%

The data also revealed a high level of agreement regarding the lack of training as a barrier to BIM implementation. Most (43%) agreed, and almost a third (31%) strongly agreed that sufficient BIM training opportunities are not offered. Adequate knowledge and skills related to BIM limit its adoption and utilization across the industry. Respondents also identified the lack of awareness as a substantial barrier to BIM implementation. A majority (38%) agreed, and an equal percentage strongly agreed that the industry faces challenges due to insufficient BIM awareness. This highlights the need for increased efforts to educate stakeholders about BIM benefits and potential.

Furthermore, the data indicated that the respondents perceive the lack of expertise as a significant challenge. Nearly 38% agreed, and over 31% agreed strongly that a shortage of specialized knowledge and skills in implementing BIM poses a barrier. Lastly, the findings highlighted the presence of resistance to change as a barrier to BIM implementation. A significant majority agreed (33%) and strongly agreed (35%) that resistance to change is a challenge.

Table 8 lists several major BIM adoption and implementation obstacles out of the study. 43.10% agree and 17.24% strongly agree that the lack of financial resources is a major barrier. This suggests that funding constraints hinder BIM adoption and implementation. The lack of human resources is another major barrier, with 41.38% agreeing and 15.52% strongly agreeing. This suggests that workforce issues in the construction industry may hinder BIM adoption due to the need for skilled BIM managers and coordinators. Training and awareness also pose problems. BIM implementation requires training programs, as 43.11% agree and 31.03% strongly agree that there is a lack of training. Many stakeholders may not fully understand BIM's benefits and applications, with 37.93% agreeing and 34.48% strongly agreeing. This lack of awareness can make stakeholders hesitant to invest in technologies they do not understand or do not see immediate benefits from. With 33.33% agreeing and 35.09% strongly agreeing, change resistance is another major challenge. The industry's cultural and organizational challenges include a reluctance to adopt new methods like BIM. BIM systems' perceived complexity, fear of the unknown, and potential workflow disruptions contributes to this resistance. Change management strategies can address these concerns, encourage innovation, and demonstrate BIM adoption's long-term benefits

4.4. BIM Benefits and Outcomes

Figure 2 and Table 9 present valuable insights into the perceived benefits and outcomes of BIM implementation. They reveal that a significant majority of respondents recognize the positive impact of BIM in various areas. Improved project coordination emerges as a notable benefit, with 90% of respondents indicating a moderate, significant, or exceptional benefit. BIM's ability to facilitate better coordination among project stakeholders, streamline communication, and enable effective collaboration is a valuable advantage. Reduced errors and rework are another prominent benefit highlighted by the data. An overwhelming majority of respondents (85%) perceive BIM as providing a moderate to exceptional benefit in this area.

