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Adoption of Building Information Modelling In Libyan Construction Firms: A Technological, Organizational, and Environmental (TOE) Perspectives

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Abstract. Building information modelling (BIM), a recent information technology (IT) innovation in virtual design and construction, has been regarded as the most critical technology in the construction industry over the last decade. As a result, BIM adoption is rapidly increasing; however, this new phenomenon is not spreading as rapidly as it is in emerging regions such as Libya. The purpose of this study is to investigate the factors that affect BIM adoption at the organizational level by integrating the diffusion of innovation (DOI) theory, the technology-organization-environment (TOE) framework, and the institution theory. The data was gathered through a survey of 411 Libyan construction firms. Partial least squares were used for data analyses and to test the hypotheses. The results demonstrated that the (Perceived Relative Advantage and Compatibility) related positively to BIM adoption, while complexity related negatively to BIM adoption will top management support positively with Coercive Pressure on the adoption of BIM. The study's findings provide significant insight into crucial factors that might increase the level of BIM adoption.

Keywords: Adoption, Building Information Modelling, Technology-Organization-Environment Framework

1. Introduction

The investment in IT and productivity of the construction industry has been compared to the other sectors by [1]–[4] and the findings revealed that the construction industry invested less in IT than other industries, which could have been the reason for the sector's poor performance in terms of productivity growth. The need for the availability and accuracy of the formation and its management in construction projects encouraged the industry to find the best practice to fulfil such needs thru adopting IT innovation such as BIM, which has been found to be effective in information management in construction projects [5], [6]. BIM was created via an intelligent digital assemblage of building components with enshrined information about the features and characteristics of the parametric object [7] It is also regarded as a knowledge resource for gaining information about the project that provides a normative framework for decision-making throughout an object's entire lifecycle [8]. Despite the fact that global BIM usage is rapidly increasing, this new phenomenon is not affecting firms in Middle Eastern countries. The low rate of BIM adoption in Middle Eastern countries in general, and particularly in Libya, may erode their limited revenue sources on the one hand, while reconstruction of what was destroyed after the conflict necessitates massive budgets that may deplete the state treasury on the other. Construction firms could play an important role in the Libyan economy in this regard. In this regard, construction companies could play an important role in Libya's economy, as Libya is heavily dependent on the export of oil and gas. According to Libya's Central Bank, oil revenues accounted for an estimated 98% of Libya's total government revenues. The Government of Libya sees the importance of cost and time saving to fulfil its obligations and responsibilities. Consequently, an investigation into the factors influencing BIM adoption is critical. Even though scholars have studied BIM adoption and developed numerous theories to explain it in various contexts, crucial challenges remain to be investigated thoroughly and addressed. First, previous research findings on how various factors influence BIM adoption have been inconsistent. second, existing theories should be validated in a variety of contexts. It has been emphasized that theories and management practices developed in developed countries should be re-examined in developing countries to fit the cultural context of the recipient countries [9]. Therefore, this study aims to identify associated technological, organizational, and environmental factors that impact BIM adoption.

2. Literature review

2.1. Factors Influencing BIM Adoption in Developed Nations

Kaleem (2020) and his colleagues has empirically examined three contexts based on TOE framework. Technology, organizational and environmental and their effect on BIM adoption in the Estonian construction industry [10]. The study included face-to-face interviews with officials and 15 group meetings. The participants had more than ten years of work experience in the field. According to the findings of the study, technological context (Trialability and Relative Advantage) and organizational context (Top management support, Training, and Learning) were important determinant that drove BIM adoption in Estonia. The TOE framework was used in a study [11] to investigate the technological, organizational, and environmental factors that influence BIM adoption in 177 organizations in the UK that provide BIM services. The study noted that technological factors (e.g., Relative advantage, Compatibility Observability), organizational factors (management support, Communication behaviour, Financial resources, Organizational readiness, Social motivation, Organizational culture, Willingness/intention, Organisation size), and environmental factors (e.g., Coercive pressures) were important determinants of BIM adoption in the UK. Similarly, an empirical study in the UK by the author of [12] reported that four technology factors (Relative, advantage, Compatibility, Complexity, Trialability, and Observability) influenced BIM adoption. The identified theoretical barriers to the diffusion of innovations were high complexity and lack of compatibility, observability, and trial opportunities. However, observability and complexity are the most important aspects of any innovation adoption; concerns about compatibility and trailing opportunities remain prominent in the case of BIM adoption. Study [14] investigated the five environmental factors that impact on BIM adoption in New Zealand, the study found Standards, organizational culture, Client expectation, Information, and Retrofit Tools as the factors that influence BIM adoption.

