SEMARAK ILMU PUBLISHING

Journal of Advanced Research in Applied Sciences and Engineering Technology

Journal homepage: https://semarakilmu.com.my/journals/index.php/applied_sciences_eng_tech/index
ISSN: 2462-1943

Building Information Modelling (BIM) Adoption for Cost Engineering Consultant; Case Study of Southern China

Mariati Taib[1,*], He Quanhua[1], Nooriati Taib[1]

[1] School of Housing, Building and Planning, Universiti Sains Malaysia, 11800 Penang, Malaysia

ARTICLE INFO

Article history:
Received 14 November 2022
Received in revised form 20 December 2022
Accepted 11 January 2023
Available online 2 February 2023

Keywords:
Building Information Modelling; BIM; Cost engineering; China; Digital construction

ABSTRACT

Digital construction has paved its way into the Architecture, Engineering and Construction (AEC) industries with the technological revolution, which significantly change the design, construction, and management processes. The use of Building Information Modelling (BIM) presents a valued collaborative technology that eliminates most communication related challenges of the industry. The Chinese government has emerged as a major force promoting BIM adoption, by implementing policies and promoting efforts with government support. Yet, the adoption rate is still unsatisfactory particularly for China cost engineering industry. This paper examines the drivers and barriers of BIM adoption and consequently review its impact on the current BIM implementation processes. This study also investigated their awareness and acceptance level of BIM adoption. The main respondents are the cost engineering practitioner specifically in the area of Guangxi. The UTAUT and TAM model are adopted, to analyse on individual intention and behaviour by distributing online questionnaires. This analysis reveals that the practitioners have poor awareness of BIM and have no willingness to learn new BIM knowledge independently. At present, the proportion of BIM actual use in projects is relatively low, and no single post-construction maintenance project applied BIM technology. The main influencing factors for BIM adoption are measured based on the Performance Expectation, Effort Expectation, Generation Gap, Social Influence, Managerial Attitude and Facilitating Conditions. This paper contributes to the strategic suggestions that puts forward the role of user, consultants, governments that may facilitate the advantages of BIM technology adoption. This paper identified that successful implementation include the role of consultants on their readiness and acceptance, followed by adequate technology education and training.

1. Introduction

In China, the construction industry has grown rapidly over the past three decades and has become one of the four pillar industries for the national economy. According to China Construction Industry Research Report, the total construction output value was increased by 6.97% year-on-year to RMB 8.99 trillion in the fourth quarter of 2021. The total installation output value increased by more than 3.7% year-on-year to RMB 871.4 billion [1]. In order to cope with such rapid development of the

* *Corresponding author.*
E-mail address: mariati@usm.my

https://doi.org/10.37934/araset.29.3.2136

construction industry, the Chinese government has introduced a policy on BIM promotion in 2014, recommending construction companies to use BIM technology for all aspects of construction work, for engineering design, cost engineering and construction to the whole process [2]. For operation and maintenance application, the adoption of digital data and information system management approach for facility management greatly help the managers to manage facilities effectively. The implementation of space management, information sharing, making information complete and consistent, life cycle analysis, training professionals and system integration platform management reduce the operational costs [3]. Various solutions can be provided using a techno-economic evaluation, which include optimizing energy consumption particularly in the housing sector [4].

Meanwhile, the Ministry of Housing and Urban-Rural Development released the "Outline for the Development of Construction Industry Informatization 2016-2020" in 2016, which mentioned a form a number of construction enterprises with strong information technology innovation capabilities and information technology applications that reach international advanced levels [5]. However, although the Chinese government introduces several policies or development plans to support the adoption and promotion of BIM, at present, the degree of informationization in China's construction industry is very low, far below that of developed countries such as the United States, the United Kingdom and Japan.

According to Jin *et al.*, [6], at present, the BIM adoption rate in China is different in every region, but it is mainly concentrated in the provincial capitals of economically developed provinces such as Beijing, Shanghai and Guangzhou. Although other non-economically developed regions have begun to promote BIM adoption, the progress is slow. Ma *et al.*, [7] mentioned that most of the researches on influencing factors of BIM adoption paid little attention to the interaction among the factors, thus the identification of dominant factors, and how they influenced each other becomes unknown. Aibinu and Venkatesh [8] conducted a research on the influencing factors of BIM adoption for cost engineers in China, but they did not explain the relationship among the influencing factors in detail. Many researchers will ignore the BIM awareness of users in different areas and the variables generated by the actual BIM utilization rate in actual construction projects, which may affect the final analysis results. For example, Olanrewaju *et al.*, [9] think that obstacles to BIM implementation have an impact on BIM awareness in the project life cycle.

A questionnaire survey was conducted for cost engineering consultants in the area of Guangxi Province, a province in China that is not a less economically developed area, as a case study. A structured question model was designed to identify the factors that affect the adoption of BIM technology. The status of BIM awareness among engineering cost enterprises and individual users in Guangxi area is further identified. This study is based on the UTAUT model, which add on variables of influencing factors that occur in actual engineering cost industry.

2. Literature Review

2.1 Application Status of BIM in China

In the article "China BIM Application Value Research Report, 2015”, only 5% of the design and construction cost enterprises in China had a BIM usage rate of over 60% in 2014, and 46% of the design and construction cost enterprises had a BIM usage rate of less than 15% [10]. Although the report predicts that the future growth rate of Chinese construction enterprises will reach 108%, but the usage rate of BIM is still far less than that of developed countries in Europe and America. This shows that although the Chinese government and state-injected construction enterprises (such as China Construction Group and China Railway Construction Group) strongly support the promotion of

BIM, the promotion of BIM technology has not achieved the effect expected by the Chinese government due to various reasons.

