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Determinants of Building Information Modeling Adoption: The case of the Malaysian Construction Industry

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Abstract

The Architecture, Engineering, and Construction (AEC) industry rely heavily on Building Information Modeling (BIM). BIM is the collection of Information and Communication Technologies (ICT), interacting policies, and procedures. BIM is a tool for managing digital project data during the life cycle of a building. Despite the many benefits and features of BIM, the Malaysian construction industry's proliferation is confronted with adoption issues. Therefore, this research study intends to find the effect of BIM adoption factors in Malaysian AEC. Quantitative data collection from construction firms is gathered. The proposed model's theoretical foundations are based on Technology, Organization Environment framework. The model is tested and validated with the Smart PLS tool. The study's findings indicate that Perceived benefits, Organizational Capabilities, and Trialability are drivers of BIM adoption. Perceived cost and Insecurity are the barriers to BIM adoption. Perceived ease of use and compatibility does not affect BIM adoption. Finally, this study performs Importance Performance Map Analysis to provide recommendations to AEC stakeholders to address the BIM adoption issues for enhancing its diffusion in Malaysia.

Keywords: Building Information Modeling (BIM), Influencing factors, BIM adoption Model, Technology Acceptance, BIM Adoption.

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Introduction

The construction sector's key challenges are automation, digitization, mimetic pressure, and greater capital value (Akdogan, 2020; Mohammad et al., 2019; Shehzad et al., 2021). A competitive advantage is achieved through collective project execution and information processing (Fan et al., 2019; Muhammad et al., 2020). Building Information Modeling (BIM) is used for design preparation, 3D modeling, simulation, risk assessment, environmental analysis, site control, project control, identification, and collision detection (Bosch-Sijtsema et al., 2019; Shehzad et al., 2019). BIM uses a shared digital representation of a built environment data to facilitate the whole construction activity. It helps model designing, scheduling, estimation, construction, and delivery of the project (Ismail, Adnan, & Bakhary, 2019; Moreno, Olbina, & Issa, 2019). It develops a method for handling project data in digital format during the life cycle (Prashant, Somesh, & Sree, 2016). BIM is a series of integrated strategies, processes, and information and communication technologies. It assists with construction tasks during the project's life cycle and incorporates data from all project teams (Shehzad et al., 2021; Walasek & Barszcz, 2017). BIM is used in construction planning, 3D modeling, visualization, cost estimation, fabrication, forensic analysis, collision detection, project management, and facilities management. The primary capability of BIM provides collaboration and information integration between all the construction project stakeholders (ISO, 2016). The successful BIM implementation enhances the stakeholder's capabilities for managing and planning construction activities (Grilo & Jardim-Goncalves, 2010). The Malaysian AEC industry is a significant contributor to the national economy with an investment of RM 36.3 billion. The government sector share is 45.3 % and private sectors invested 54.7 % (MPCM, 2016). The increase in investment is recorded due to the efforts of the Government to promote the construction industry. Despite this large investment, the construction industry productivity is recorded as very low and the survey indicated that low productivity is due to a lack of digitalization adoption in construction industries (Mahamadu, Mahdjoubi, & Booth, 2014). According to a current report by the Construction Industry Development Board (CIDB), the significant awareness level of BIM is recorded in the construction industry and 84% of firms have the intention to adopt BIM (CIDB , 2017; Date, Gangwar, & Raoot, 2014; Shehzad et al., 2020).

The research study aims to find the influencing factors on BIM adoption in the Malaysian construction industry. This study combined determinants from technology adoption studies to form the basis of research. These factors are then categorized based on Technology, Organization, Environment framework. The study's first contribution is to examine the factors by collecting empirical data from the AEC industry to analyze the BIM adoption phenomena in Malaysian construction organizations. The second objective of this study is to propose the BIM adoption model for the Malaysian AEC industry. Finally, this study uses statistical validation with the help of a Smart PLS tool using partial least square to confirm the structural model and measure model and the relationship among factors.

1. This study is organized as follows: Literature Review section discusses the related works and existing studies. The proposed model is discussed in the methodology section. The findings and analysis section provides the results of the study. The discussion on results is provided in the discussion section. Finally, the conclusion and the overall summary of this research study are presented.

Literature Review

This section reviews and analyze the existing research on BIM adoption. BIM has revolutionized the construction industry practices by providing multi-dimension modeling (Al-Hammadi & Tian, 2020; Ljevo et al., 2019). Similarly, from a technology adoption perspective, studies include assessing motivations for adopting BIM (Liu et al. 2019), understanding intention to use BIM (Liu, Issa, and Olbina 2019), affecting BIM adoption. Other studies discuss BIM diffusion, BIM awareness in developing countries, and the level of BIM adoption (Enegbuma et al., 2016; Enegbuma, Dodo, & Ali, 2014; Matarneh & Hamed, 2013; Takim, Harris, & Nawawi, 2013). Similarly, the studies investigate external environmental factors that affect BIM diffusion using institutional theory (Ghaffarianhoseini et al., 2017; Juan, Lai, & Shih, 2017). It categorized the factors into coercive pressure, normative pressure, and mimetic pressure. Similarly, a conceptual model of factors proposed examines BIM adoption (Ljevo et al., 2019). Another study categorizes factors into external environment characteristics, innovation characteristics, and internal environment characteristics (Ahmed & Kassem, 2018; Cemesova, Hopfe, & Mcleod, 2015). A study on BIM conceptual construct clarifies the stages of BIM adoption as diffusion stage, implementation stage, and readiness stage and assesses macro-level BIM adoption (Succar & Kassem, 2015, 2016). Similarly, BIM inhibitors are categorized as management dimension, personnel dimension, cost dimension, legal dimension, and technology dimension (Ahmed, 2018).