Table 1. BIM Adoption in Developed Countries

Authors	Theory Used	Variables and General Findings
[13]	TOE	"Among fifteen factors, relative advantage, trialability, management support, and organizational awareness were affected BIM adoption positively. "
[14] New Zealand	Related scientific research	"Significant influence on adoption: Standard, Information, Technology, Organizational culture Insignificant influence on adoption: Client expectation Retrofit."

[15] UK	Innovation diffusion theory Institutional theory Technology acceptance model	"Significant influence on adoption: Coercive pressures Relative advantage Compatibility Observability, Top management support, Communication behaviour, Financial resources, Organizational readiness, Social motivation, Organisational, culture, Willingness/intention, Organisation size, Insignificant influence on adoption: Mimetic pressures, Normative pressures, Complexity, Trialability"
[16]	Innovation diffusion theory	"significant influence on adoption: Relative advantage, Compatibility, Complexity, Trialability, Observability."
[17] UK/USA	diffusion of innovation	"significant influence on adoption: Relative advantage, Compatibility Observability, Complexity Insignificant influence on adoption: Trialability."
[18] USA	Related scientific research	"significant influence on adoption: perceived benefits, external forces, and internal readiness "
[19] USA	"technology acceptance model, diffusion of innovation theory, and task-technology fit."	"significant influence on adoption: Top management support, Training, Team BIM capability BIM experience, Job relevance, Internal support, Perceived technology difficulty, Interoperability, Scope of work, Delivery method Insignificant influence on adoption: Technology cost"

2.2. Factors affecting BIM adoption in Developing Countries

Study [20] used a mixed approach and engaged sixty-three Malaysian companies to identifying the key factors that influence the adoption of BIM technology. The identified factors included a lack of knowledge, financial issue, human resource, awareness and readiness. Study [21], relied on the TOE framework to investigate the factors preventing BIM adoption in 321 Chinese construction firms. From the reports, management support, readiness, Relative advantage, Company size, Company age, Compatibility, and Complexity were found to affect BIM adoption strongly. Hence, the environmental context was found to have no significant impact on BIM adoption upon including organizational and technological factors with the environmental pressures. Furthermore, the compatibility and environmental factors were found to have no significant influence on BIM adoption in the Chinese construction sector.

Study [22] used the Institutional theory to investigate the impact of environmental characteristic (coercive, mimetic, and normative pressures) on adopting BIM in 125 construction projects. They revealed that mimetic pressures and coercive pressures had a significant impact on adoption of BIM. On the other hand, the results indicated an insignificant influence of normative pressures on BIM adoption in China construction firms. In India, the authors of [23] used the TOE framework to study the factors influencing BIM adoption in 184 Indian AEC industry professionals. The study found that the significant factors were trialability, BIM expertise, and top management support, while the respondents disagreed with the significance of perceived cost, complexity, compatibility, trade partner readiness, and client demand on adoption decisions.

Many studies have researched BIM adoption from many theoretical perspectives in the literature on BIM adoption. Tables 1 and 2 summarize important studies on BIM adoption. Many scholars have concentrated on BIM adoption due to the significant benefits that BIM systems can provide to construction firms. However, an investigation of the literature revealed important observations. The first point to recognize is that, while academics have identified a number of factors influencing BIM adoption, their findings have not been consistent. Factors discovered to be important by one researcher are not necessarily discovered to be important by others. For instance, complexity is one of the technological factors that has been investigated numerous times, but the results have been contradictory (e.g., significant by [21] and insignificant [24]). Furthermore, while BIM processes necessitate organizational wide adoption, few scholars have investigated the factors influencing BIM adoption in construction firms [25]. This has resulted in work gaps at the organizational level. As a result, the purpose of this research is to fill that gap by investigating the impact of TOE factors on BIM adoption in Libyan construction firms using three different theories at the organizational level.