In 2019, Wang and Ma [11] studied 314 listed AEC companies (including real estate companies) in China. It is evident that the earliest time these companies first mentioned the use of BIM technology was in 2010. BIM technology utilization rate of these listed companies was about 34.7 %, equivalent to 109 companies that used BIM technology during 2010-2019. Thus, it can be concluded that the adoption rate of BIM in China was less than 5% before 2014. However, since the Chinese government promoted the BIM policy in 2015, the BIM utilization rate rose to 23.6% by 2019, but even so, China's overall BIM utilization rate still lags behind other developed countries.

Meanwhile, Jiang *et al.,* [12] claimed out of 30 projects that used BIM, 93% are of large-scale projects, and the remaining are medium-sized and small-scale projects respectively. BIM was identified to be used the most in design stage, followed by construction and the least management. Zhang and Jia [13] surveyed a total of 12 architects and 24 construction project managers, and 92% of them agreed that the projects they worked for only consists less than 30% BIM components. While in the projects that have already used BIM, the application phase of BIM is mainly used in the design and engineering phase.

2.2 BIM Cognition and Consciousness

Jin *et al.,* [36] conducted a questionnaire survey on an international engineering consulting company headquartered in London and located in Beijing, China. The awareness rate is 100%, and 95% of them were exposed to BIM technology after 2010. Only 12% of these people think that they use BIM with 15-30% adoption rate, and 88% think that BIM accounts for less than 15% of the projects they use. As for the awareness of BIM, 55% of the participants think that BIM has a moderate impact in the industry, but they think the negative impact will be more than the positive one, and 75% of the volunteers say that it is very difficult to learn new BIM technology or BIM software. Ahn and Kim [15] reached a conclusion in a survey of BIM awareness among Asian architecture students (mainly from South Korea, China and Japan). The architecture students mainly use CAD software instead of BIM software for design, and majority of the students did not received any BIM backgrounds. From the analysis of conscious factors, it is concluded that the students are more interested when they are aware of BIM.

2.3 Influencing Factors on BIM Adoption

The obstacles to BIM technology was investigated using the immaturity level of BIM software by Lee *et al.*, [16], which makes the difficulty of data exchange and possible unexpected errors in data exchange become the factors that affect BIM adoption, and the BIM team collaboration. Lin and Yang [17] believe that BIM managers play an important role in successful projects using BIM technology. A good BIM manager not only has excellent BIM professional knowledge, but also has the ability to effectively communicate with the team and coordinate team collaboration. If everyone in the BIM team only cares about the work at hand, but does not coordinate the work of the upper and lower parts, or lacks communication with each other, the project may be difficult to succeed. Apart from the problems of software itself and team communication, Tan *et al.,* [18] think that the factors that affect BIM adoption resources from external environment. For example, there is a lack of professional BIM skills education, insufficient external motivation to implement, and lack of research on BIM promotion policies in China. Zhang *et al.*, [19] concluded that high cost and time on BIM training discourages ordinary users, which was supported by Xu *et al.,* [20]. On the other hand, Jin *et al.,* [14] thinks that the return on investment of BIM will be the most important factor for many company managers, and getting real return from BIM investment will enable business leaders to improve BIM adoption. However, Son *et al.,* [21] summarised that the awareness and attitude of the company's top managers, and whether there are corresponding incentives to support new technologies are the decisive factors that influence BIM adoption. Therefore, they think that the attitude of senior managers or managers greatly affect the implementation of BIM. Zhang *et al.*, [22] measures the impact of promotion of BIM policy led by the government their influence on training as well as investment for BIM educators, which greatly improve the BIM awareness and BIM adoption of AEC grass-roots staff.

2.4 User Acceptance Behavior Model Theory

User acceptance behavior model is a model of foreign researchers' willingness to adopt a technology or product, and to study the relationship between the key factors affecting user willingness and other factors. It is a model theory based on social psychology and organizational behavior, and using behavioral science for comprehensive research. In 2003, Venkatesh *et al.,* [23] uses TAM model as the core, aiming at several models recognized by many researchers and make best use of the advantages to finally put forward the unified theory of acceptance, applying it on technology (UTAUT).

Venkatesh *et al.,* [34] that the comprehensive model needs to involve multiple disciplines such as psychology, behavior, sociology and information system, after interdisciplinary investigation and verification. After their repeated demonstration, finally, more than 20 variables in the eight models are summarized into four core variables affecting use behavior and intention: performance expectation, effort expectation, social influence and facilitating conditions in addition, four adjustment variables, gender, age, experience, volatility of use, are added. These four regulatory variables will affect the four core variables. Most of the research analyses on the influencing factors were conducted using a structural model followed by analysis of the model to obtain the results. [22,24,25,33,35]. It is thus evident that hypothetical argument analysis of influencing factors using structural models is feasible throughout the world of academic research.

3. Methodology

3.1 Research Framework

Venkatesh *et al.,* [34] establishes the use of UTAUT model for different research in different fields. it needs to be expanded or modified according to the dimensions of their own research background, and it is unnecessary to use the original model completely. Foon and Fah [24] applied the model to study the influencing factors of online banking adoption in Kuala Lumpur. While Kijsanayotin [35] also used the UTAUT model to study health technology in community health centers in Thailand. Their research uses UTAUT model, and all of them contain four variables: performance expectation, effort expectation, social influence, and facilitating conditions. Fundamentally, the UTAUT models has identified four core variables: Performance expectation, effort expectation, social influence, and facilitating conditions, which is an added variables required for the model.

On the basis of retaining the core variables of the UTAUT model, four control variables were adopted; gender, age, experience and voluntariness with some modification to the traditional UTAUT model. From the cost engineering perspective, the proportion of male and female is relatively balanced based on some practitioners feedback, thus, this variable can be discarded. For the variable of age and experience, it can be combined into one variable which is Generation Gap. Based on the duration of their working experience, their thinking and behavior choices might vary. For example, the generation gap caused by age gap mentioned affect the adoption behavior [16,37]. As for the variable voluntariness, it is learnt that each company has their own work plan to complete the project and to efficiently connect with other people in the project team. Thus, at this time, the variable is considered not critical. The practitioners must complete their work according to the requirements of the company. Therefore, the variable voluntariness of use should also be discarded.