Other benefits of BIM include improved coordination and communication (Hatem, 2018), improved work quality, reduced rework, cost reduction, timely identification of errors, market accessibility (Ali et al., 2020; Jongsung & Ghang, 2013), competitive advantage, better risk management, and improved decision making. Additionally, it supports the facility managers in health and labor management. Construction practitioners view BIM as a technology and a method only. The high cost of adoption and insecurity of return on BIM investment is the reason for the hesitation to participate in BIM implementations (Aryani et al., 2016). Numerous factors that influence BIM adoption include willingness to adopt BIM (Juan et al., 2017) and internal and external factors (Hanafi et al., 2016; Latiffi, Brahim, & Fathi, 2017). Other factors include cultural differences (Herr & Fischer, 2018), legal issue (Latiffi et al., 2017), trialability and BIM quality (Ngowtanasawan, 2017), cost of implementation (Ghaffarianhoseini et al., 2017; Sinoh, Othman, & Ibrahim, 2018), normative pressure (Bosch-Sijtsema et al., 2017), lack of infrastructure, resistance to change, incapable BIM professionals, limited government initiatives (Ahuja et al., 2018; Mustaffa, Salleh, & Ariffin, 2017), lack awareness, and lack of industry readiness (Glanville, 2013; Latiffi et al., 2016).

BIM was introduced in Malaysia in 2007 (Enegbuma et al., 2014; Latiffi et al., 2013; Mohammad et al., 2019). The fourth industrial revolution has presented many challenges for the Malaysian government that require digitalization and industry transformation (MITI, 2018). Understanding the BIM adoption challenges in the Malaysian Construction Industry is a prerequisite to predicting the BIM adoption process. Identifying these challenges provides strategies to tackle the issue with BIM adoption. Hence, there is a need to identify the construction industry's adoption challenges (CIDB, 2017). Despite the various BIM benefits, its adoption in Malaysia is recoded low (CIDB , 2017). Also, the barriers and factors of BIM adoption got limited attention in existing studies.

Therefore, the contribution of the study is to find factors that affect BIM adoption in Malaysian AEC. Based on technology adoption literature, factors are identified and tested. The BIM adoption model for the Malaysian AEC industry is proposed. This study will help AEC organizations and practitioners to address factors identified, to assess and promote BIM adoption in Malaysia.

Methodology

Technology adoption is the acceptance and use of new technology. Researchers use technology acceptance theories such as the Technology Acceptance Model and Diffusion of Innovation to examines the technology adoption process. The theory of planned behavior declares that a person's intention to do any act is based on individual attitude toward that action and perceived behavioral control and subjective norms (Enegbuma et al., 2016). Perceived behavioral control plays its role as a proxy to demonstrate the difficulty or easiness of doing a particular behavior. Technology Acceptance Model suggested by Davis (1989) and is the most widely used acceptance model.

It explains the role of attitude, intention, behavior in accepting or rejecting technologies. According to this model, external variables influence Perceived Ease of Use and Perceived Usefulness and attitude. Attitude influences behavioral intention. Behavioral intention influences actual use. UTAUT combines eight theories, including TAM, TRA, Combined TAM, and DOI, to predict behavioral intentions to use technology. It is also a widely used theory as it contains elements from other theories also. However, it has some limitations and is revised (Grilo & Jardim-Goncalves, 2010). UTAUT consists of seven elements: facilitating conditions, social influence, performance expectancy, effort expectancy, behavioral intention, and use behavior. The Diffusion of innovation theory is proposed by Reuters (2018). This theory is based on the belief that innovation diffusion determinants are innovation attributes. There are five Innovation attributes in DOI, including observability, complexity, compatibility, trialability, and perceived benefits.

The theory of reasoned action is developed by Lee, Sacks, & Eastman (2006) is a social science theory and is applied in many areas. The theory is used to find relationships of attitude and behavior concerning human action. It measures how an individual behaves with existing behavioral intention and attitude. The constructs of this theory are the attitude toward the act of behavior and subject norm. Attitude and behavior influence behavioral intentions, and behavioral intentions influence actual behavior. The information system success model is developed to assess the failure or success of enterprise information systems (Simonen & McCann, 2008; Smith and Edgar, 2008). Institutional theory is developed by Scott (2004), and it focuses on the role of the institutional environment in shaping behavioral changes and obtaining social legitimacy.

The main construct of this theory is isomorphism. Three types of isomorphic pressure are coercive, mimetic, and normative. Coercive isomorphism is the study of changes due to pressure from an external organization. Mimetic isomorphism focuses on imitating one organization's organizational structure in the hopes of reaping the same benefits as other organizations. The pressure from regulatory bodies and practitioners involved in licensing and certifications is known as normative isomorphism.