Table 2. BIM Adoption in Developing Countries

Authors	Theory Used	Variables and General Findings
[26]	Related scientific research	Significant influence on adoption: BIM knowledge, Financial constraints, Awareness level, readiness and Human resource .”
[27]	Related scientific research	“Significant influence on adoption: cost, expertise, training, Cultural, resistance to change, collaboration, Organizational structure, Lack of subcontractors, Security, Difficulties in measuring impacts of BIM
[21]	TOE	Significant influence on adoption: management support organizational readiness relative advantage organizational size organizational age compatibility complexity. insignificant influence on adoption: government pressure competitor pressure customer pressure
[28]	Related scientific research	The top three key factors for BIM adoption are “BIM Training for Existing Non-BIM Personal “Efficiency of BIM Software and “Initial Investment Cost. Insignificant influence on adoption: Organizations’ financial resources and Prequalification of Team Member
[23]	TOE	The significant influence on adoption: trialability, top management support, and BIM expertise promote BIM adoption. Insignificant influence on adoption: Compatibility, complexity, trade partner readiness, and client requirements have limited or no influence on adoption.”
[29]	Related scientific research	Significant influence on adoption: Quality, Relative advantage, Trialability, Ease of use, and compatibility. Insignificant influence on adoption: adopter characteristics, firm characteristics and environmental characteristics
[30]	Related scientific research	Significant influence on adoption: Compatibility, knowledge and awareness, structure/culture of the industry, appropriate technology and infrastructure, cost of implementation, BIM standards/ guidelines insignificant influence on adoption: Business Environment was less significant than other”
[31]	Institution theory	Significant influence on adoption: coercive and mimetic pressures Insignificant influence normative pressure

2.3. Theories of Organizational innovation adoption

Studies that investigated the factors influencing BIM adoption in organizations are based on three frameworks, namely, the Diffusion of Innovation (DOI) theory [32], Institutional theory [31], and Technology-Organization-Environment (TOE) theory [33]. Models with different emphases are constructed based on the aforementioned theories in order to investigate various factors of BIM adoption. For example, one of the most widely used theories in predicting BIM adoption is the diffusion of innovation theory (DOI) [32], [21], [24]., five technological characteristics have been identified by Rogers [32] (relative advantages, Compatibility, Complexity, trialability, and observability). The DOI theory, however, has limitations because it does not provide a lens through which to examine the organizational and environmental context. Models based on institutional theory, on the other hand, attempt to investigate environmental factors such as competitive, normative, and coercive pressure; however, this theory ignores the organizational and technological context. The technology-organization-environment (TOE) [33] framework, along with DOI theory and institutional theory, is one of the most widely used theories of IT adoption. According to the literature, the TOE framework is a useful to start when researching BIM adoption because it looks at it from three different perspectives. According to TOE theory, technological, environmental, and organizational factors all influence IT adoption in organizations. As a result, this study is based on the use of the TOE framework to investigate the factors that influence BIM adoption in a Libyan construction firm. The reason for developing a new BIM adoption model in this study is that the TOE framework does not explicitly state the major constructs and variables in each context [34] Previous researchers used the TOE theory to select each construct and variable in their research model based on their research objectives.

3. Research Model and Hypotheses Development

The findings of previous studies on how technological, organizational, and environmental factors affect firms to adopt BIM have been inconsistent. For example, while some studies find the significant influences of technology complexity [21], others show that it is insignificant[24]. Similarly, researchers have found the compatibility factor as one of the critical factors [21], [35] while others find it insignificant[13], [24]. Since BIM adoption is decided by two or more stakeholders (e.g., Mandatory requirement to execute government projects) [36], the factors in a firm's environment must be considered [37]. On the other hand, by using different constructs, the result of the conducted studies shows the insignificant impact of environmental factors on BIM adoption[21], [24] the scholars also emphasized continuing to analyse the environmental context [21], [24], [31]. Then, the other theoretical perspectives that relate to the institutional environment can be applied, such as the use of institutional theory to capture the unique environmental features, which may be tedious to investigate [21], [31]. Therefore, the proposed model in this study paid more attention to this context and incorporated three environmental factors: Mimetic pressures, Normative pressures & coercive pressures.

3.1. Technological factors

3.1.1. Relative Advantages

Organizations adopt technology when there is a perceived need to use the technology to overcome a lack of productivity and efficacy or exploit a business opportunity. Relative Advantages (RA) refer to the expected benefits and interest in using the technology compared to the other applications [32]. The degree of RA can be determined by technical, economic, or sociological factors; note that RA can be expressed in various ways, such as social benefits, economic profitability, and improved organizational status [32]. Firms typically consider the ability of these technologies to provide real-time information to business partners, better business process integration, and better decision-making support as needed to respond to emerging contingencies when evaluating the relative advantage of ICT adoption in the supply chain [38]. As a result of the foregoing considerations, it is hypothesized that a greater perceived relative advantage of BIM adoption will lead to greater BIM technology adoption.
H1: Relative advantage strongly relates positively to BIM adoption.