In contrast, a new variable, Managerial Attitude, should be added. As mentioned above, the attitude and decision of the managers of the company will greatly affect the possibility of users using BIM in cost engineering work [21,25]. If the company decides not to use BIM technology for this project, then practitioners can only give up using BIM technology in this project. Therefore, the variable Managerial Attitude should be increased correspondingly. Managerial Attitude will directly affect the user behavior. At this time, there are only four core variables: Performance Expectation, Effort Expectation, Social Influence, Facilitating Conditions, and new variables: Generation Gap and Managerial Attitude.

3.2 Research Hypothesis

In the research model of this paper, eight variables are selected for testing, they are Performance expectation, effort expectation, social influence, facilitating conditions, length of service, behavioral intention and user behavior. Because this model is based on revised UTAUT model, so the relationship between these eight variables can only be inferred and proved after hypothesis. Therefore, the hypothesis is shown in Table 1.

Table 1
The table of hypothesis

Number	Hypothesis
H1	There is a positive correlation between Performance Expectation and Behavioral Intention
H2	There is a positive correlation between Effort Expectation and Behavioral Intention
H3	There is a positive correlation between Social Influence and Behavioral Intention
H4	There is a positive correlation between Generation Gap and Behavioral Intention
H5	There is a positive correlation between Behavioral Intention and User Behavior
H6	There is a direct positive correlation between Managerial Attitude and User Behavior
H7	There is a positive correlation between facilitating conditions and User Behavior

Combining these seven hypotheses, the hypothesis of BIM software user adoption behavior model is shown in Figure 1.

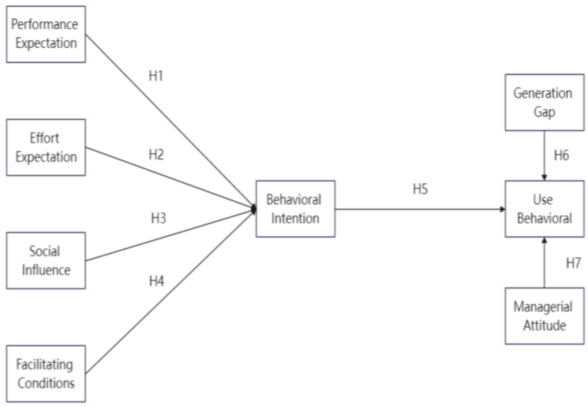

Fig. 1. Variables and hypothesis relation diagram

3.3 Data Collection

The respondents was selected from practitioners in the cost engineering industry in Guangxi, who came from private enterprise, state-owned enterprise, government agencies or government-related workers, universities or other research institutions. This study used a web-based questionnaire for data collection. The survey was conducted using a combination of the snowball survey method and a random sampling method via web questionnaire. In order to ensure that the respondents are in line with the standards of the target group, the region for the questionnaire was selected. Firstly, the snowball survey method was used to select the first batch of respondents (27 people in total) who are working in the cost engineering industry in Guangxi. Next, they were asked to pass it to their colleagues in the same company and tell their colleagues to forward it to other people who were also working in the cost engineering industry.

Then it was a random sampling method using the network questionnaire, and the questionnaire was shared in the network forum for Guangxi cost engineering subgroup. The questionnaire survey was conducted for 11 days in total. A total of 229 questionnaires were collected, and after eliminating those that did not meet the requirements, 168 questionnaires remained valid. The effective collection rate was about 73.36%. After Margin of error calculation using the sample calculation method, the actual Margin of error for this survey when the Confidence level is 95% with 7.5%, which is higher than 5% and lower than 10%. It belongs within the acceptable range. Using IBM SPSS Amos 28 Graphics and IBM SPSS Statistics 26, the analysis includes descriptive and inferential statistics for analytical interpretation [26], reliability test [27], validity analysis [28], validation factor analysis [29], structural equation model validation [30], evaluation of structural equation model parameters [31] and structural equation model goodness-of-fit test [32].

4.Result

4.1 BIM Awareness

According to the survey results, only 26 % of the users know BIM well and often use it at work. The proportion of people who voluntarily learn new BIM knowledge is only 24%. Clearly know the BIM policy advocated by the government, and only 17 % of them know it voluntarily. It can be inferred that the respondents' BIM awareness is not good, and the number of people who voluntarily learn new BIM knowledge and learn the latest BIM policies is very small. Poor awareness of BIM among groups will make it more difficult to adopt and promote BIM.

4.2 Actual Usage Rate Of BIM

The results of the survey show that 55% of the respondents think that only 0-20% of the projects they work on use BIM technology, and no more than 15% of the respondents think that more than 40% of the projects use BIM technology. 90% of the respondents think that the most used type of BIM technology is Project costing as shown in Figure 2. And BIM technology is mainly applied during construction and pre-construction as shown in Figure 3. By cross-analyzing the data of BIM stage and BIM type, it can be concluded that the respondents think that there is no project that uses BIM technology exclusively for maintenance in Guangxi for the time being. Based on the data, it can be inferred that the actual use of BIM technology in the costing engineering industry in Guangxi is less involved and there is no project that uses BIM technology exclusively for the sake of maintenance for the time being.