Technology Organization Environment Framework

The enterprise level's innovation process can be better described with the Technology Organization Environment Framework (TOE). It is developed by Baker (2012). The frameworks divide characteristics into three dimensions. First is the Technology dimension, second is organizational, and third is the environment. The technology dimension represents internal and external technologies, availability of technology, and technical characteristics. The environmental context consists of industry characteristics, the role of government, competition, and environment structure. In organizational context size, formal, informal structures, processes, and practices are included. The theoretical foundations of this study are based on TOE. The first reason to use TOE is the BIM, highly revolutionary nature with advanced processes that require critical evaluation before adoption. Secondly, BIM is a community-oriented innovation that provides coordination and interfaces for collaboration among the construction industry stakeholders.

Model development

For selecting variables for this study, a list of all the variables from the existing studies is created and the frequency and weight for each variable are calculated. From the list of variables, the top ten variables are selected for this study. This method of variable selection is in line with existing studies (Jeyaraj et al. 2006; Lemsys, 2017). The factors are (1) Mimetic pressure (2) Insecurity (3) Coercive support (4) Perceived cost (5) Organizational capabilities (6) Perceived benefits (7) Compatibility (8) Perceived ease of use (9) Trialability (10) Government support as shown in Figure 1. The definitions and measure items of each factor are shown in Table 1 and Table 2.

Instrument development and data collection

Three academicians with BIM experience from a Malaysian public university were consulted to ensure the instrument's validity, and the instrument was revised based on their input. The data is gathered from AEC firms in Malaysia's Kuala Lumpur and Selangor. The companies' contact information is obtained from the Construction Industry Development Board (CIDB) and the myBIM portal. Websites include a directory of registered AEC practitioners as well as contact information. The questioners were posted to Google Forms, and all participants were given a link to access the form. For this analysis, a total of 505 valid responses were analyzed. This research uses ten constructs from theories and frameworks to suggest a theoretical model for BIM adoption.

The following hypothesis is developed for this study:

H1: Perceived ease of use has a positive relationship with BIM adoption.

H2: Perceived benefits of BIM technology are positively related to its adoption.

H3: Trialability of BIM has a positive effect on BIM adoption

H4: Compatibility of BIM with existing applications and practices is positively related to BIM adoption.

H5: Mimetic pressure will have a positive relationship with BIM adoption.
H6: Government support will have a positive relationship with BIM adoption.
H7: Coercive support positively influences BIM adoption.
H8: Organizational capabilities are positively related to BIM adoption.
H9: Insecurity is negatively associated with BIM adoption.
H10: Perceived cost is negatively related to BIM adoption.

Table 1. Factors and Definitions

Variable	Definition
Perceived benefits	The extent to which an innovation is thought to be advantageous to an organization's success (Rogers, 2003)
Compatibility	The extent to which an idea is considered to be compatible with potential adopters' current beliefs, past experiences, and needs (Grilo & Jardim-Goncalves, 2010)
Perceived ease of use	The extent to which an innovation is thought to be simpler to understand and use (Acquah, Eyiah, & Oteng, 2018)
Mimetic pressure	Mimetic pressure is described as its impact on a company's incentives to develop new products and processes (Cao, Li, & Wang, 2014; Gallaher et al., 2004)
Government support	Government assistance may have a positive or negative impact on innovation. If governments enforce new regulations on businesses, they are effectively forced to innovate (Karam et al., 2018; Wong, Ge, & He, 2018; Zhu et al., 2018)
Coercive Support	The formal and informal limitations imposed on an organization's systems and activities by government regulations or business standards influencing what an organization can and cannot do is coercive support (Muller et al., 2017)
Triabalility	The extent to which an invention can be tried out on a small scale (Rogers, 2003)
Organizational Capabilities	Refers to an organization's willingness to adopt and use emerging technology to achieve work-related objectives (Arayici et al., 2018)
Perceived cost	Perceived cost refers to the cost of applications, training cost, upfront implementation cost" (Tommasi & Achille, 2017)
Insecurity	"Insecurity is the doubt in the mind of technology adopters and uncertainty about promises and delivery of the technology innovation to meet organizational automation requirement" (Fuchs, 2005)