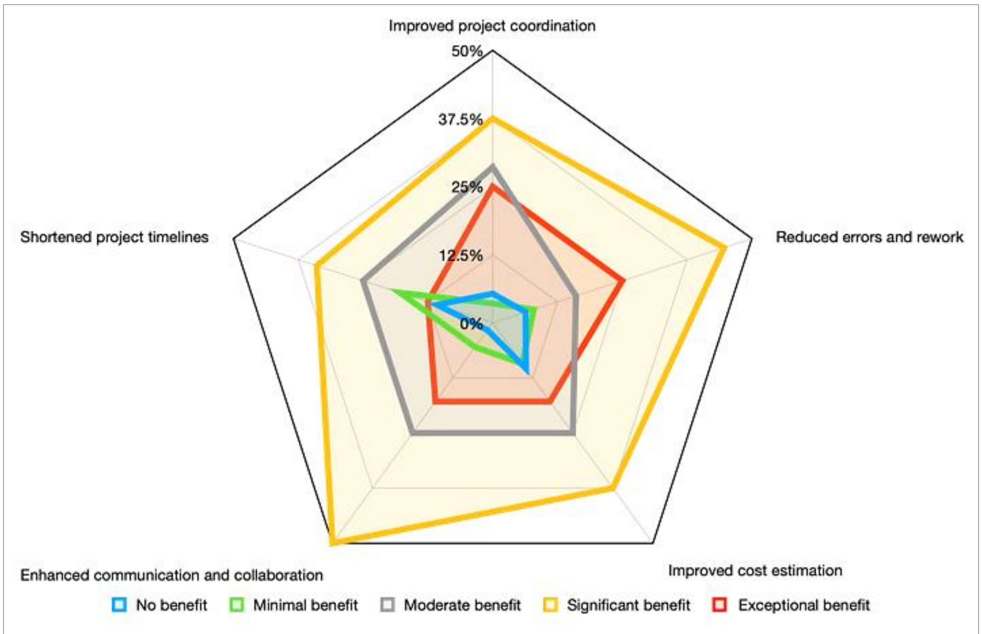

Figure 2. BIM Benefits and Outcomes

Table 9. BIM Benefits and Outcomes

	No benefit	Minimal benefit	Moderate benefit	Significant benefit	Exceptional benefit
Improved project coordination	5.36%	3.57%	28.57%	37.50%	25.00%
Reduced errors and rework	6.36%	7.93%	16.07%	44.64%	25.00%
Improved cost estimation	10.40%	9.24%	25.00%	37.50%	17.86%
Enhanced communication and collaboration	1.64%	5.50%	25.00%	50.00%	17.86%
Shortened project timelines	10.71%	17.86%	25.00%	33.93%	12.50%

Regarding cost estimation, the data indicate that most respondents see BIM as beneficial. Over three-fourths of participants (78%) perceive BIM as providing a moderate to significant benefit in improving cost estimation accuracy. Enhanced communication and collaboration are also considered a valuable outcome of BIM implementation. Most respondents (93%) perceive BIM as providing a moderate to exceptional benefit in this area. BIM serves as a central hub for project information, enabling real-time access and collaboration among stakeholders. This improves information sharing, facilitates effective communication, and enhances collaboration throughout the project lifecycle.

Regarding project timelines, the data shows that BIM is perceived to have a positive impact. Most respondents (71%) recognize BIM as providing at least a moderate benefit in shortening project timelines. The findings highlight the potential of BIM to drive improved project outcomes, increase productivity, and enhance stakeholder satisfaction. By embracing BIM technologies and processes, the construction industry can harness these benefits and pave the way for more efficient and successful projects.

5. Discussion

The results of this study on BIM in MENA construction industry provide informative comparisons and contrasts with previous research, highlighting both specific regional traits and widespread global trends in BIM adoption and application. The study's analysis of BIM expertise and demographics shows that various contracting firms actively utilize BIM, indicating a widespread recognition of BIM significance in various construction industry sectors. This variety is consistent with the research conducted by Merschbrock & Munkvold [2], who emphasized the value of digital cooperation for construction projects involving various stakeholders.

The regression analysis supported these findings. Institutional pressures positively and significantly affect BIM adoption and implementation (Model 1), supporting H1. However, institutional pressures do not significantly affect BIM barriers and challenges (Model 2), challenging H2. BIM benefits and outcomes are positively impacted by institutional pressures (Model 3-H3), while such institutional pressures have a non-significant effect on BIM expertise and training (Model 4-H4). Further analysis of other variables showed that BIM expertise and training neither affect the adoption and implementation of BIM (H5), nor its projected benefits and outcomes (H8). At the same time, such BIM adoption and implementation are neither influenced by its potential barriers and challenges (H6) nor by its expected benefits and outcomes (H7).

Regarding the advantages and benefits of BIM, the documented enhancements in project coordination, reduced errors, and improved communication correspond with the advantages noted in the works of Isaac et al. [46] and Lee et al. [47]. These advantages support the potential of BIM to positively transform project management and collaboration within the construction industry [21, 40]. The regional variation of the use of BIM may be related to varying degrees of governmental support and industry maturity, as noted by Mehran [8] and Chen et al. [48] in their respective studies. The discovery of a sizable number of organizations that have recently adopted BIM, indicating a growing recognition of its benefits, was pointed out in research within the context of Finland [20].

In contrast, the viewpoints regarding BIM-related obstacles and challenges align with the conclusions drawn by Akinade et al. [11] and Waqar et al. [3], who noted comparable challenges like budgetary and human resource constraints. The finding that resistance to change is a significant BIM adoption barrier is consistent with the larger issues that the construction industry faces when adopting new technologies, as emphasized by Chan [39] and Jia et al. [49].

The financial and human resources barriers to BIM adoption are consistent with the findings of Ahmed et al. [14] and El Hajj [15]. Ahmed et al. [14] noted that interoperability factors significantly affect BIM adoption in Malaysia, emphasizing the need for sufficient financial resources to address these issues. The study found that 60.34% of respondents agree or strongly agree that lack of financial resources is a significant barrier to BIM adoption in the MENA region, consistent with El Hajj et al. [15]. Previous studies emphasized the need for adequate funding to promote BIM technology adoption and implementation. This study confirms the challenges faced by SMEs in sectors like the HVAC industry, as reported by Hall et al. [16] and Yılmaz et al. [17]. Like the current study, Hall et al. [16] found financial and human resources constraints preventing New Zealand SMEs from adopting BIM. Yılmaz et al. [17] identified challenges in the HVAC industry, including insufficient training and expertise, which are significant barriers in the current study. This consistency suggests that SMEs and specialized sectors face similar BIM adoption challenges regardless of location or industry, emphasizing the need for targeted support and training.