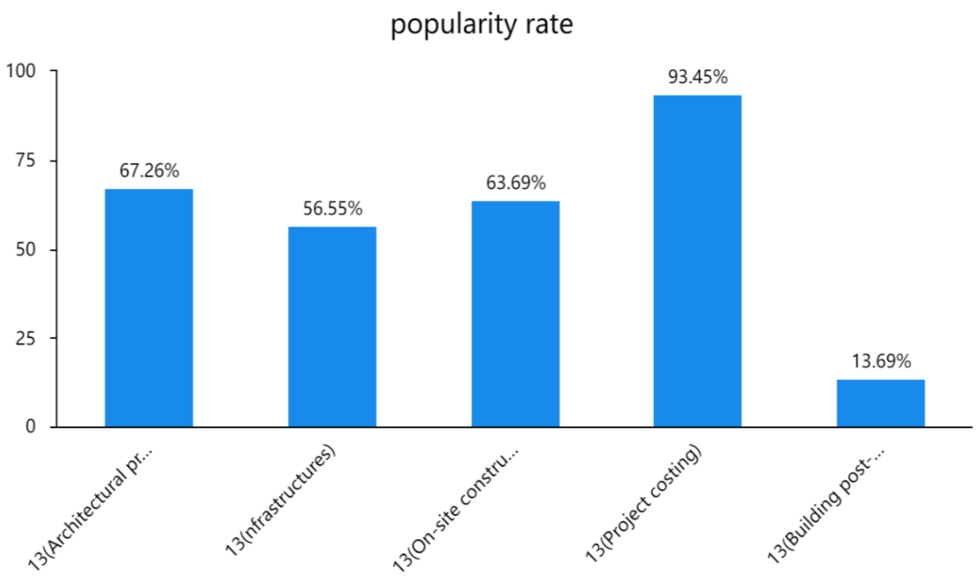

Fig. 2. BIM type

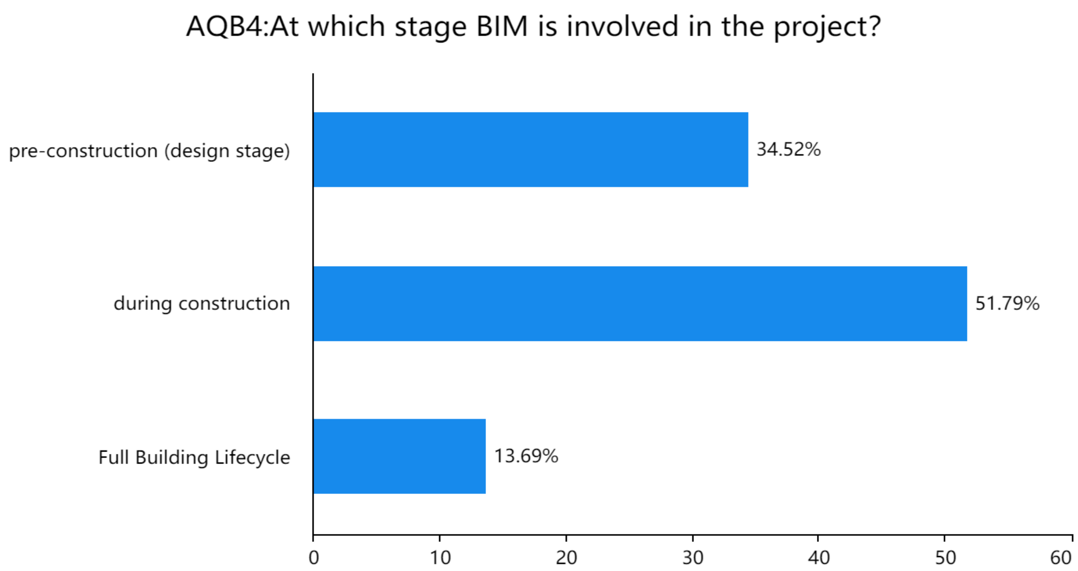

Fig. 3. BIM stage

4.3 Factors Influencing BIM Adoption

4.3.1 Reliability test

The reliability stated in Table 2 shows that the Cronbach's α of each variable is greater than 0.8 except for the effort expectation, but the effort expectation is also greater than 0.7. This indicates that all variables fall within the credible range and suitable for validated factor analysis.

Table 2
The table of Reliability Test

Variables	Questions	Corrected Item-Total Correlation (CITC)	Cronbach's Alpha if Item Deleted	Cronbach's α
PE	PE1	0.664	0.858	0.869
	PE2	0.723	0.833	
	PE3	0.769	0.815	
	PE4	0.737	0.827	
EE	EE1	0.497	0.697	0.738
	EE2	0.607	0.641	
	EE3	0.599	0.637	
	EE4	0.435	0.735	
SL	SL1	0.701	0.826	0.858
	SL2	0.687	0.826	
	SL3	0.726	0.813	
	SL4	0.715	0.815	
FC	FC1	0.727	0.862	0.886
	FC2	0.753	0.853	
	FC3	0.745	0.855	
	FC4	0.780	0.842	
GG	GG1	0.641	0.779	0.822
	GG2	0.602	0.796	
	GG3	0.617	0.789	
	GG4	0.725	0.739	
MA	MA1	0.618	0.794	0.823
	MA2	0.689	0.757	
	MA3	0.638	0.786	
	MA4	0.664	0.769	
BI	BI1	0.702	0.844	0.869
	BI2	0.705	0.839	
	BI3	0.723	0.831	
	BI4	0.764	0.815	
UB	UB1	0.661	0.810	0.840
	UB2	0.762	0.757	
	UB3	0.604	0.826	
	UB4	0.703	0.793	

4.3.2 Validation factor analysis

Using AMOS software to model according to the theoretical model mentioned above, the Confirmatory factor analysis model can be obtained as shown in Figure 4. The value of KMO in the KMO and Bartlett's Test after automatic calculation using AMOS is 0.840, which is much greater than 0.5, indicating that the correlation between the variables is excellent. sig is 0.000, which is less than 0.05, which indicates that the variables are not independent and there is a very significant correlation between the variables.