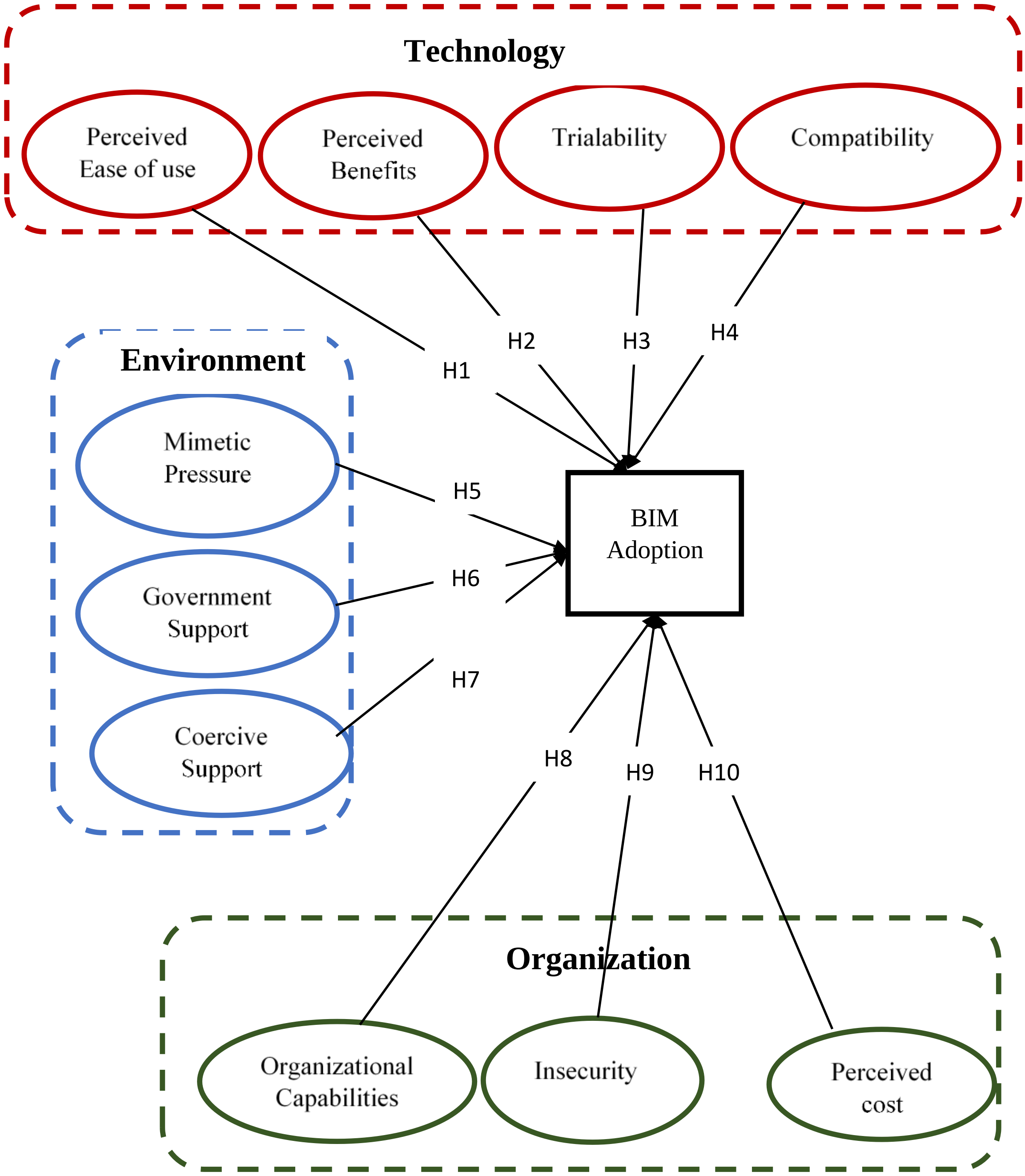

Figure 1. The Proposed BIM Adoption Model

Table 2. Factor Measurements

Variable	Measurement	Source
Perceived benefits	This construct's measurement items include reduced construction cost, improved quality of work, and effectiveness on the job.	(Bynum, Issa, & Olbina, 2013; Desbien, 2017; Matějka et al., 2016)
Compatibility	The measurement items for this construct include BIM consistency with existing practices, beliefs, and values.	(Costa & Madrazo, 2015; Lee, Eastman, & (Pauwels, Lee, 2015) Zhang, & Lee, 2017)
Perceived ease of use	It is measured in terms of ease of understanding BIM models, shorter time to learn BIM, Simple implementation process.	(Costa & Madrazo, 2015; Karam et al., 2018; Lee & Yu, 2015; Pauwels et al., 2017)
Mimetic pressure	This construct's measurement items include the pressure from competing organizations, peer projects, and a good reputation by industry contestants.	(Hu, 2016; Luo & Chen, 2017; Poirier, Staub-French, & Forgues, 2015; Venugopal, Eastman, & Teizer, 2015)
Government support	The items to measure include BIM mandated by the government and its role in the promotion of technology.	(Grilo & Jardim-Goncalves, 2010; Liu, Zhang, & Zhang, 2016; Figueiredo et al., 2015)
Coercive Support	The measurement items include support from professional bodies, government, and industry associations	(Pishdad-Bozorgi, Gao, Eastman, & Self, 2018; Staden & Mbale, 2012)
Trialability	The measurement items include availability to satisfactorily evaluate BIM functionalities, free trial version applications, and software available for enough to verify its capabilities.	(Ahuja et al., 2018; Kim, Park, & Chin, 2016)
Organizational capabilities	The measurement items include the availability of resources, skilled persons, and BIM awareness.	(Clark & Jones, 1999; Poirier, Forgues, & Staub-French, 2014)
Perceived cost	The measurement items include the upfront cost, maintenance cost, and training cost.	(Howell et al., 2016; Niknam & Karshenas, 2015, 2017; Pauwels et al., 2017; Törmä, 2013; Yang & Zhang, 2006)
Insecurity	The measurement items for this construct include insecurity in data and risk of an investment, security and privacy issues	(Jin et al., 2017; Mahamadu, Mahdjoubi, & Booth, 2013; McArthur, 2015)

Findings and Analysis

Demographic Analysis

According to the data analysis, 36 percent of respondents are architects, which is the highest response rate for BIM adoption. Engineers, with a 33.3 percent response rate, are the second-highest group of respondents. Quantity surveyors recode the next 12.5 percent of participants. Consultants make up 5.9% of the workforce, while contractors make up 7.7%. Finally, the client's least active involvement is recorded. In terms of respondents' experience, 55.6 percent have less than five years of experience. 18.6% of those surveyed have 6-10 years of experience. Finally, as seen in Figure 2 and Figure 3, the most experienced respondents account for 0.8 percent of the respondents.

