Research on Obstacle Factors of Project Operation and Maintenance Based on BIM Technology

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Abstract Building Information Modeling (BIM), as one of the emerging technologies in the development of the construction industry, is tried to be applied in the operation and maintenance of projects. The project operation and maintenance based on BIM technology is limited by various obstacles and has not been widely promoted. By reading relevant literature and combining with expert opinions, this paper has sorted out 13 independent influencing factors from five dimensions of industry, economy, policy, technology, and law. In this study, questionnaire survey and key interview were used to obtain preliminary data. Principal component analysis has been used to reduce the dimension of obstacle factors, and social network has been used to further analyze the centrality of obstacle factors. The data analysis results show that the deep influencing factors that hinder the operation and maintenance of BIM are insufficient technology and lack of policies, while "supervision intensity," "scientific research support," "compatibility," and "integrity" are important factors that hinder the development of BIM operation and maintenance. The results of this study can provide effective reference for the promotion and development of project operation and maintenance based on BIM technology, help improve the maintenance level of building equipment, and promote the efficient and sustainable operation of intelligent buildings.

Keywords BIM · Project operation and maintenance · Obstacle factors · Principal component analysis · Social network analysis

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1 Introduction

The full life cycle of a project usually consists of four stages, including planning, design, construction, operation, maintenance, and abolition. If the project cost is planned according to four stages, the operation and maintenance stage usually accounts for more than 80% of the total cost, far exceeding the use cost of other stages. Thus, it can be seen that the efficient operation of project operation and maintenance can greatly save the use cost. With the continuous maturity of BIM technology in recent years, more and more researchers carry out in-depth research on BIM operation and maintenance. So far, the idea of BIM operation and maintenance has been applied in all aspects [1]. For example, BIM operation and maintenance is applied to the space management of educational office buildings to enable users to observe indoor facility layout and environment through three-dimensional layout drawings [2]. A 3D data cube model is established based on BIM, and a new operation and maintenance data mining method is adopted to improve the data-driven method of operation and maintenance management of large public buildings [3]. The bridge management system based on BIM technology realizes the collaborative management of different users and provides a beneficial platform for the maintenance and management of large bridges in China [4]. The management system of highway tunnel facilities based on BIM specification greatly improves the productivity of highway construction [5]. In spite of this, the BIM operation and maintenance system is still being continuously improved. For example, the establishment of EBS codes suitable for different stages of the project can greatly improve the compatibility of BIM operation and maintenance system [6]. Establish BIM - LCA/lCC framework for information integration and exchange in BIM environment, and overcome functional limitations caused by lack of BIM semantic information [7]. Clarifying the transformation mechanism between BIM and asset information model has also become an indispensable requirement [8]. BIM operations exposed a lot of deficiency in the process of practical application, the use of BIM operations reduced for complex interior design accurate representation, but further increased the difficulty of data processing [9], at the same time, the operational platform plus the lack of information sharing, the lack of specific information collecting channel for project and work [10], the compatibility and integration of BIM itself a limited development of BIM operations [11], and transformation mechanism and classification of BIM ops lack of unified standard, make different project information cannot be Shared to use [12]. BIM-based information modeling has changed the working mode of conventional information and created a new working mode that can change the design and construction industry [13]. However, the research on BIM operation and maintenance still needs to be further advanced, and energy management has become the main direction of BIM operation and maintenance [14]. In view of the current development status of BIM operation and maintenance, this study investigates and studies its main obstacles from five dimensions, namely industry, economy, policy, technology, and law and summarizes its biggest development weaknesses at present.

The remaining part of this paper is organized as follows. In Sect. 2, it makes an in-depth study of the principle of sample collection and sets up the obstacle factors by referring to literature. In Sect. 3, it adopts principal component analysis to reduce the dimension of obstacle factors and reduce the difficulty of data analysis. In Sect. 4, the node centrality of obstacle factors is analyzed by adjacency matrix, and the social network with obstacle factors as nodes is constructed. In Sect. 5, the conclusion is drawn.

2 Research Strategy

2.1 Questionnaire Design

Scientific principle: When promoting the index system of influencing factors of BIM technology-based project operation and maintenance application, rational analysis should be made, combining theory with practice, fully considering the characteristics of passive buildings, so as to objectively reflect the actual situation of BIM operation and maintenance application in all aspects.