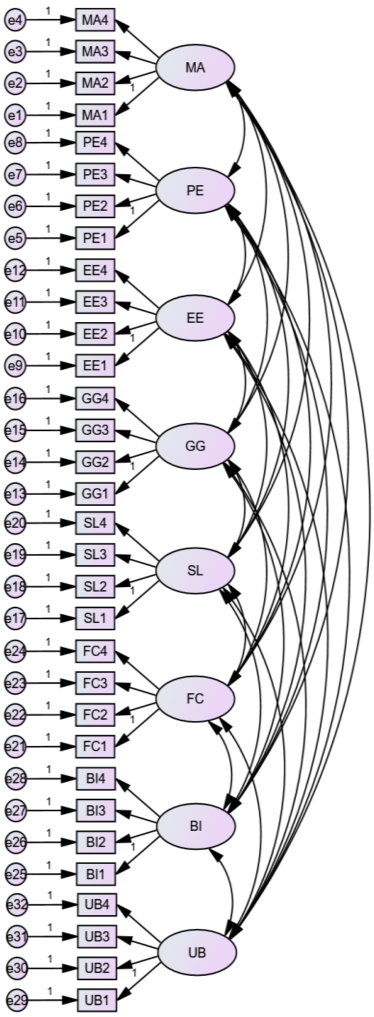

Fig. 4. Confirmatory factor analysis model

For convergent validity test shown in Table 3, the values of Factor loading (Rotated) for each Variables are greater than 0.6, except EE4. While values of AVE are greater than 0.5 except for Variable EE. Thus, it can be seen that the convergent validity is satisfactory. On the other hand, the value of CR was greater than 0.6 for all Variables, which as a complementary data is good to reconfirm the good consistency of this questionnaire.

Table 3
Test table of convergent validity

Variables	Questions	Factor loading (Rotated)	AVE	CR
PE	PE1	0.73	0.631	0.872
	PE2	0.799		
	PE3	0.831		
	PE4	0.814		
EE	EE1	0.631	0.433	0.609
	EE2	0.746		
	EE3	0.702		
	EE4	0.531		
SL	SL1	0.755	0.609	0.861
	SL2	0.772		
	SL3	0.818		
	SL4	0.775		

FC	FC1	0.783	0.661	0.886
	FC2	0.81		
	FC3	0.799		
	FC4	0.857		
GG	GG1	0.749	0.543	0.825
	GG2	0.669		
	GG3	0.676		
	GG4	0.841		
MA	MA1	0.686	0.549	0.829
	MA2	0.793		
	MA3	0.749		
	MA4	0.732		
BI	BI1	0.757	0.630	0.872
	BI2	0.767		
	BI3	0.806		
	BI4	0.842		
UB	UB1	0.709	0.589	0.850
	UB2	0.893		
	UB3	0.651		
	UB4	0.795		

For discriminant validity test, the square root value of AVE for all variables was greater than the maximum value of the absolute value of the inter-factor correlation coefficients as shown in Table 4, so there was good discriminant validity among all variables in this investigation.

Table 4
Test table of discriminant validity

	PE	EE	SL	FC	GG	MA	BI	UB
PE	0.794							
EE	0.505	0.658						
SL	0.371	0.531	0.780					
FC	0.417	0.289	0.291	0.813				
GG	0.281	0.320	0.203	0.228	0.737			
MA	0.170	0.053	0.058	0.155	0.232	0.741		
BI	0.517	0.579	0.505	0.244	0.369	0.126	0.794	
UB	0.310	0.170	0.250	0.320	0.164	0.243	0.301	0.768

Note: Diagonal blue numbers are AVE square root values

4.3.3 Structural equation model test

The corresponding structural equation models were drawn using AMOS software based on the results of the theoretical model and factor analysis presented in the previous section, as shown in Figure 5.

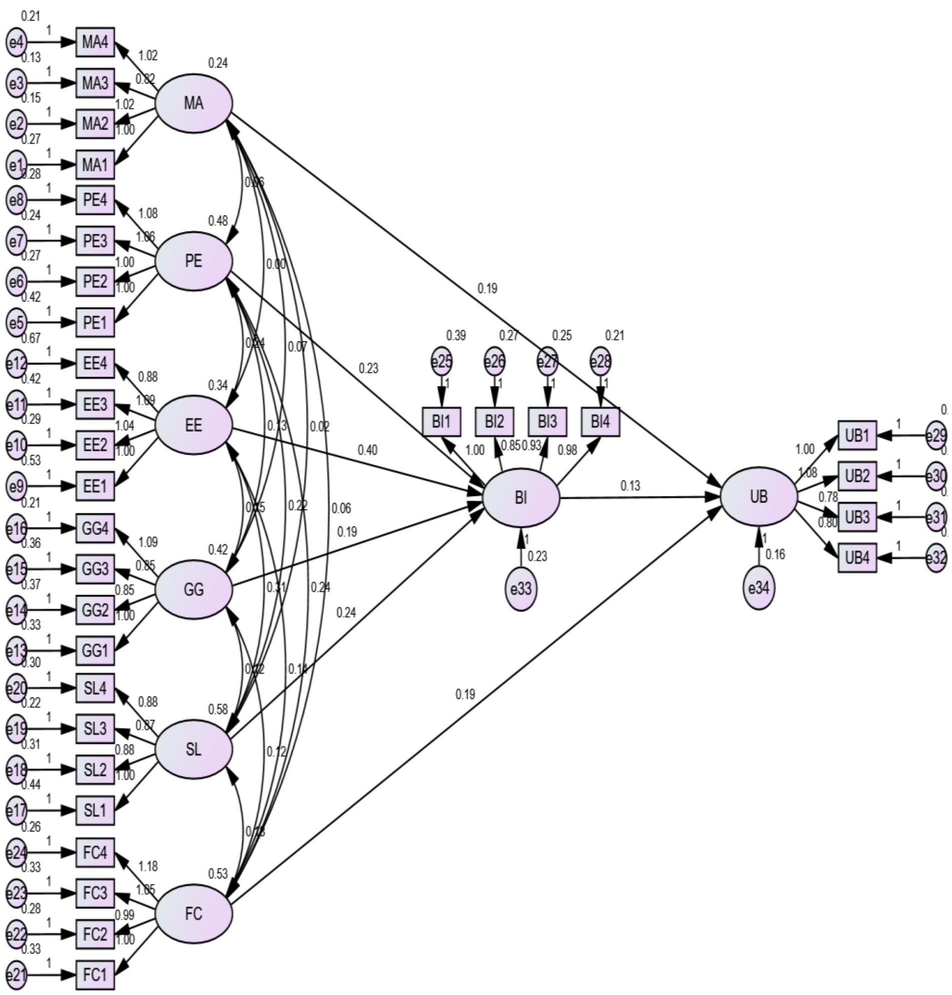

Fig. 5. Structural equation model test

Table 5 shows the Standardized path coefficient of the model. In general, when P is less than 0.05, it means that the path is significant. For this study, all paths have CR values greater than 2 and all P values are less than 0.05, so all paths are significant, which can also mean that all hypothesized paths are valid.