This study discovered that institutional pressures greatly boost BIM adoption and benefits (H1 and H3). However, this only partly agrees with what Zhang et al. [18] and Saka et al. [10] said, that green innovation and institutional pressures greatly enhance project sustainability outcomes. This supports the finding that institutional pressures improve BIM benefits and outcomes. Saka et al. [10] found that institutional pressures had little effect on Nigerian SMEs' BIM barriers and challenges, contradicting the non-significant H2 and H4 findings of our study. This suggests that institutional pressures can increase adoption and benefits, but their effects on barriers and expertise may vary by region and context.

BIM adoption improves project coordination, reduces errors and rework, and improves communication, collaboration, according to Datta et al. [19], Merschbrock & Munkvold [2]. The current study confirms Datta et al. [19]' findings that BIM improves sustainability and efficiency. Merschbrock & Munkvold [2] hospital construction project case study showed how BIM improves digital collaboration and project outcomes. These consistent findings across studies support the current study's findings about BIM's tangible and intangible benefits to construction projects.

6. Theoretical Contributions

The study illuminates how institutional pressures boost BIM adoption and implementation. The findings show that regulatory requirements and industry standards drive innovative technology adoption. This applies institutional theory to construction technology adoption and emphasizes the need for a supportive institutional environment to integrate BIM. The study contributes to the discourse on external factors that enable technological advancements by examining how these pressures affect adoption. The study focuses on expertise and training in BIM implementation as another significant contribution. While institutional pressures are necessary, targeted training programs are essential for overcoming adoption barriers and maximizing BIM's potential. This emphasizes the theoretical importance of human capital development in technology adoption. The study expands the literature on professional development and technology adoption by showing the importance of expertise and training.

The study also identifies and analyzes the main barriers to BIM adoption, providing a nuanced understanding of the construction industry's BIM integration challenges. Financial and human resources constraints, lack of training and awareness, and change resistance are significant obstacles. These findings advance technology adoption barrier theory, particularly in construction. The study provides practical solutions to BIM adoption challenges by expanding the discourse on strategic interventions. The study also examines BIM technology's main benefits and outcomes, expanding the theoretical framework on technology adoption and project performance. The findings show that BIM adoption improves project coordination, error and rework reduction, communication and collaboration, and cost estimation. These benefits demonstrate BIM's value in improving construction efficiency and productivity. This supports the literature on technology-driven performance improvements, demonstrating BIM potential to improve project outcomes.

Finally, the study examines how expertise and training affect BIM adoption benefits and outcomes. It concludes that institutional pressures are significant, but BIM expertise is essential to maximize its benefits. This highlights how institutional support and human capital affect technology adoption. The study adds depth to the theoretical framework of technology adoption by expressing the critical role of expertise in realizing BIM's full potential, suggesting that comprehensive strategies encompassing external pressures and internal capabilities are necessary for successful implementation. The study sheds light on institutional pressures, expertise and training, barriers, and benefits in BIM adoption, making significant theoretical contributions. It provides a comprehensive framework for understanding how these factors affect construction technology adoption and implementation. Researchers and practitioners can use these insights to promote BIM adoption and maximize its benefits in construction projects.

7. Managerial Implications

The research results on the use of BIM in the construction industry in the MENA region have significant managerial ramifications for industry practitioners and decision-makers. First, the management of construction companies should consider creating thorough BIM integration plans, especially in nations with higher BIM adoption rates like Saudi Arabia and Egypt. Additionally, institutional pressures positively and significantly affect BIM adoption and implementation, suggesting that MENA construction firms should actively align their practices with institutional standards and policies to increase BIM adoption. The non-significant impact of institutional pressures on BIM barriers and challenges, expertise, and training suggests that while external pressures are important, they are not enough to overcome all challenges, improve expertise, or enhance training. Construction firms should build internal capacity and address specific barriers. The positive effect of institutional pressures on BIM benefits and outcomes shows that BIM adoption can improve efficiency and project outcomes.

Strategic planning and change management initiatives are necessary to address the obstacles and challenges of BIM implementation that have been identified in this research, including financial and human resource constraints and resistance to change. Proactively addressing these issues requires management to engage stakeholders, communicate effectively, and cultivate an open culture of new ideas and approaches. Additionally, managers ought to explore joint ventures with tech companies and other types of partnerships or collaborations that can help them offset their budgetary constraints.