Principle of feasibility: The selected evaluation indicators should be quantifiable and easy to collect data, and evaluation procedures and work should be made as simple as possible.

Principle of comprehensiveness: Through repeated comparison, the main factors affecting BIM operation and maintenance are screened out.

2.2 Pre-survey and Improvement of the Questionnaire

In order to conduct a field test on the contents of the survey plan and understand whether the survey work arrangement is reasonable, the team conducted a pre-survey test on the questionnaire. The objects of this survey are designers, and real estate developers from architectural design institutes involved in architecture-related projects. This survey is conducted in the form of offline distribution, mainly for architectural design institutes.

2.3 Obstacle Factors

Industry dimension: degree of emphasis, energy, data sharing.

Technical dimension: compatibility, coding system, integrity.

Economic dimension: research cost, training expenses, revenue cycle.

Legal dimension: laws and regulations, standardization.

Policy dimension: supervision strength, scientific research support.

Technology, economics, policy, legal, and policy obstacles are set up separately, among which obstacles indicators are defined in combination with labels. For example, the compatibility is set as F_4, and the survey results are analyzed by principal component analysis in combination with the questionnaire data.

3 Data Analysis

In practical analysis, when the Kaiser–Meyer–Olkin (KMO) statistic is above 0.8, the effect of factor analysis is generally better. Through the analysis of the questionnaire data in this paper, the KMO value was greater than 0.9 and passed the Bartley ball test with a significance level of 0.00, indicating that the questionnaire had a good structure and can be used for factor analysis (Table 1). The data of this table comes from the analysis of online questionnaire.

3.1 Principal Component Analysis

Based on the questionnaire, the two main components of the obstacle reduction factor are obtained. The detailed meaning of indicators is shown in Table 2.

$$A_1 = 0.655F_1 + 0.626F_2 + 0.738F_3 + 0.493F_4 + 0.699F_5 + 0.445F_6 + 0.690F_{10} + 0.703F_{11} + 0.634F_{12} + 0.721F_{13} \quad (1)$$

$$A_2 = 0.611F_4 + 0.681F_6 + 0.715F_7 + 0.841F_8 + 0.766F_9 + +0.356F_{12} + 0.327F_{13} \quad (2)$$

The cumulative contribution rate of the extracted principal component was more than 70%, component 1 was 60. 547%, and the total cumulative contribution rate was 85. 756%. Principal component 1 for F_1, F_2, F_3, F_5, F_{10}, F_{11}, F_{12}, F_{13}. Principal component 2 was more dependent on F_4, F_6, F_7, F_8, F_9.

Table 1 Bartley ball test

KMO sampling suitability		0.912
	Approximate Chi square	2828.884
Bartlett sphericity test	Degree of freedom	186
	Significant	0.000

Table 2 Node degree centrality

Index	Code name	Barriers	Degree	NrmDegree
1	F_1	Degree of emphasis	48.000	40.000
2	F_2	Synergy	46.000	38.333
3	F_3	Data sharing	58.000	48.333
4	F_4	Compatibility	56.000	46.667
5	F_5	Coding system	44.000	36.667
6	F_6	Integrity	54.000	45.000
7	F_7	Research cost	50.000	41.333
8	F_8	Training expenses	34.000	28.333
9	F_9	Revenue cycle	46.000	38.333
10	F_{10}	Laws and regulations	54.000	45.667
11	F_{11}	Standardization	46.000	38.333
12	F_{12}	Supervision strength	62.000	51.667
13	F_{13}	Scientific research support	62.000	51.667

4 Social Network Analysis

Different from the traditional data analysis, social network focuses on the analysis of the relationship between variables and the impact on the whole network structure. When the input variables are relatively small, the training of neural network is sometimes affected by the input order and has some defects. In order to improve the reliability of data analysis, this paper USES social network to analyze the questionnaire data again.

In this paper, the obstacle indexes that affect BIM operation and maintenance are set as nodes of the social network, and the relevant parameters between each index are set as connections of the neural network. By combining the questionnaire data and using SPSS to analyze the correlation of the questionnaire indicators, BIM operation and maintenance obstacle factors ($[F_1 \sim F_{13}]$) adjacency matrix are obtained. The adjacency matrix of obstacle factors is input into ucinet6 for data analysis. At the same time, the network structure of BIM operation and maintenance is drawn by using Netdraw software, as shown in Fig. 1.