Table 5
Standardized path coefficient table of final model

Path			Estimate	S.E.	C.R.	P
BI	<---	PE	0.227	0.096	2.358	0.018
BI	<---	EE	0.403	0.178	2.268	0.023
BI	<---	GG	0.192	0.087	2.219	0.027
BI	<---	SL	0.239	0.104	2.298	0.022
UB	<---	MA	0.188	0.081	2.312	0.021
UB	<---	FC	0.187	0.058	3.243	0.001
UB	<---	BI	0.125	.055	2.268	0.023

Then comes the model goodness-of-fit test, and the recommended and actual values of the selected parameters are shown in Table 6. As can be seen, all actual values are greater than the Recommended Value, except for the GFI, which is slightly lower, but also has a value of 0.828, which is greater than 0.8. In general, the fit of the model is good, and some of the values are slightly lower than the Recommended Value but are within an acceptable range.

Table 6
Table model goodness-of-fit test

Indicators	PCMIN/df	RMSEA	GFI	IFI	TLI	CFI
Recommended Value	<3	<0.10	>0.9	>0.9	>0.9	>0.9
Actual value	1.389	0.048	0.828	0.936	0.927	0.935

Combining the above results, the final result can be obtained as follows. Behavioral Intention will be influenced by Performance Expectation, Effort Expectation, Generation Gap, and Social Influence, and the degree of influence will be Effort Expectation > Social Influence > Performance Expectation > Generation Gap in descending order. User Behavior will be influenced by Managerial Attitude and Facilitating Conditions and Behavioral Intention, and the degree of influence will be Managerial Attitude> Facilitating Conditions > Behavioral Intention in descending order.

Combining all the relationship hypotheses and test results are summarized, and the hypothesized relationships and test results are summarized as shown in Table 7. As shown in the table, all seven hypotheses originally designed for this study have been tested to be valid.

Table 7
Table hypothetical content and result

Code	Hypothetical content	Results of the test
H1	there is a positive correlation between performance expectation and behavioral intention	valid
H2	there is a positive correlation between effective expectation and behavioral intention	valid
H3	there is a positive correlation between social influence and behavioral intention	valid
H4	there is a positive correlation between generation gap and behavioral intention	valid
H5	there is a positive correlation between behavioral intention and use behavioral	valid
H6	there is a positive correlation between managerial attitude and user behavior	valid
H7	there is a positive correlation between facilitating conditions and user behavior	valid

5.Discussion

5.1 BIM Influencing Factors

In most of the studies on technology adoption, performance expectation has the highest impact on the final adoption intention. It can be concluded that performance expectation will directly affect behavioral intention and indirectly affect use behavior in this study on BIM technology adoption factors. With the analysis, it can also be seen that respondents attach more importance to technical ease of use for instance the simplicity of BIM to operate and learn, and among the four factors that directly affect behavioral. Among the four factors that directly affect behavioral intention, effective expectation has the greatest influence. This implies that users or potential users of BIM technology are more inclined to learn the technology that is easy to use and can be mastered with less time and effort.

For BIM software developers, it is suggested that they need to optimize the software according to the personal habits of Chinese cost engineering practitioners. It is necessary to make the software more in line with the local habits and logic of thinking. the improvement of these aspects will drive the promotion speed of the whole BIM technology.

Social influence is the second most influential factor affecting behavioral intention in this study. In China, most of the BIM software used to calculate project quantity differs in each region. Similar approach applied to the list of the project materials. Thus, it causes interchangeability for the BIM user in the case where the work is scheduled in other provinces, they will have to adapt to local team setup. In addition, the Chinese government's strong promotion of BIM technology in recent years and the use of BIM by the head enterprises in China's construction industry have proven the advantages of BIM adoption. Thus, social influence is an important driving factor to influence the adoption of BIM technology by enterprises.

Since the degree of BIM promotion is different among different provinces in China at this stage, and the preferred BIM software is different across provinces, the government side should consider how to solve these problems when revising the new BIM promotion policy. The government should use the policy to let various BIM software developers strengthen the connection between different software for better interoperability and compatibility.

The influence of generation gap is the smallest, probably because most of the respondents in this study are young people who have worked for less than 10 years. For users of different age groups with different working experience, each of them has different ideas about using BIM technology. However, from other researchers' studies on the effect of age on job performance, it is also clear that older workers are more likely to favor conservative technologies and rarely take the initiative to convert to new technologies.

The facilitating conditions directly affects user behavior, which is second highest impact on user behavior. This indicates that most respondents believe that they would be more willing to use BIM technology if they could easily use BIM software and learn professional BIM technology. At present, most of the BIM technologies or software in China require high professional licensing fees, which are too expensive for many individual users or students who want to learn BIM technology. In addition, high cost of professional training for BIM technology also discourages many people learn more on BIM technology. For most who want to learn professional BIM technology can have free online option but with low quality and fragmented public courses. This option does not provide systematic learning practice and theory. The government or enterprises need to communicate with BIM software developers to solve the high licensing fees of BIM, so that more people can afford to buy genuine BIM software on their own computers. Availability of training courses may solve the issues on facilitating conditions for successful adoption.

The factors affecting BIM adoption can be divided according to different groups; namely user, Government, Company and Software developer are four different groups of influencing factors. Suggestions are made for users to enhance their awareness of self-learning BIM, the government's policies should make the practitioners experience the advantages of adoption BIM, cost engineering companies should invest more on BIM technology education and training, and developers of BIM software should enhance the direct compatibility of different software and simplify the difficulty of operation.

