Research on the Obstacles and Countermeasures of the Construction Unit Based on SEM for the Development of BIM Technology

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Abstract. As the mainstream technology of China's construction industry in the future, BIM has the advantages of multi-dimensional display and information sharing compared with traditional methods, and is recognized as the future trend of the construction industry, but the current development of BIM technology in China's construction units is not ideal, and there are many obstacles, so through the research of scholars at home and abroad, a total of 16 construction units are summarized from the policy, economic and personnel aspects of the obstacles to the development of BIM technology, and the weight calculation is carried out through factor analysis and structural equation. Put forward feasible suggestions for the promotion of BIM technology in construction units.

Keywords: BIM, Structural Equations, Construction Units, Hindrances

1 INTRODUCTION

The economic, environmental, and societal impact of major architectural projects highlights the need to study the challenges that affect their performance and completion. Building Information Modeling (BIM) is a critical tool for enhancing project completion in the AEC field and has been widely used globally, especially in major projects[1].BIM technology is based on 3D modeling, which is not just a 3D model but a digital representation of the building's geometric shape, physical, and functional characteristics.

2 DOMESTIC AND INTERNATIONAL DEVELOPMENT TRENDS AND CURRENT STATUS OF BIM TECHNOLOGY

Nowadays, BIM technology has been widely used and promoted both domestically and internationally. Internationally, many developed countries have already adopted BIM

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technology as a standard tool for architectural design, construction, and facility management. These countries include the United States, the United Kingdom, Australia, Singapore, and others. However, compared to developed countries, China still faces certain gaps and challenges in some aspects of BIM technology.The BIM technology has been introduced from abroad to China, and our country has made considerable progress in many aspects. However, we have not been able to achieve the successful application of BIM technology throughout the entire life cycle of engineering projects like developed countries abroad. Many scholars in China have conducted investigations and analyses on this issue. Currently, the main obstacles encountered in the promotion of BIM technology in construction units in China are reflected in the following areas.

3 OBSTACLES TO DOMESTIC BIM TECHNOLOGY IN CONSTRUCTION UNITS

At present, there are abundant research results on the barriers to the promotion and application of BIM at home and abroad, but the influence relationship and causality between various factors are seldom considered from the perspective of the whole construction unit. By analyzing and summarizing the factors mentioned in the above literature, this paper summarizes and concludes 20 major obstacles affecting the promotion and development of BIM technology in domestic construction units (as shown in Table 1), and marks each aspect of the factors as A1, A2, A3...A14, A15, and A20 respectively.

Table 1. Indicator Statistics of Factors Affecting the Promotion of BIM Technology in Construction Units

Factor category	marking	Specific influencing factors	bibliography
Policy factor	A1	Lack of relevant BIM standards	[1][2][4][6][7][8][9][10][12][14][18]
	A2	Lack of policy incentives and guidance	[1][3][7][8][13][14][15][18]
software factor	A3	Poor interaction between BIM software	[2][4][5][7][8][9][10][12][14][15][16][17][18]
	A4	BIM software is not robust enough	[1][4][7][15][16][17][18]
	A5	Low number of domestic BIM software	[4][6][14][16]
economic factor	A6	High investment costs for hardware and software	[5][6][7][8][9][10][12][13][14][15][16][17][18]
	A7	BIM technology inputs not proportional to outputs	[1][6][7][8][10][12][14][15][16][17][18]
BIM Personnel Factors	A8	Low level of BIM technicians	[8][10][11][14][16]
	A9	Fixed thinking and exclusion	[3][5][6][7][8][14][16][18]
	A10	Increased workload of staff	[5][7][12][16]
	A11	Insufficient knowledge of BIM technology	[1][2][4][8][10][12][16][18]
	A12	Lack of BIM talents	[1][2][3][8][9][10][12][16][17][18]
Management factors	A13	Low acceptance of BIM technology by construction organizations	[4][8][9][10][15][17]
	A14	Low level of synergy among the parties involved	[4][7][8][9][10][12][15][16]
	A15	Failure to establish a sound BIM workflow	[5][6][7][9][11][12][14][16]
Industry-related factors	A16	Lack of legal provisions to protect BIM models	[5][6][8][10][13][14][15][16][18]
	A17	Low participation and motivation of market players	[6][8][10]
	A18	BIM industry chain is not perfect	[8][16]
	A19	Lack of BIM success stories in China	[3][8][14][16][17]
	A20	Lack of relevant BIM education and training	[2][5][8][14][16][17]

In order to reduce the limitations of the measurement system, indicators with a statistical frequency of occurrence of less than 4 in the journals in which they appear are excluded. Due to the industry background of construction units in China's construction field, in-depth interviews involving relevant practitioners were conducted and summarized.Based on the existing research, this paper combines the actual project BIM technology application environment, and further summarizes the 20 measurement indicators into six dimensions: policy factors, software factors, economic factors, BIM personnel factors, management factors, and industry factors. Figure 1 shows the measurement system of construction unit's hindering factors for the development of BIM technology constructed in this paper.