Measurement Model

Convergent validity, discriminant validity, and scale reliability are evaluated as part of the measurement model study. Cronbach alfa and Composite Reliability (CR) are used to assess reliability. Table 3 and Table 4 show that CR and Alfa are greater than 0.70, as expected by the literature. Average Variance Extracted (AVE) is used to determine convergent validity, and the optimal threshold of 0.50 is met (Hair et al. 2016). The results of the study indicate that the measurement model meets the reliability threshold and discriminant validity.

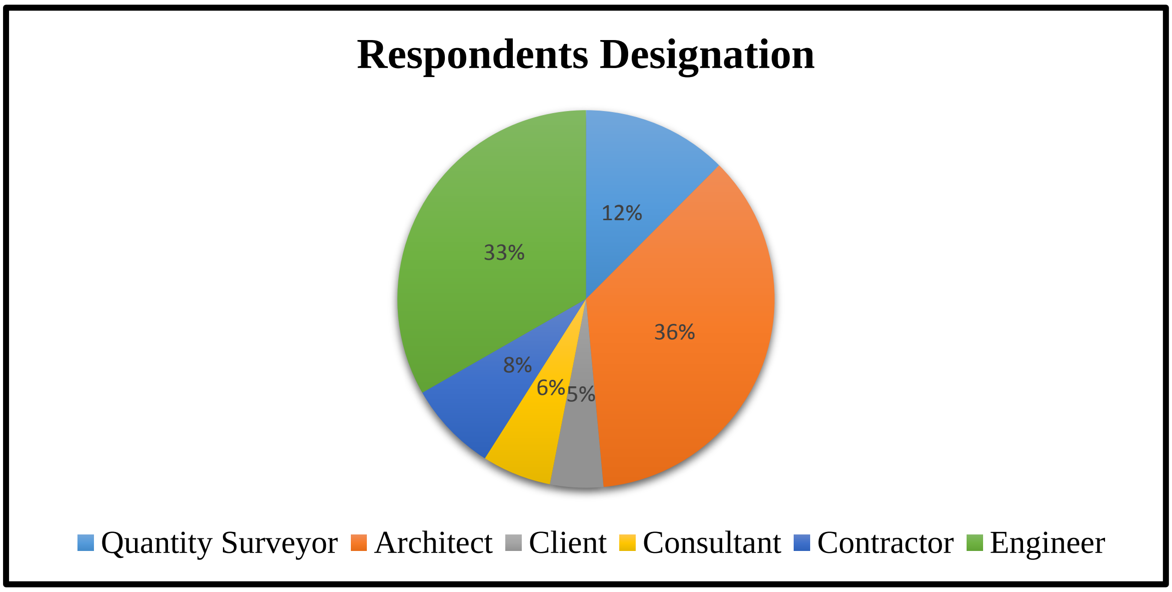

Figure 2. Respondent's designation analysis

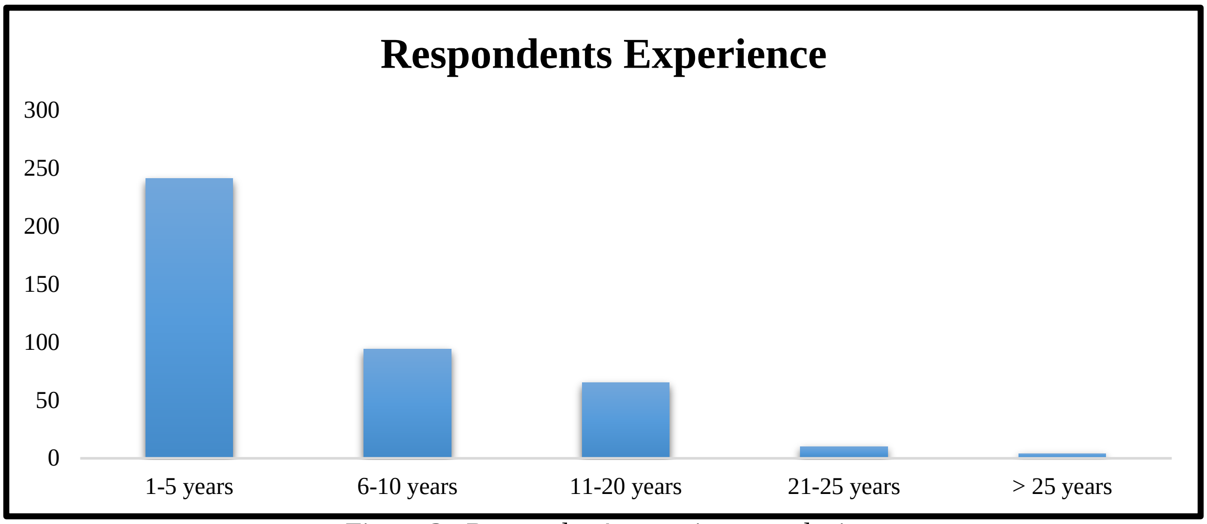

Figure 3. Respondent's experience analysis

Table 3. Construct Reliability and Validity

Construct	CA	CR	AVE
BIM Adoption	0.7110	0.8388	0.6348
Coercive Support	0.8678	0.9038	0.6534
Compatability	0.7328	0.8257	0.5435
Perceived cost	0.7624	0.8065	0.5165
Government support	0.8299	0.8901	0.7311
Insecurity	0.6639	0.8171	0.5985
Mimatic Pressure	0.7515	0.8365	0.5618
Organizational Capabilities	0.8243	0.8955	0.7413
Perceived benefits	0.7354	0.8484	0.6513
Perceived Ease of use	0.8443	0.8952	0.6818