6. Conclusion

This study investigates the awareness and BIM acceptance for cost engineering industry in non-economically developed areas of China. From the descriptive analysis, it can be seen that the current progress of BIM promotion in non-economically developed regions of China is rather not positive. This is mainly due to the fact that most practitioners have poor awareness on BIM and have no willingness to learn new knowledge on their own initiative. At the same time, they do not care much on BIM policy advocated by the government, but they will only recognise the relevant BIM policy when the company project requires them.

Although the perception of BIM in the cost engineering practitioners in Guangxi is relatively high, it only concern the learning and using BIM technology because it is either work or school related. Meanwhile, in the cost engineering industry, the practitioners in Guangxi that use BIM technology to complete the whole project is still small, 55% of the users think that only 0-20% of the work in the project uses BIM technology. A 30% of the users think that only 20%-40% of the work uses BIM technology. BIM was identified to be mainly used during construction and pre-construction, while only little mentioned the use on building maintenance throughout the life cycle of the construction project. This also shows that in China's non-economically developed regions, the main application stages of BIM are design, cost calculation and construction process.

In terms of influencing factors affecting BIM adoption, this study analyzes the modeling with the UTAUT model, and it can be concluded that Behavioral Intention are affected by Effort Expectation, Social Influence, Generation Gap Performance Expectation accordingly. Meanwhile, Use Behavioral is influenced by Managerial Attitude, Facilitating Conditions and Behavioral Intention which is in order of the highest factor. This study provide some reference for managers in the cost engineering industry when formulating strategies for using BIM to achieve more effective BIM adoption and promotion.

Acknowledgement
This research was funded by a short term grant from Universiti Sains Malaysia with Project Code: 304/PPBGN/6313092

References
[1] EMIS, China Construction Sector Report 2022 1st Quarter (na:EMIS Insights, 2022)
[2] MOHURD, *Several Opinions of the Ministry of Housing and Urban-Rural Development on Promoting the Development and Reform of the Construction Industry*, MOHURD. Jianshi [2014] No 92, Jianshi: MOHURD, 2014. https://www.mohurd.gov.cn/gongkai/fdzdgknr/tzgg/201407/20140708_218403.html
[3] Wang, Dan, Terh Jing Khoo, and Zhangfei Kan. "Exploring the Application of Digital Data Management Approach for Facility Management in Shanghai's High-rise Buildings." *Progress in Energy and Environment* 13 (2020): 1-15.
[4] Nabil, Meftah, and Mahri Zine Labidine. "Application Efficiency Measures Through TRNSYS Software on Algerian Building to Save Energy." *Journal of Advanced Research in Fluid Mechanics and Thermal Sciences* 93, no. 2 (2022): 160-172. https://doi.org/10.37934/arfmts.93.2.160172
[5] MOHURD. "Notice of the Ministry of Housing, Urban and Rural Development on the Issuance of the Outline of the Development of Information Technology in the Construction Industry from 2016 to 2020." Ministry of Housing and Urban-Rural Development of the People's Republic of China , MOHURD, 23 Aug. 2016,
[6] Jin, Ruoyu, Craig Hancock, Llewellyn Tang, Chao Chen, Dariusz Wanatowski, and Lin Yang. "Empirical study of BIM implementation–based perceptions among Chinese practitioners." *Journal of management in engineering* 33, no. 5 (2017). https://doi.org/10.1061/(ASCE)ME.1943-5479.0000538
[7] Ma, Guofeng, Jianyao Jia, Jiyong Ding, Shanshan Shang, and Shan Jiang. "Interpretive structural model based factor analysis of BIM adoption in Chinese construction organizations." *Sustainability* 11, no. 7 (2019): 1982. https://doi.org/10.3390/su11071982
[8] Aibinu, Ajibade, and Sudha Venkatesh. "Status of BIM adoption and the BIM experience of cost consultants in Australia." *Journal of professional issues in engineering education and practice* 140, no. 3 (2014): 04013021. https://doi.org/10.1061/(ASCE)EI.1943-5541.0000193
[9] Olanrewaju, Oludolapo Ibrahim, Ahmed Farouk Kineber, Nicholas Chileshe, and David John Edwards. "Modelling the relationship between Building Information Modelling (BIM) implementation barriers, usage and awareness on building project lifecycle." *Building and Environment* 207 (2022): 108556. https://doi.org/10.1016/j.buildenv.2021.108556
[10] Stephen A. Jones and Harvey. M. Bernstein. "The business value of BIM in China." *Dodge Data and Analytics, Research and Analytics, Bedford, MA, USA* (2015).