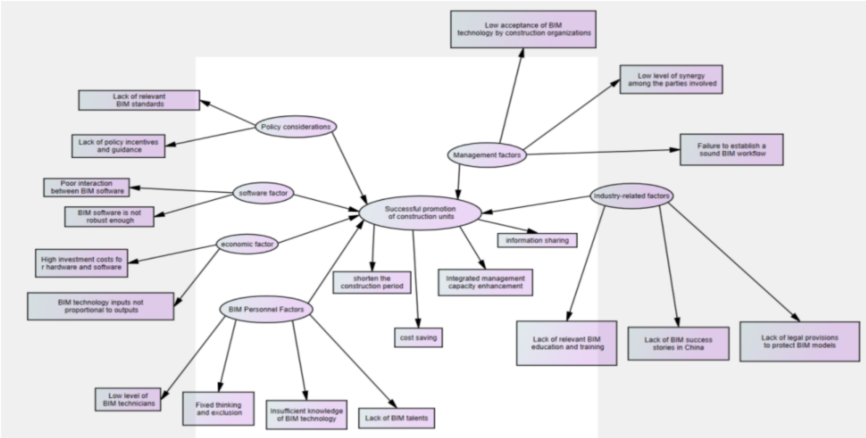

Fig. 1. Constructors' impediments to the development of BIM technology

4 DATA ACQUISITION AND ANALYSIS

4.1 Questionnaire Design and Analysis

In order to ensure the scientificity and credibility of the research on the obstacles to the development of BIM technology in the construction unit, a questionnaire was used to obtain relevant data. Firstly, we design the scale of obstacles to the development of BIM technology for construction units, and the generated survey scale is mainly divided into two parts, the first part is the personal background information of the survey respondents; the second part is the evaluation of obstacles to the development of BIM technology for construction units.In addition the questionnaire uses the Likert 5 scale method, which allows the respondents to score the inputs of the degree of influence of each indicator in the questionnaire, where 1 to 5 in descending order represents the importance of each indicator. Table 2 shows the results of the frequency analysis of the questionnaire.

According to the results of the frequency analysis, the participants of this survey showed some diversity in terms of gender, age, education and occupation, with a high percentage of people who were male, aged 18 to 30 years old, with a specialist degree and working in a design unit.

4.2 Reliability and Validity Tests for Data

In order to find out the reliability of the data sample, SPSS 22.0 software was used to conduct the reliability test of the data sample. The reliability test was conducted by Cronbach Alpha reliability analysis,bartlett's Test of Sphericity is carried out as a requirement for the factor analysis to establish whether the correlations between variables are substantially different from zero[21]. It is generally accepted that the Cronbach Alpha reliability score should be at least greater than 0.7 to indicate that the questionnaire has a high level of reliability. Through the reliability analysis of SPSS software, the Cronbach Alpha reliability scores are more stable across different variables. Table 2 shows that the Cronbach Alpha reliability scores of all dimensions are more than 0.7, indicating that the questionnaire has a high degree of reliability.

Table 2. Reliability statistics

variant	Cronbach Alpha	item count
Policy factors	0.833	2
software factor	0.823	2
economic factor	0.842	2
BIM Personnel Factors	0.924	4
Management factors	0.88	3
Industry factors	0.87	3
Successful promotion of construction units	0.904	4

Validity test of the questionnaire with SPSS software, using factor analysis for information condensation research, first analyze whether the research data is suitable for factor analysis, as can be seen from Table 3: KMO is 0.874, which is greater than 0.6, meeting the prerequisite requirements for factor analysis, meaning that the data can be used for factor analysis research. As well as the data passed the Bartlett sphericity test ($p<0.05$), indicating that the research data is suitable for factor analysis.

Table 3. KMO and Bartlett's test

KMO		0.874
Bartlett Sphericity Check	approximate chi-square	2419.606
	df	190
	p	0.000

After testing the reliability and validity of the questionnaire, the reliability and validity of the questionnaire have been tested, indicating that the indicators in the questionnaire better reflect the degree of influence of the construction unit on the various impeding factors for the development of BIM technology, and the questionnaire can be used to carry out the next step of factor analysis.