3.1.2. Compatibility

The issue of inter-product interoperability is one of the main problems for BIM early adopters. Compatibility is the degree to which an innovation adapts to an organization's existing operational needs and procedures [32]. New technology is more likely to diffuse easily and freely if it matches the organization's existing business processes. IT adoption studies have identified positive roles of technology compatibility in their adoption [39]– [47]. Compatibility, from the technical perspective, is a major determinant of BIM adoption and has been cited as the key technological challenge to BIM

implementation [24], [48], [49]; consequence, BIM-related changes must be compatible with existing organizational practices. It is, therefore, proposed that:
H2: Compatibility positively affects adoption of BIM

3.1.3. Complexity
Adopting a new technology may confront companies with challenges in terms of changing the processes in which they interact with their business systems. Complexity is the difficulty in using and understanding new technology [32]; if a firm considers a new technology complex, it may be discouraged from adopting it [50]. According to the existing literature on innovation diffusion, the adoption rate decreases as technology complexity increases [51]–[57] Based on the previous study, it seems reasonable that greater complexity is more likely to stymie BIM adoption [21]–[58]. As a result, the following hypotheses are proposed:
H3: Complexity negatively affects the adoption of BIM

3.2. Organizational factors

3.2.1. Management Support
Top Management Support is essential to provide the necessary resources (e.g. hard-ware & software, training, technical support) for the effective use of IS and to promote the interest of employees' satisfaction with in- formation technology, management support is defined as "the involvement and participation of an organization's top-level management in organizational IT activities." [59]. That is, managers who understand the importance of BIM tend to persuade other members of the organization to adopt it. [24], [48], [60]. Top Management Support is crucial to ensuring that IS is used effectively and fostering employee satisfaction with information technology by providing the required resources. top management engagement and commitment are critical for adopting new technologies, and experts contend that a absence of top management support is an important barrier to adopt BIM. With the above arguments, the following hypotheses are proposed.
H4: Top management support relates positively to BIM adoption.

3.3. Environmental Factors

3.3.1. Normative pressures
Normative pressures are typically generated by the demands of customers, trading partners, professional bodies, government agencies [61]. Innovation adoption can be influenced by federal laws and policies [62]. Firms can be persuaded to accept shared decisions by other entities that promote the technology under normative pressures, and because normative pressures have an impact on socially acceptable behaviors and activities, they are viewed as a major element shaping norms and a sense of responsibility in developing countries. Clients/owners may become a possible focal point of these normative impacts because they play a key role in their organisation in terms of deciding whether to adopt new technology Therefore BIM adoption in an organization can be influenced by normative pressures [63]. Taking into consideration the above arguments, normative pressures is considered as the level of influence exerted by trading partners, professional bodies, and government agencies to take BIM advantages. Hence, the arguments presented lead to the fifth hypothesis:
H6: Normative pressures positively influence BIM adoption.

3.3.2. Mimetic pressures
Mimetic pressure results from the ground that firms can mimic or imitate the activities of their competitors in the same sector in terms of sharing the same suppliers and customers, producing similar products, and facing similar problems [64]. This normally causes higher tendencies to adopt innovation that is used by their perceived competitors [65], [66]. Organizations can be exposed to mimetic pressures in two significant ways; the first occurs when more organizations in the business environment have followed the same line of action; the second is when the actions of competitive organizations are considered more successful and beneficial by an organization. In conclusion, this

study postulates that pressure (from competitors' organizations, customers/suppliers) has a beneficial/positive impact on a firm's BIM adoption based on empirical and theoretical considerations.
H7. Mimetic pressures positively influence BIM adoption.

3.3.3. Coercive pressures

Coercive pressure is defined as "the formal and external pressures exerted on them by other organizations on which they rely, as well as the cultural expectations in the society in which the organization operates"[67]. The institutional perspective of coercive pressures is naturally authoritarian, leading to the firm adopting a submissive posture toward the entity exerting such pressure. Regulatory authorities and industry associations could be the main sources of coercive pressure (often partly affiliated with the government). Governments (or their related organizations) in various countries have created plans for the BIM mandate for public projects due to the potential benefits of the technology. Regulatory authorities such as "Professional councils, the Council for the Built Environment, Construction Industry Development Board, and Construction Education and Training Authority" may be driving mandates for successful BIM adoption. Previous researches indicated that pressures from government agencies and clients remain one of the major drivers of BIM adoption [68], [69]. Thus, based on the above arguments, the formal and informal (governmental agencies and other organizations) pressure BIM practice and could positively impact BIM adoption.
H8. Coercive pressures positively influence BIM adoption.