[11] Wang, Zhimin, and Jianjun Ma. "Understanding the effects of BIM implementation in corporation finance: An empirical study in China." *Organization, Technology and Management in Construction: an International Journal* 13, no. 2 (2021): 2484-2495. https://doi.org/10.2478/otmcj-2021-0028
[12] Jiang, Bo, Rana Raheel Afzal Khan, Ahmed Vian, and Zhijun Cheng. "BIM implementation in China: A case study approach." (2015). https://doi.org/10.2991/icitmi-15.2015.186
[13] Zhang, Kefei, and Jing Jia. "Promotion of the Application of BIM in China—A BIM-Based Model for Construction Material Recycling." *Recycling* 6, no. 1 (2021): 16. https://doi.org/10.3390/recycling6010016
[14] Jin, Ruoyu, Llewellyn Tang, and K. Fang. "Investigation into the current stage of BIM application in China's AEC industries." *WIT Transactions on The Built Environment* 149 (2015): 493-503. https://doi.org/10.2495/BIM150401
[15] Ahn, Euisoon, and Minseok Kim. "BIM awareness and acceptance by architecture students in Asia." *Journal of Asian Architecture and Building Engineering* 15, no. 3 (2016): 419-424. https://doi.org/10.3130/jaabe.15.419
[16] Lee, Yong-Cheol, Charles M. Eastman, and Wawan Solihin. "Rules and validation processes for interoperable BIM data exchange." *Journal of Computational Design and Engineering* 8, no. 1 (2021): 97-114. https://doi.org/10.1093/jcde/qwaa064
[17] Lin, Yu-Cheng, and Hui-Hsuan Yang. "A framework for collaboration management of BIM model creation in architectural projects." *Journal of Asian Architecture and Building Engineering* 17, no. 1 (2018): 39-46. https://doi.org/10.3130/jaabe.17.39
[18] Tan, Tan, Ke Chen, Fan Xue, and Weisheng Lu. "Barriers to Building Information Modeling (BIM) implementation in China's prefabricated construction: An interpretive structural modeling (ISM) approach." *Journal of Cleaner Production* 219 (2019): 949-959. https://doi.org/10.1016/j.jclepro.2019.02.141
[19] Zhang, L., Y. Li, and Y. Gao. "Barrier and countermeasures of the BIM application in China." *Journal of Civil Engineering and Management* 30, no. 3 (2013): 65-69.
[20] Xu, Huier, Jingchun Feng, and Shoude Li. "Users-orientated evaluation of building information model in the Chinese construction industry." *Automation in construction* 39 (2014): 32-46. https://doi.org/10.1016/j.autcon.2013.12.004
[21] Son, Hyojoo, Sungwook Lee, and Changwan Kim. "What drives the adoption of building information modeling in design organizations? An empirical investigation of the antecedents affecting architects' behavioral intentions. "*Automation in construction* 49 (2015): 92-99. https://doi.org/10.1016/j.autcon.2014.10.012
[22] Zhang, Ruixue, Yuyan Tang, Liang Wang, and Zeyu Wang. "Factors influencing BIM adoption for construction enterprises in China." *Advances in Civil Engineering* 2020 (2020). https://doi.org/10.1155/2020/8848965
[23] Venkatesh, Viswanath, Michael G. Morris, Gordon B. Davis, and Fred D. Davis. "User acceptance of information technology: Toward a unified view." *MIS quarterly* (2003): 425-478. https://doi.org/10.2307/30036540
[24] Foon, Yeoh Sok, and Benjamin Chan Yin Fah. "Internet banking adoption in Kuala Lumpur: an application of UTAUT model." *International Journal of Business and Management* 6, no. 4 (2011): 161. https://doi.org/10.5539/ijbm.v6n4p161
[25] Li, Jing, Jia-Le Liu, and Huan-Yong Ji. "Empirical study of influence factors of adaption intention of mobile payment based on TAM model in China." *International Journal of u-and e-Service, Science and Technology* 7, no. 1 (2014): 119-132. https://doi.org/10.14257/ijunesst.2014.7.1.12
[26] Stapor, Katarzyna. "Descriptive and inferential statistics." In *Introduction to Probabilistic and Statistical Methods with Examples in R*, pp. 63-131. Springer, Cham, 2020. https://doi.org/10.1007/978-3-030-45799-0_2
[27] Cronbach, Lee J. "On estimates of test reliability." *Journal of Educational Psychology* 34, no. 8 (1943): 485. https://doi.org/10.1037/h0058608
[28] Cronbach, Lee J., and Paul E. Meehl. "Construct validity in psychological tests." *Psychological bulletin* 52, no. 4 (1955): 281. https://doi.org/10.1037/h0040957
[29] Byrne, Barbara M. *Structural equation modeling with Mplus: Basic concepts, applications, and programming*. routledge, 2013. https://doi.org/10.4324/9780203807644
[30] Fan, Yi, Jiquan Chen, Gabriela Shirkey, Ranjeet John, Susie R. Wu, Hogeun Park, and Changliang Shao. "Applications of structural equation modeling (SEM) in ecological studies: an updated review." *Ecological Processes* 5, no. 1 (2016): 1-12. https://doi.org/10.1186/s13717-016-0063-3
[31] Bagozzi, Richard P., and Youjae Yi. "On the evaluation of structural equation models." *Journal of the academy of marketing science* 16, no. 1 (1988): 74-94. https://doi.org/10.1007/BF02723327
[32] Wang, Kai, Ying Xu, Chaolong Wang, Ming Tan, and Pingyan Chen. "A corrected goodness-of-fit index (CGFI) for model evaluation in structural equation modeling." *Structural Equation Modeling: A Multidisciplinary Journal* 27, no. 5 (2020): 735-749. https://doi.org/10.1080/10705511.2019.1695213
[33] Wu, Xiaoli, and Wenbo Kuang. "Exploring influence factors of WeChat users' health information sharing behavior: Based on an integrated model of TPB, UGT and SCT." *International Journal of Human–Computer Interaction* 37, no. 13 (2021): 1243-1255. https://doi.org/10.1080/10447318.2021.1876358

[34] Venkatesh, Viswanath, James YL Thong, and Xin Xu. "Unified theory of acceptance and use of technology: A synthesis and the road ahead." *Journal of the association for Information Systems* 17, no. 5 (2016): 328-376. https://doi.org/10.17705/1jais.00428

[35] Kijsanayotin, Boonchai, Supasit Pannarunothai, and Stuart M. Speedie. "Factors influencing health information technology adoption in Thailand's community health centers: Applying the UTAUT model." *International journal of medical informatics* 78, no. 6 (2009): 404-416. https://doi.org/10.1016/j.ijmedinf.2008.12.005

[36] Jin, Ruoyu, Craig Matthew Hancock, Llewellyn Tang, and Dariusz Wanatowski. "BIM investment, returns, and risks in China's AEC industries." *Journal of Construction Engineering and Management* 143, no. 12 (2017). https://doi.org/10.1061/(ASCE)CO.1943-7862.0001408

[37] Reed, Andrew E., Joseph A. Mikels, and Kosali I. Simon. "Older adults prefer less choice than young adults." *Psychology and aging* 23, no. 3 (2008): 671. https://doi.org/10.1037/a0012772