4.3 Factor Analysis

The use of factor analysis for information enrichment research, first analyze whether the research data is suitable for factor analysis, as can be seen from Table 3: KMO is 0.874, which is greater than 0.6, meets the prerequisite requirements of factor analysis, meaning that the data can be used for factor analysis research. As well as the data passed the Bartlett sphericity test ($p<0.05$), indicating that the research data is suitable for factor analysis.

Table 4. Table of variance explained

Factor number	characteristic root			Explanatory rate of variance before rotation			Post-rotation variance explained		
	characteristic root	Variance explained %	Cumulative %	characteristic root	Variance explained %	Cumulative %	characteristic root	Variance explained %	Cumulative %
1	8.947	44.733	44.733	8.947	44.733	44.733	3.687	18.433	18.433
2	1.817	9.086	53.818	1.817	9.086	53.818	3.151	15.753	34.186
3	1.633	8.164	61.982	1.633	8.164	61.982	2.688	13.438	47.625
4	1.601	8.007	69.989	1.601	8.007	69.989	2.609	13.047	60.671
5	1.135	5.674	75.663	1.135	5.674	75.663	2.083	10.413	71.085
6	1.014	5.068	80.731	1.014	5.068	80.731	1.929	9.647	80.731

The above table analyzes the factor extraction situation and the amount of information extracted from the factors. From Table 4, it can be seen that: the factor analysis extracted a total of 6 factors, the eigenroot value is greater than 1, the variance explained by the rotation of these 6 factors is 18.433%, 15.753%, 13.438%, 13.047%, 10.413%, 9.647% respectively, and the cumulative variance explained by the rotation is 80.731%. rate was 80.731%.

The data in this study were rotated using varimax in order to find out the correspondence between factors and research items. The above table shows the information extraction of the factors for the study items and the correspondence between the factors and the study items, all the study items correspond to a commonality value higher than 0.4, which means that there is a strong correlation between the study items and the factors, and the factors can extract the information effectively.

5 CONSTRUCTION UNIT FOR THE DEVELOPMENT OF BIM TECHNOLOGY HINDERING FACTORS MODEL CONSTRUCTION

Structural equation modeling integrates two statistical methods, factor analysis and path analysis, to study the structural relationship between variables, verify whether the assumptions used to construct the model are reasonable, whether the model is correct, and correct the problems in the model [22].

The measurement model is the relationship between the latent variable and the observed indicator, and its equation is expressed as follows.

$$\begin{aligned} y &= \varphi_y \boldsymbol{\beta} + \boldsymbol{\varepsilon} \\ x &= \varphi_x \boldsymbol{\alpha} + \boldsymbol{\delta} \end{aligned} \tag{1}$$

Where:β is the endogenous latent variable; α is the exogenous variable; y is the vector consisting of endogenous observed variables; x is the vector consisting of exogenous observed variable.φ_y, φ_x are the factor loading matrices of the indicator variables y and x, respectively $\varepsilon, \delta$are the error terms of the latent variables.

$$\beta = A\beta + B\alpha + \gamma \tag{2}$$

Where:A is the effect coefficient of the interaction between endogenous latent variables:B is the path coefficient of the influence of exogenous latent variables on endogenous latent variables is the unexplainable part of the variables and the relationship between variables.According to the path coefficients obtained from the AMOSS22.0 calculation, the weight coefficients of each transformation content are calculated, and the calculation of the weight coefficients of the main hierarchy is shown in equation (3).

$$\boldsymbol{\beta_i} = \frac{\boldsymbol{\lambda_i}}{\sum_{i=1}^{n} \boldsymbol{\lambda_i}} \tag{3}$$

where β_i refers to the weight coefficient of the main hierarchy and λ_i is the path coefficient of the main hierarchy.

5.1 Modeling Research Assumptions

Based on a review of the literature related to the construction unit's impediments to the development of BIM technology, combined with the establishment of the established structural equation modeling, this paper proposes the following hypotheses:

H1：Policy factors positively correlate the impact of successful promotion of BIM technology in construction organizations;

H2：Software factors positively correlate the impact of successful promotion of BIM technology in construction organizations;

H3：Economic factors positively correlate the impact of successful promotion of BIM technology in construction organizations;

H4：BIM personnel factors positively correlate the impact of successful promotion of BIM technology in construction organizations;

H5：Management factors positively correlate the impact of successful promotion of BIM technology in construction organizations;

H6：Industry factors positively correlate the impact of successful promotion of BIM technology in construction organizations.

5.2 Validation Factor Analysis

Based on the measurement system shown in Figure 1 and the research hypotheses in the model, AMOSS22.0 software was used to establish a research model of the construction unit's impediments to the development of BIM technology.