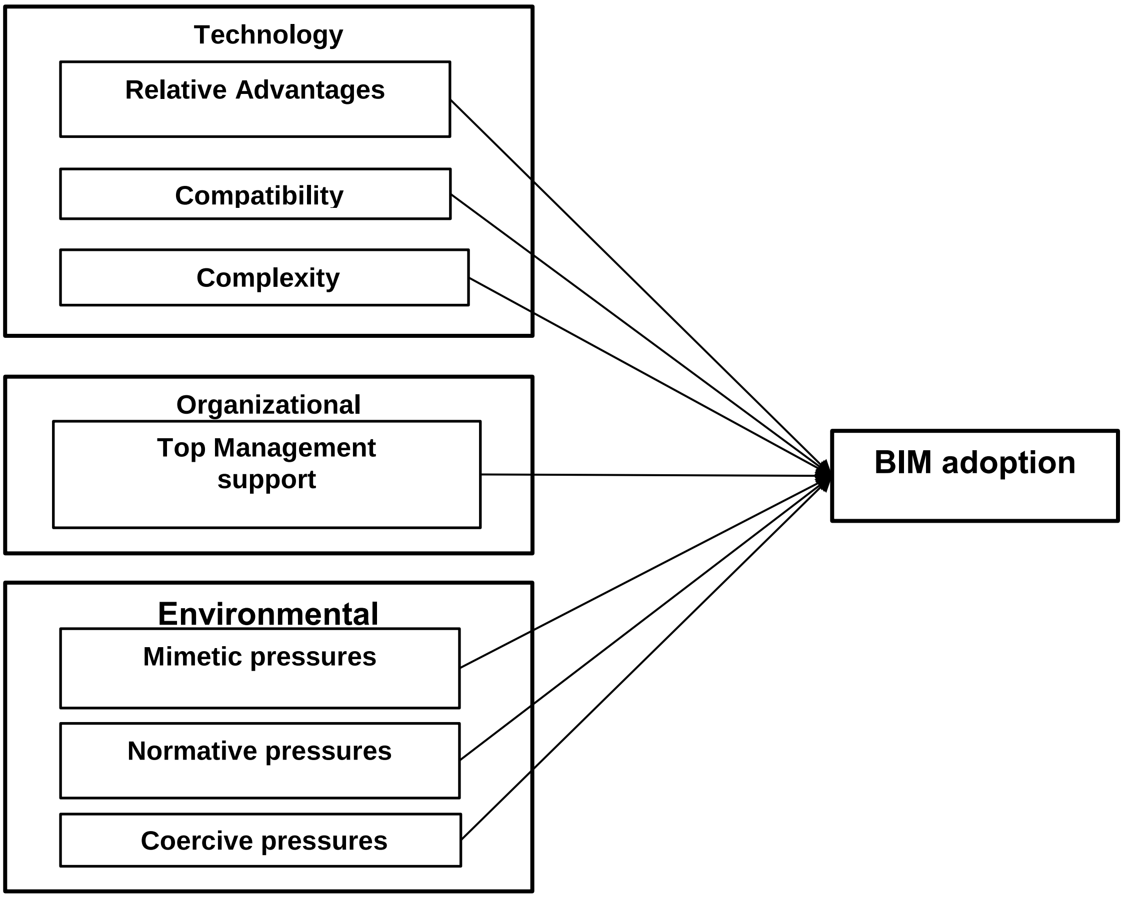

Figure 1. Research model

4. Methodology

4.1. Data collection

The targeted population includes all construction firms, located in the large industrial cities in Libya located in Tripoli, Benghazi, Misrata, Al-Bayda, Derna, and Tobruk. Information systems managers, project managers, upper management, project engineer, CAD/BIM manager, and owners that coordinate the activities of the companies are the targeted respondents in this study. The companies that make up the sample population include consulting engineer companies, general contractors, industrial infrastructure companies, real estate construction companies, and mechanical, electrical, and plumbing contractors. These key respondents were chosen for the current study because, as active executives, they have a strong understanding of their companies' organizational culture and the environment in which they operate, and they have participated actively in strategic decision-making. Due to the study's population size, a stratified random sample was collected, and each group's necessary components were chosen using random sampling. The stratified random sample is divided into five groups, as shown in Table3.