To enhance the adoption of BIM, it is recommended that contractors invest in continuous training programs to improve staff expertise. These programs should be developed in partnership with educational institutions and software providers to ensure they meet industry needs. Moreover, contractors should consider implementing pilot projects to demonstrate the benefits of BIM. These projects should be selected based on criteria such as project complexity, visibility, and potential for impact, allowing organizations to manage risks and learn from small-scale implementations before wider rollout.

Ultimately, the advantages of BIM in terms of better project coordination, decreased errors, and improved communication are well documented, and this emphasizes how crucial it is for construction companies to incorporate BIM into their fundamental operational strategies. To gain a competitive edge in the quickly changing construction sector, the management of construction companies can promote more strategic and informed decision-making through the alignment of BIM implementation with defined organizational goals and project objectives. This strategic approach should include the development of a phased BIM implementation roadmap, the establishment of clear performance metrics, and the use of collaborative platforms to enhance stakeholder communication and project management.

8. Conclusion

This study has elucidated the complex interplay of institutional pressures, resource constraints, and technological challenges in the adoption of BIM within the MENA region's construction sector. It has highlighted how contractors, despite facing significant barriers such as financial limitations, lack of skilled manpower, and resistance to change, can still derive substantial benefits from BIM adoption. These benefits include enhanced project coordination, improved efficiency, and better collaboration among stakeholders. Moreover, the research underscores the critical role of supportive policies, industry standards, and educational initiatives in facilitating BIM adoption. It displays that while external pressures and incentives from government and industry bodies are crucial, the onus also lies on organizations to cultivate an internal environment conducive to innovation and learning.

The study shows demographic trends in BIM adoption and expertise across regions and roles. BIM adoption is highest in Kuwait and the UAE. Most respondents have less than ten years of BIM experience, indicating a need for training and development. Many roles involve digital transformation and BIM management. Most respondents agree that financial and human resources constraints hinder BIM adoption. Lack of training and awareness are also significant issues, according to many respondents. Change resistance is another barrier to BIM adoption, requiring cultural and organizational changes. The regression analysis shows that institutional pressures boost BIM adoption and benefits. Institutional support is essential for BIM implementation and its benefits, such as better project coordination and fewer errors. However, institutional pressures have less of an impact on overcoming specific barriers and improving BIM expertise, suggesting further.

BIM improves project coordination, reduces errors and rework, improves communication and collaboration, and improves cost estimation, according to the study. These benefits show how BIM can improve project outcomes and efficiency. Despite these benefits, the study shows that significant barriers remain to obstruct the full utilization of BIM in the MENA's construction industry. In synthesizing the findings, this study reflects on the necessity for a balanced approach that combines external support mechanisms with strong internal commitment to overcome the adoption barriers. The implications of this research are profound, offering actionable insights for contractors, policymakers, and industry stakeholders aiming to navigate the technological shifts in the construction sector.

8.1. Limitations and Future Directions

The study, in its scope, presents certain limitations that open avenues for future research. One notable area for improvement is the use of convenience sampling, which may not fully represent the diverse range of construction industry stakeholders in the MENA region. This sampling method could limit the generalizability of the findings, as it might overlook nuanced perspectives from less accessible segments of the industry. Future studies could address this by employing a more stratified or random sampling approach to encompass a broader demographic and organizational spectrum. Additionally, the study predominantly focuses on current practices and perceptions, leaving room for longitudinal research to assess the evolution of BIM implementation and adoption and their long-term impacts on the construction industry in the MENA region. Investigating these changes over time would provide deeper insights into the sustained effectiveness of BIM and the evolving challenges and opportunities it presents.

9. Declarations

9.1. Author Contributions

Conceptualization, M.S.A., M.S., and S.O.S.; methodology, M.S.A., M.S., and S.O.S.; software, M.S.; validation, S.O.S. and M.T.; formal analysis, M.S.A. and M.S.; investigation; M.S.A., M.S., and S.O.S.; resources, M.S.A., M.S., and S.O.S.; data curation, M.S.A., M.S., and S.O.S.; writing—original draft preparation, M.S.A. and M.S.; writing—review and editing, M.T.; visualization, M.S.A. and M.S. ; supervision, M.S.A. and M.S. ; project administration, M.S.A. and M.S.; funding acquisition, M.S.A. and M.S. All authors have read and agreed to the published version of the manuscript.

9.2. Data Availability Statement

The data presented in this study are available on request from the corresponding author.

9.3. Funding

The authors received no financial support for the research, authorship, and/or publication of this article.

9.4. Conflicts of Interest

The authors declare no conflict of interest.

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