The model of construction unit's impediments to the development of BIM technology is tested for fitness through the indicators of GFI, AGFI, RMSEA, NFI, IFI, CFI, RFI, CMIN/df, and PGFI. The results of the model fitness test obtained through the software are shown in Table 5, and the model path coefficients and their significance test results are shown in Table 6. From Table 5, it can be seen that each fitness index meets the requirements, indicating that the model matches well with the scale, the model fit is high, and the model is valid.

Among the individual paths as shown in Table 6, the standardized path coefficients are as follows and all of them reach the significance level (P<0.05), indicating that all paths have a significant positive impact.

Table 5. model fit

Indicator category	Indicator name	Adaptation Standards	Test results	Acceptability
absolute fitness parameter	GFI	>0.8	0.87	acceptance
	AGFI	>0.8	0.817	acceptance
	RMSEA	<0.08	0.07	acceptance
Value-added fitness parameters	NFI	>0.8	0.895	acceptance
	IFI	>0.8	0.951	acceptance
	CFI	>0.8	0.95	acceptance
	RFI	>0.8	0.866	acceptance
Simple fitness parameter	CMIN/df	<3	1.789	acceptance
	PGFI	>0.5	0.617	acceptance

Table 6. Model path coefficients and significance tests

trails	Standardized path factor	Non-standardized path coefficients	S.E.	C.R.	P
Policy factors→Successful promotion of construction units	0.295	0.402	0.086	4.653	***
software factor→Successful promotion of construction units	0.216	0.322	0.096	3.334	***
economic factor→Successful promotion of construction units	0.12	0.142	0.065	2.17	0.03
BIM Personnel Factors→Successful promotion of construction units	0.225	0.296	0.073	4.026	***
Management factors→Successful promotion of construction units	0.149	0.215	0.076	2.812	0.005
Industry factors→Successful promotion of construction units	0.308	0.469	0.082	5.748	***

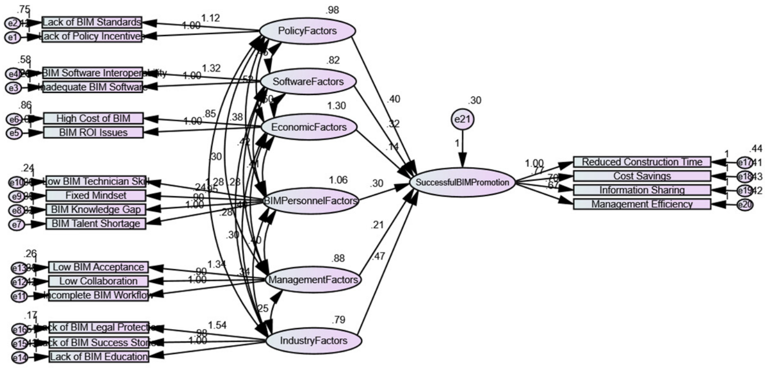

Fig. 2. Modeling of construction units' impediments to the development of BIM technology

The model of construction unit's hindering factors for the development of BIM technology is shown in Fig. 2, and this model is the best-fit model through the model fitness test and significance test.The weighting coefficients of each latent variable and the weighting coefficients of each observed variable on the main hierarchy are summarized by calculating through Equation (3) as follows Table 7.

Table 7. Indicator weights of factors

Level 1 indicators	weights	Secondary indicators	Percentage of level 1 weights
Policy factors	0.225	e1	0.546
		e2	0.454
software factor	0.165	e3	0.509
		e4	0.491
economic factor	0.091	e5	0.583
		e6	0.417
BIM Personnel Factors	0.171	e7	0.251
		e8	0.237
		e9	0.243
		e10	0.269
Management factors	0.113	e11	0.320
		e12	0.316
		e13	0.363
Industry factors	0.235	e14	0.319
		e15	0.303
		e16	0.378

6 CONCLUSIONS AND OUTLOOK

The conclusions of this paper lie in the fact that 1. construction industry organizations can develop and improve industry standards and specifications for BIM technology to provide clear guidance and basis for construction units. 2. software developers can enhance the research and development of BIM software to improve its functionality and ease of use. This study from the construction unit for the development of BIM technology impediments to the perspective of the domestic scholars have been based on the research proposed a new construction unit for the development of BIM technology indicator system, and the use of factor analysis and structural equation method to calculate the weight of each impact indicator, for the promotion of BIM technology in China's construction units to provide a reference. Although this paper has some meaningful conclusions, but there are still some shortcomings, through the questionnaire way of data collection may have a slight gap with the reality of the actual situation, in the follow-up research should be further optimized.

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