Table 3. The Sample percentage

Employees	10 - 100	580	0.66
	101 -200	229	0.26
	201-500	47	0.053
	501-1000	14	0.016
	> 1000	10	0.011
Total		880	100%

4.2. Measurement development

Each construct in this research was created based on literature reports in the related fields, such as organizational technology adoption. A multiple-item scale was also developed for each independent variable to tap the underlying theoretical dimension, with each item being measured using a five-point Likert scale. For some items, the existing ones that have been validated in the previous literature were adapted and modified to suit the BIM context, as shown in table 4. the researcher has used the [21], [23] frameworks to operationalize BIM adoption, which applies to the construction sector of developing countries. The measurement and scaling procedures were carefully constructed during the questionnaire design phase of this study.

Table 4. Source of Items

Constructs	Source	No/items
Relative Advantage	[21] [70] [71]	6
Compatibility	[72] [21] [48] [73]	7
Complexity	[74] [75] [71]	6
Top management support	[72] [76][73]	5
Mimetic Pressure	[77] [22] [78]	5
Coercive Pressure	[78] [22] [79]	6
Normative Pressure	[80]	5
BIM Adoption	[73] [21] [39] [53]	6

The original version of the questionnaire was in English; first, the questionnaire content was checked for grammar and wording before being translated into Arabic by a certified English- Arabic translator. Next, three bilingual academics vetted the translation with a doctorate in English linguistics. Finally, the translated questionnaire was also sent to an experienced Arabic language lecturer for further review regarding appropriateness, grammar, and syntax.

4.3. Questionnaire Distribution

Because of Corona and the accompanying restrictions on movement, the researcher adopted the Internet as the only available way to distribute the questionnaire. The authors of [81] has indicated that in the COVID-19 period, online surveys provided unique research opportunities. Google Forms was used to create and design the survey in this study. Google Form is a powerful and flexible online survey tool with a simple and professional layout; respondents can easily navigate the created survey pages and execute many functions therein [82]. By the end of the agreed pick-up time for the survey (that is, 25th May 2021), only 465 out of 800 distributed questionnaires were returned. Out of the total number of received questionnaires, 54 were considered non-fit for the study and were discarded because a significant portion of the questionnaires was not responded to or was filled with only one number on all the Likert scale items.

5. Results

5.1. Research Model Assessment

To evaluate the measurement and structural model, structural equation modelling (SEM) was used in accordance with the principles of [83]. The measurement model was evaluated by assessing the reliability, convergent validity, and discriminant validity of all multiple-item scales. Table 4 present the test findings. Composite reliability (CR) was used to assess reliability. The CR in the survey data was more than 0.70 (Table 4) [84]. According to Hair et al. [83], convergent validity is the degree to which the items that are indicators of the specific latent variable should share or converge a high proportion of variance in common. For convergent validity, the literature requires item loadings greater than 0.70 and average variance extracted (AVE) greater than 0.50. [84]. Similar threshold values were adopted in previous studies [85]–[90].

Table 5. Model Assessment test

Construct/ Items	Factor loadings	Composite Reliability	(AVE)
BIM Adoption		0.913	0.678
BIM1	0.747		
BIM2	0.841		
BIM3	0.835		
BIM4	0.841		
BIM5	0.848		
Perceived Relative Advantage		0.937	0.713
RLA1	0.816		
RLA2	0.816		
RLA3	0.833		
RLA4	0.875		
RLA5	0.856		
RLA6	0.867		
Compatibility		0.918	0.615
COMP1	0.779		
COMP2	0.851		
COMP3	0.848		

COMP4	0.796		
COMP5	0.701		
COMP6	0.746		
COMP7	0.760		
Complexity		0.902	0.649
CX1	0.733		
CX2	0.816		
CX3	0.831		
CX4	0.831		
CX5	0.814		
Top management support		0.941	0.726
TM1	0.850		
TM2	0.893		
TM3	0.844		
TM4	0.852		
TM5	0.867		
TM6	0.805		
Coercive Pressure		0.895	0.630
CP1	0.779		
CP2	0.784		
CP3	0.818		
CP4	0.784		
CP5	0.803		
Mimetic Pressure		0.911	0.672
MP1	0.708		
MP2	0.859		
MP3	0.859		
MP4	0.823		
MP5	0.840		
Normative Pressure		0.922	0.704
NP1	0.818		
NP2	0.841		
NP3	0.846		
NP4	0.821		
NP5	0.869		