4.1 Point Degree Centrality

The degree centrality of nodes can reflect the communication ability of nodes, the concentration degree of network relations and the communication ability of factors. The greater the point degree center of the factor node, the stronger the communication ability of the node and the closer the connection with other nodes, which is conducive to the construction of a stable network system. The point degree and center degree

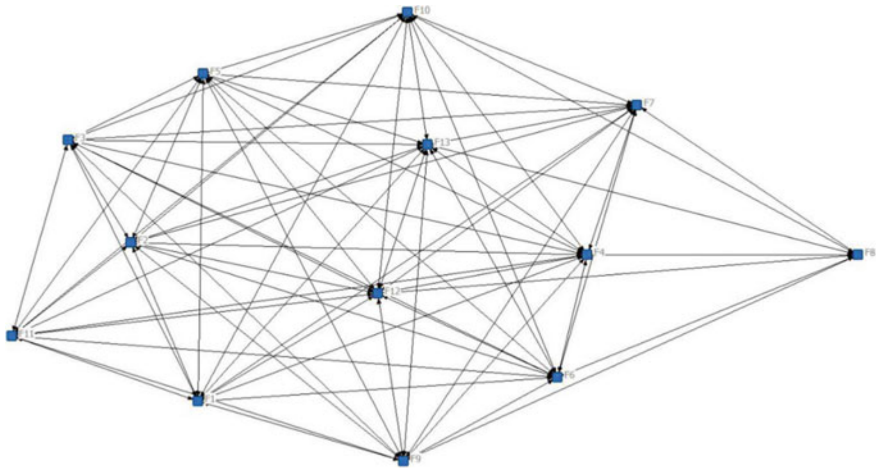

Fig. 1 BIM operation and maintenance obstacles network architecture

of obstacles to BIM + operation and maintenance platform promotion are shown in Table 2.

According to the data analysis results in the table above, the center degree of supervision and scientific research support is the highest, which is most closely related to other indicators, followed by laws and regulations, scientific research cost, data sharing, compatibility and integrity.

The center degree of the seven indexes is above 50, and the average relative point degree is also higher than other indicators, indicating that these seven indicators have a great influence on other indicators. The point degree of centrality only reflects the influence of a single node, and the obstacle factors should be analyzed in combination with other indicators.

4.2 Degree of Mediation Center

The degree of mediation center reflects that a node ACTS as an important medium for other nodes to communicate with each other, helping other nodes to transmit information. Based on the adjacency matrix, this paper analyzes the intermediary degree of obstacles to BIM + operation and maintenance platform promotion (Table 3).

According to the data analysis in the table above, the seven obstacle indicators of scientific research support, integrity, compatibility, supervision, laws and regulations, revenue cycle and research cost have the highest degree of intermediary centers with strong ability to transmit information. The overall data shows that the overall degree of intermediary center is not high, and it still needs to be analyzed in combination with other indicators.

Table 3 Node intermediary centrality

Index	Code name	Barriers	Betweenness	nBetweenness
1	F_1	Degree of emphasis	2.929	1.408
2	F_2	Synergy	2.929	1.408
3	F_3	Data sharing	2.929	1.408
4	F_4	Compatibility	2.929	1.408
5	F_5	Coding system	2.652	1.270
6	F_6	Integrity	2.652	1.270
7	F_7	Research cost	1.634	1.004
8	F_8	Training expenses	0.988	0.289
9	F_9	Revenue cycle	0.934	0.273
10	F_{10}	Laws and regulations	0.912	0.255
11	F_{11}	Standardization	0.561	0.121
12	F_{12}	Supervision strength	0.191	0.021
13	F_{13}	Scientific research support	0.191	0.031

4.3 Proximity Centrality

Proximity centrality refers to the reciprocal of the sum of the shortest distance between a node and other nodes in the network. The greater proximity centrality is, the closer its relationship with a node is, the easier it is to establish a connection. The proximity to the center of obstacles in BIM + operation and maintenance platform promotion is shown in Table 4.