Table 4. Construct Convergent Validity

Factor	Cross loadings	Factor	Cross loadings
BIM Adoption	0.7704	Organizational Capabilities	0.7984
	0.7747		0.898
	0.8428		0.8830
Compatibility	0.7686	Perceived benefits	0.8357
	0.6411		0.7684
	0.7810		0.8154
	0.7500	Coercive support	0.7744
Perceived ease of use	0.7578		0.8659
	0.8879		0.8209
	0.8502		0.8303
	0.8010	Trialability	0.7865
Mimetic pressure	0.7881		0.7990
	0.7858		0.7908
	0.7102		0.774611
	0.7100	Insecurity	0.9213
Perceived cost	0.6177		
	0.5221		
Government Support	0.7446		0.9304
	0.8766		
	0.7583		0.8785
	0.9217		

Hypothesis Testing

The hypothesis testing results of T-values and P-values are presented in Figure 4. Regarding the hypothesis, this study found the perceived ease of use has no influence on BIM adoption hence rejecting (H1). Similarly, the perceived benefits of BIM are a significant driving factor for BIM adoption. Therefore (H2) is supported. Trialability is found to have a positive influence and hence supporting (H3). Besides, the insignificant path of compatibility shows no effect on BIM adoption rejecting (H4).

Regarding Organizational factors, the insignificant path of Mimetic pressure shows no effect on the BIM adoption rejecting (H5). Government support significantly influences BIM adoption hence supporting (H6). The impact of coercive support is found significant supporting (H7). Organizational capabilities are found substantial supporting (H8). Insecurity is negatively associated with BIM adoption, hence supporting (H9). The perceived cost was found to impact the BIM adoption negatively, indicating that BIM cost is an inhibiter of adoption, supporting the hypothesis (H10). The hypothesized model is shown in Figure 4.