5.2. Structural model Assessment

The effect of relative advantage on BIM adoption was significant, according to the research hypotheses, (0.098, t-value:1.914, p-values: 0.028), implying that the relative advantage of BIM was a driving factor in BIM adoption. As a result, H1 was accepted. The insignificant compatibility path loading (0.182, t-value3.317, p-values 0.000) revealed that BIM compatibility significantly impacted BIM adoption; hence H2 is supported. The finding supported H3 that complexity has a negative influence (-0.191, t-value3.329, p-values 0.000). Management support was significant (0.144, t-value 2.955, p-values 0.002) among the organizational factors examined in the current study, supporting H4. Furthermore, with the exception of Coercive Pressure (0.231, t-value 5.185, p-values 0.000), all environmental variables were shown to be insignificant.

Table 6. Structural model Assessment results

No	Relationship	β	p-values	Decision
H1	Perceived Relative Advantage -> BIM Adoption	0.098	0.028	Supported
H2	Compatibility -> BIM Adoption	0.182	0.000	Supported
H3	Complexity -> BIM Adoption	-0.191	0.000	Supported
H4	Management support -> BIM Adoption	0.144	0.002	Supported
H5	Normative pressure -> BIM Adoption	0.037	0.219	Not Supported
H6	Mimetic pressure – competitors -> BIM Adoption	0.003	0.477	Not Supported
H7	Coercive pressure -> BIM Adoption	0.231	0.000	Supported

6. Discussion

6.1. Technological Context

6.1.1. Relative advantage

Relative advantage (RA) is the fifth identified factor that influences BIM adoption (after top management support). This finding is consistent with previous research [21], [91]. Through estimated benefits of BIM, RA is specifically identified as a key factor that determines the adoption and extent of advantage of innovation M. This suggests the positive influence of RA on the organization's innovation adoption decision [32]; RA is specifically identified as a key factor that determines the adoption and extent of advantage of innovation (e.g., BIM or ICT) via estimated benefits [75] [92].

6.1.2. Compatibility

Compatibility ranks third in the influence potential of the seven identified factors; the compatibility issue has additionally been addressed as a practical issue in successful BIM adoption by previous studies and found significant [12], [48], [91], [93]. Being that most project participants are used to specific tools, data transfer is frequently constrained due to incompatibility, affecting the sharing of information with the other participants. BIM adoption and usage necessitate the integration of numerous software programs, and only a consistent data exchange procedure can successfully communicate data [25]. As a result, any BIM-related modifications must be compatible with the existing organizational culture and practices, else, BIM may not integrate properly into the organization's process.

6.1.3. Complexity

This work showed that the complexity factor significantly and negatively impacts BIM adoption in Libyan construction firms. This finding is consistent with the majority of previous studies on BIM adoption.. The complexity factor, as per organization literature, is a major threat to organizational decisions towards adopting and using such technology [21], [94], [95]. If an adopting firm perceives an innovation to be difficult, the firm may be discouraged from adopting such innovation. Businesses, on the other hand, are more likely to promote and adopt technical innovations that are less difficult [96], [97]. The more the Complexity of BIM tools, the more resistance to changes and business perceptions of the risk associated with BIM [95]. Complex BIM technology is less likely to be accepted by construction firms; hence, BIM may be more likely to be adopted if it is easier to implement than the existing systems. However, the level of Complexity of BIM in any firm could be due to a lack of expertise required to deploy and use it.

6.2. Organizational factors

6.2.1. Management support

Top management support comes fourth in the rank (i.e., after compatibility) of the power of influence of the identified factors affecting this stage. This result support prior finding related to organizational technology adoption, suggesting that top management support is an important factor and positively influences BIM adoption [21], [60], [73], [98], [99] To provide vision and encourage the use of BIM technology, top management support is required. Top management support is critical in securing the resources needed to transition current working techniques to BIM-based processes. BIM should be viewed as a vital business aspect instead of just another IT system. In the case of BIM technology, top management support at the organizational level is critical in providing the appropriate strategic vision and direction. In this manner, upper management establishes the importance of appreciating both tangible and intangible benefits associated with the use of BIM technology.