Table 4 Node approaching centrality

Index	Code name	Barriers	Farness	nCloseness
1	F_1	Degree of emphasis	22.000	96.623
2	F_2	Synergy	22.000	96.623
3	F_3	Data sharing	22.000	96.623
4	F_4	compatibility	22.000	96.623
5	F_5	Coding system	28.000	92.308
6	F_6	Integrity	28.000	92.308
7	F_7	Research cost	28.000	92.308
8	F_8	Training expenses	28.000	92.308
9	F_9	Revenue cycle	28.000	92.308
10	F_{10}	Laws and regulations	28.000	92.308
11	F_{11}	Standardization	28.000	92.308
12	F_{12}	Supervision strength	36.000	85.714
13	F_{13}	scientific research support	39.000	70.588

Table 5 Identification of key obstacle indicators

Index	Code name	Barriers	Point degree centrality	Intermediary centrality	Approaching centrality
13	F_{13}	Scientific research support	48.000	2.929	96.623
6	F_6	Integrity	46.000	2.929	96.623
4	F_4	Compatibility	58.000	2.929	96.623
12	F_{12}	Supervision strength	56.000	2.929	96.623

According to the data analysis in the table above, the four indicators of scientific research support, integrity, compatibility, and supervision are close to the maximum centrality.

4.4 Identification of Key Obstacle Indicators Based on Centrality Analysis

Combining the data analysis results of point degree centrality, intermediate degree centrality and proximity degree, the key obstacle indexes were identified. The selected key indicators are in the center of the network structure, which can effectively maintain the stability of the network structure. The key indicators are shown in Table 5.

According to the data in the table above, scientific research support, integrity, compatibility, and supervision are the key obstacle indicators for the development of BIM operation and maintenance. This indicates that the establishment of BIM operation and maintenance platform is especially inseparable from the macro-control of the state, and active scientific and technological research can effectively promote the development of BIM operation and maintenance platform. Netdraw software was used to conduct statistical analysis of the results as shown in Fig. 2.

As shown in Fig. 2 [F_4, F_6, F_7, F_9, F_{10}, F_{12}, F_{13}], the larger the index nodes, it means that these obstacle have a larger weight in the overall core and have a greater impact on the entire network architecture. In network architecture, the connection between each node represents the relevant parameters between each node, and the deeper the connection, the greater the degree of correlation between the two.

5 Conclusion

According to the collected samples, the types of projects managed through BIM + operation and maintenance platform are limited, most of them are public places close

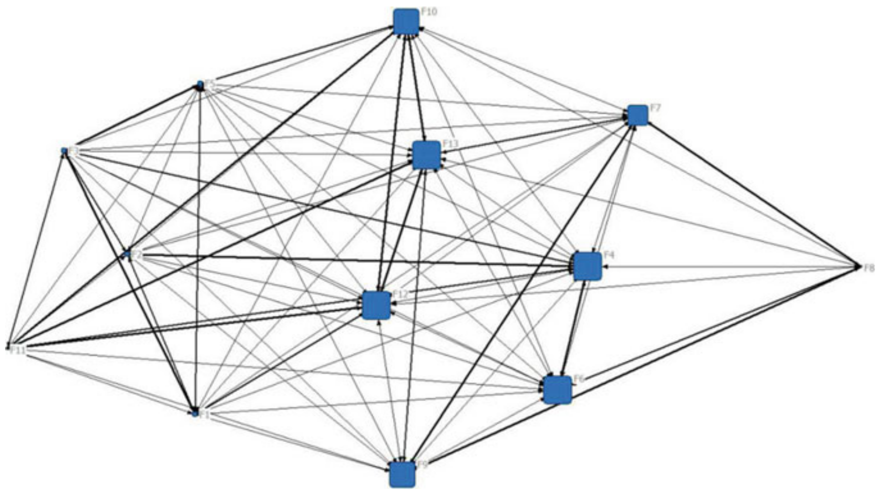

Fig. 2 Analysis of key obstacle indicators

to people's living needs, but seldom involved in the types of using advanced technology such as comprehensive pipe gallery, bridge, and tunnel. More than 80% of the respondents think that the basic operation of BIM + operation and maintenance platform is more complex. Combined with the questionnaire data, this paper analyzes the adjacency matrix of questionnaire data based on social network and analyzes the centrality from three aspects: point centrality, intermediary centrality, and proximity centrality. The three aspects of centrality analysis can take into account the individual and the overall multi angle analysis. From the analysis data of point centrality, intermediary centrality, and proximity centrality, it can be concluded that supervision, scientific research support, integrity and compatibility are the main obstacle indicators for the development of BIM operation and maintenance. The results of data analysis show that the lack of policy and technology has great restrictions on the promotion of BIM operation and maintenance platform.

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