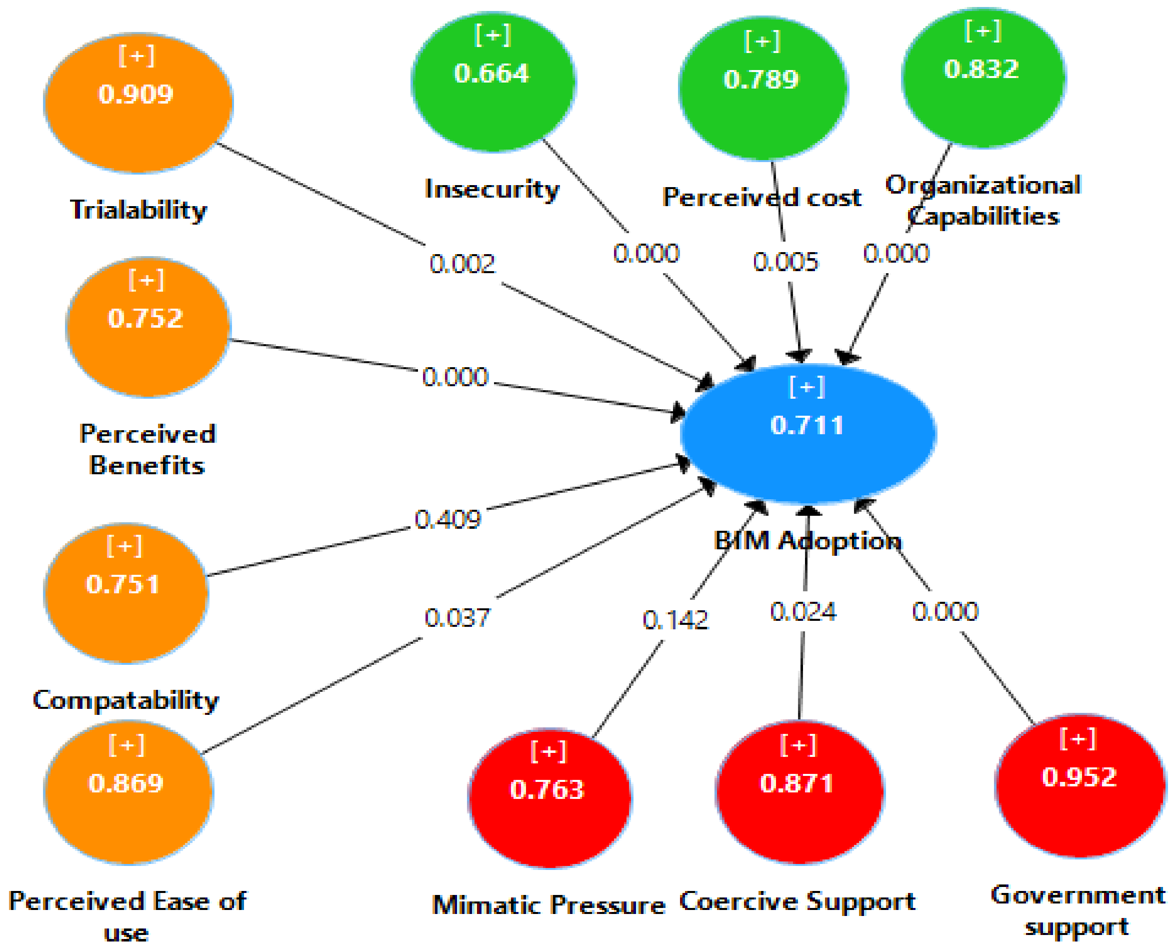

Figure 4. Hypothesized BIM Adoption Model

Discussion

This study found that the perceived benefits and trialability of BIM are the influencing factors on BIM adoption in Malaysian AEC. The AEC stakeholders consider BIM as a beneficial technology that helps manage business operations and construction activities. This finding is consistent with existing studies (Jiang et al., 2017; Khurshid et al., 2020). Furthermore, surprisingly, compatibility does not affect the BIM adoption like (Azhar, Hein & Sketo, 2011) also found insignificant in their studies. This finding suggests that compatibility has no contribution to BIM adoption. Malaysian AEC may consider it incompatible with their existing work procedure and practices. The analysis results show that organizational capabilities are an essential indicator of BIM adoption. Organizations with sufficient IT infrastructure to implement BIM and available internal expertise to use BIM are more likely to adopt BIM. Another advantage of organizations' internal competency is to try the software before actual implementation, boast confidence in the adoption decision. These findings are consistent with existing studies (Chien, Wu, & Huang, 2014; Khurshid, et al., 2020). The perceived cost is the cost of BIM adoption, ongoing cost, and implementation cost. This study found a negative association between cost and BIM adoption.

Similarly, insecurity is negatively associated with BIM adoption. Construction stakeholders are reluctant in BIM investment due to the prevailing uncertainty about return on investment (Ahmad Latiffi et al., 2017) and lack of data ownership (Wang & Chien, 2011). There is a need for copyright and legal laws (Ahmed et al., 2021; Gao, Li, & Tan, 2013; Juan et al., 2017; Rodgers et al., 2015; Takim et al., 2013). Based on the discussion, insecurity is the dominant factor affecting BIM adoption. This finding is consistent with the existing study (Chong, 2015).

It seems as there is no pressure from competing organizations, as found in the analysis. The other possibility is that AEC stakeholders are waiting for specific gains and benefits from early BIM adopters before adopting BIM in their organizations. This finding is consistent with previous literature (Manderson, Jefferies, & Brewer, 2015). This study found the coercive support driving factors towards BIM adoption. These findings are consistent with the existing study (Chien et al., 2014), indicating that BIM is demanded and supported by regulatory bodies. Additionally, complexity is negatively associated with BIM adoption represents a significant barrier. The technology that is easier to use and manage is more likely widely adopted.

Similarly, learning time for a complex technology is relatively long, hence inhibits technology adoption. The Malaysian AEC considers BIM complex to use and learn. This finding is supported by an exiting study (Ahuja et al., 2016). Government support has been found as another driver for BIM adoption in Malaysia. This finding is consistent with existing studies (Awan et al., 2021; Waziri, 2016).

Recommendation Guidelines for BIM adoption

The Importance Performance Map Analysis (IPMA) is the criterion for assessing the structural model. IPMA's prime objective is to determine which construct is relatively crucial for the target construct (Hair, 2009). By extracting the fundamental relationship between constructs, estimating indirect effect, and direct effect, the basic PLS-SEM analysis highlights the construct's importance (Garson, 2016). It is helpful to recognize areas for future improvements in the constructs that are of high significance but currently performs poorly (Kim et al., 2018). However, attention must be given to relatively high-value constructs to boost the dependent latent variable's performance level in the future (Garson, 2016). IPMA adds another dimension to the research, expanding the traditional PLS-SEM findings of path coefficient estimates (Hair et al., 2013). The IPMA test was performed in SmartPLS, and the IPMA graph is shown in Figure 5. Three factors, namely, Perceived benefits, government support, and organizational capabilities, have high importance for BIM adoption. Organizational capabilities have the highest importance value in the model. The total effect of organizational capabilities is 0.48, and performance values are 62.94.