6.3. Environmental Context

6.3.1. Mimetic pressures

Surprisingly, mimetic pressures had no discernible impact on BIM adoption. Previous construction innovation studies, particularly those involving BIM technology, investigated the impact of mimetic pressures on innovation adoption and found conflicting results. For example [22] investigated the impact of mimetic pressures on Chinese construction firms' adoption of BIM technology and discovered a significant relationship between BIM adoption and mimetic pressures. [91] He investigated the impact of Mimetic pressures on three stages of innovation adoption (Awareness, Intention/adoption interest, and Decision stage) in the UK construction industry, and he concluded that Mimetic pressures have no significant influence on organizations' BIM adoption. In previous studies, competitive pressures or intensity have been utilized as a proxy for mimetic pressure and have been found to be a significant variable in numerous contexts. These findings are intriguing even though they may reflect the innovation's relative newness during the data collection phase. When companies first learn about innovation, they may not want to be among the first to implement it as most of the peer organizations that the firm could look to for inspiration have not implemented the innovation or have but are not generally known. As previously stated, these companies first seek advice from their industry support organizations before making specific decisions. Considering the lack of best practices, organizations may wish to adopt a wait-and-see approach before deciding on adopting innovation after being aware of such innovation.

6.3.2. Coercive pressures

Among the seven factors influencing BIM adoption, coercive pressures are ranked first. This finding is consistent with researches conducted the impact of coercive pressures on technology adoption [22], [42]. Coercive pressure may have an impact on BIM adoption because it is mandated, requiring enterprises to act rather than simply announcing their intention to do so. In addition, external stakeholders, such as government agencies and non-governmental organizations, put coercive pressure on businesses, forcing them to comply with various norms and standards. The UK government, for example, mandated BIM in its Government Construction Strategy in 2011, declaring that fully collaborative 3D BIM will be a basic standard by 2016 [6].

Furthermore, the Smart Market Report (2015) reported that the UK's 136% growth could be ascribed to the government's position for BIM on government-sponsored projects. [100] conducted a study on government mandates and their impact on BIM adoption in Dubai; the study discovered that government mandates are primarily responsible for the early phases of BIM adoption. All over the world, governments have acknowledged the inefficiencies that plague the construction sector and have advised and required the use of BIM as a way to combat poor BIM adoption.

6.3.3. Normative pressure

In terms of normative pressures, there was no evidence of a significant impact on BIM adoption in this study. This finding is in line with previous research [22]. This can be explained by the fact that construction industry participants frequently rely on information provided by outside professionals to determine whether or not to adopt innovations. Some scholars believe that normative isomorphic pressure emerges from formal education and advice from professional organizations [101], [102]. As a result, it has been proposed that normative pressure is a result of professionalization, involving two pressures. For starters, it is assumed that members of professions receive similar training, which socializes them into a similar approach to task performance. Second, members of professions interact with one another through professional and trade associations, which help to spread ideas among them [103]. BIM adoption was not significantly influenced by normative pressures, possibly due to a lack of effort by related professionals to promote the use of BIM in the industry.

7. Conclusion

The TOE frameworks were developed to investigate the implementation of BIM in Libyan construction sector. It was realized that BIM technology was a problematic organizational technology that had many impacts on organizations. So, to understand this complex issue, a BIM adoption model was developed for organizations in developing nations which was found sufficiently relevant in assessing the structural and measurement models based on the findings of path analyses. This research uncovered significant findings about the factors influencing BIM adoption in Libyan construction firms.

First finding concerned the extent to which BIM is used in Libyan construction firms. The efforts made by Libyan construction firms can be said to be limited mainly by their decision to rely on traditional technologies like CAD; however, effective organizational BIM adoption requires the integration of BIM as a novel technology that can address the critical problems in the organization, such as low productivity, especially in the coming period.

Another finding was that the compatibility factor has more influence on BIM adoption than the rest of the technological factors within the Libyan construction firms. As previously stated, the majority of project participants are accustomed to specific work tools (software and hardware); as a result, data transfer is frequently hampered due to incompatibility, limiting the sharing of critical information among project participants. The non-transferred data must be recovered, and more attempts should be made to recover or add more data for other tools. Even though these drivers of BIM adoption in organizations are significant in this study, coercive pressure seems more significant in achieving the appropriate degree of BIM adoption.

Lastly, corporate culture influenced the relationship between BIM adoption and normative pressure. This suggests that the moderating role of corporate culture may aid in resolving the inadequacies of institutional theory. The recognized institutional life sector comprises key suppliers, regulatory agencies, resource and product consumers, and organizations that offer similar products or services. Thus, the interaction between organizational culture and institutional pressure may affect BIM adoption.

8. References

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