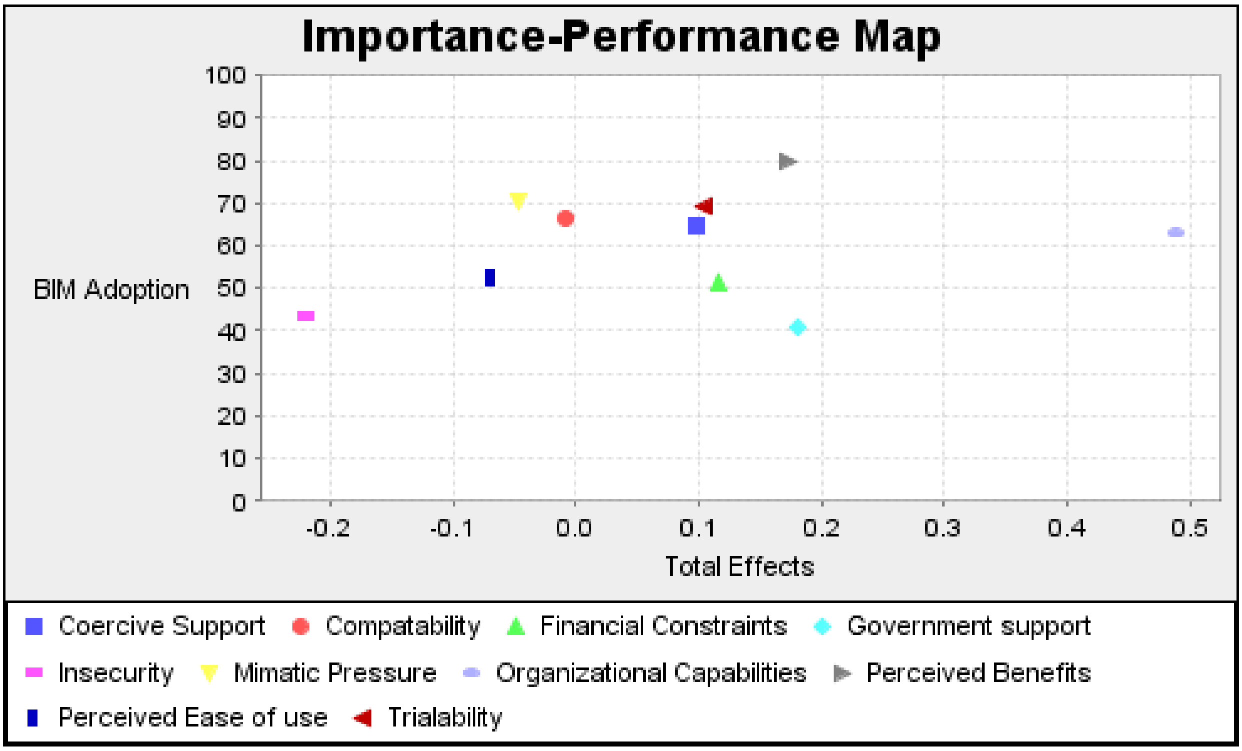

Figure 0. Graphical representation of IPMA

Besides, perceived benefits and government support have the second-highest importance, with a total impact of 0.17 and a performance value of 79.9 and 70.75. On the other hand, cost constraints, trialability, and coercive support were performed at the comparable level with a total effect of 0.12, 0.14, and 0.16, respectively. Despite their high performance, the remaining constructs had a total minor impact. Therefore, the three factors, namely, Perceived benefits, Government Support, and Organizational capabilities, have high importance for BIM adoption. Furthermore, considering these constructs for BIM adoption will increase the degree of adoption intensity.

Technology factors: Perceived benefits were the most influential factor in Malaysian AEC's adoption of BIM. BIM is regarded as a valuable technology by AEC stakeholders because it assists in managing business operations and construction activities. It is suggested that BIM developer companies boost BIM software features to fulfill all AEC stakeholders' needs. Furthermore, complexity is negatively correlated with BIM adoption and is a significant roadblock. The easier it is to use and handle, the more broadly it will be embraced. It is recommended that BIM developer companies reduce BIM applications' sophistication to make them more user-friendly and easier to understand and apply. Trialability provides the opportunity to investigate the BIM benefits without the risk of investing capital and provision of trialability by the application developers to help the stakeholders judge the applicability of the application for their firms and reduce the uncertainty level and promote BIM adoption.

Organizational factors: Organizational capabilities are a significant predictor of BIM adoption, according to the study's findings. BIM adoption is more likely in organizations that have adequate IT infrastructure and internal experience to incorporate BIM. Another benefit of an organization's internal competency is that it can test the software before implementing it, giving them confidence in their decision. As a result, AEC companies should invest in BIM training to develop their employees' skills. It's also a good idea to set aside money in your budget to buy and introduce new BIM goods. The most significant financial obstacle to BIM adoption is the expense of initial hardware, software setup, maintenance, and training. Small profit margins combined with a limited budget significantly impact an organization's technical innovation adoption. Small businesses, on the other hand, are more affected by financial difficulties than large corporations. Any new technology necessitates team training, and BIM is no exception. The cost of BIM technology training is exceptionally high. As a result, BIM production companies are urged to lower the cost of BIM software to be affordable to small and medium businesses. To help many potential users, BIM companies can also provide BIM training at a fair cost.

Environmental Factors*:* Government support has been found as another driver for BIM adoption in Malaysia. The government should also provide tax rebates, subsidies, or other government incentives for technology adoption. The government is currently moving slowly in developing its legislation to meet new trends in the building industry. Most government bodies, including Malaysia, are still following the traditional project approval methods by submitting 2D drawings, which hinders the applicability of BIM in construction procurement and contracts. The AEC stakeholders are waiting for specific gains and benefits from early BIM adopters before adopting BIM in their organizations. Technology leaders should play a role in BIM adoption.

Conclusion

Eventually, the research aims to evaluate the impact of various factors on BIM adoption in Malaysian AEC. After that, the variables are classified using the Technology, Organization, and Environment framework. This study presents the Malaysian AEC industry's BIM adoption model, which is validated through data collection and statistical analysis. Because of its applicability in the AEC and related disciplines, BIM is a fascinating area of research. While this study offers a detailed look at the factors affecting BIM adoption in Malaysia, it is not without shortcomings. The first limitation is the participant selection process, as only two major Malaysian cities are considered for data collection. Future research should have a broad sample size that includes people from different parts of Malaysia, such as east Malaysia. The use of a single technology adoption theory is the second. Future research can incorporate variables from other models and perspectives to get a fuller picture of the adoption phenomenon. Future research should consider using moderators in conjunction with current technology acceptance models to examine BIM adoption thoroughly. Future research should look into the impact of interoperability factors on BIM adoption. This paper will assist technology adoption researchers in conducting additional research in the BIM adoption domain. This research will also assist AEC organizations and practitioners in addressing the established factors and assess and encourage BIM adoption in Malaysia.

Conflict of interest

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