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Analysis of Influencing Factors of Construction Cost Based on Building Information Model

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Abstract: Construction cost is a complex and multi-level system, influenced by many factors. By combining the risk influence factor analysis method with actual cost management, a knowledge graph model of the influencing parameters of construction project cost based on the Building Information Model (BIM) is established. The model includes two types of internal influence factors and external influence factors, focusing on analyzing and establishing the logical relationship between different influencing factors. The aim is to fully explore the influencing factors of construction costs and their cross-influencing relations under different stages and execution subjects, thus helping to realize effective control over the influencing factors of construction costs.

Keywords: Building Information Model (BIM); Project cost; Influencing factors; Knowledge graph

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1. Introduction

The purpose of project cost management is to maximize benefits throughout the entire life cycle of a project, which encompasses stages such as investment decision-making, design, bidding, construction, and completion. Effective identification, analysis, and control of cost factors in engineering projects are essential to ensure project success.

Building Information Model (BIM) has gained widespread adoption throughout the life cycle of engineering projects, offering visualization, coordination, simulation, optimization, and graphing capabilities. Both domestic and foreign experts and scholars have produced significant research outcomes in BIM [1], with research hotspots primarily focusing on model creation, design, construction, and cost management [2-5]. However, there is a general lack of systematic analysis and research on influencing factors.

The concept of geoscience knowledge graphs emerged in the 1990s [6], offering powerful semantic processing and open organizational capabilities, which are essential in the era of digital intelligence. Scholars worldwide have explored the construction, reasoning, and application of such graphs across various domains [7], including hydraulic engineering [8], electric power engineering [9,10], railway systems [11], design [12], drawing review [13], construction [14], and visualization [15].

In light of existing shortcomings and emerging trends, this paper proposes the integration of BIM models and knowledge graphs. Based on practical construction project cost management, it aims to analyze the influencing factors of construction project cost and develop a novel model that integrates BIM and knowledge graphs to address these factors effectively.

2. Decomposition of influencing factors of construction cost based on BIM

Construction cost encompasses the estimated or actual expenses incurred during the construction period of a project. The entire project cost includes various components such as land purchase, design, construction, materials, equipment, labor, management, project risk, and other expenditures. It serves the functions of prediction, evaluation, and control. Real-time monitoring of price fluctuations during the construction process is essential for smooth project execution and effective evaluation.

2.1. Analysis of internal and external influencing factors

Project costs can be categorized into investment estimates, design estimates, revised estimates, construction drawing budgets, project settlements, completion final accounts, and more. Given the extensive duration, involvement of multiple stakeholders, wide-ranging influence, comprehensiveness, and complexity of influencing parameters, factors can be categorized as external or internal. External factors encompass influences across different stages of the project, including social, political, legal, natural, and economic factors. Internal factors, on the other hand, are associated with various stages of project implementation and are divided into six stages: decision-making, investigation and design, bidding, construction, and completion acceptance. These factors span ten categories, totaling thirty-one types.

2.2. Main actors of influencing factors

Construction projects, with their lengthy duration, can be subdivided into independent sub-projects. Cost management throughout the construction project involves various stakeholders, including government departments, owner units, design firms, construction companies, and their collaborative departments. These entities interact with influencing factors and collectively impact the overall project cost direction within a three-dimensional space.

3. Map framework of influencing factors of construction cost integrated with BIM

The framework involves identifying influencing factors of project cost based on BIM, extracting information from influencing parameter objects and establishing the topological relationships between them. Based on this foundation, it correlates, maps, and aligns with the knowledge of the cost impact domain to construct a knowledge graph. This facilitates the analysis, knowledge mining, impact identification, and decision support for construction-related data.

To address the need to identify and evaluate influencing factors of construction project cost, combined with the characteristics of the BIM model and the project construction process, the identification and association of influencing factors, semantic attribute logic mapping, and relationship extraction are conducted in a top-down manner. This process leads to the construction of the knowledge graph framework for influencing factors of construction project cost based on BIM (see **Figure 1**). It primarily consists of three parts: monomer, semantic, and structured components.

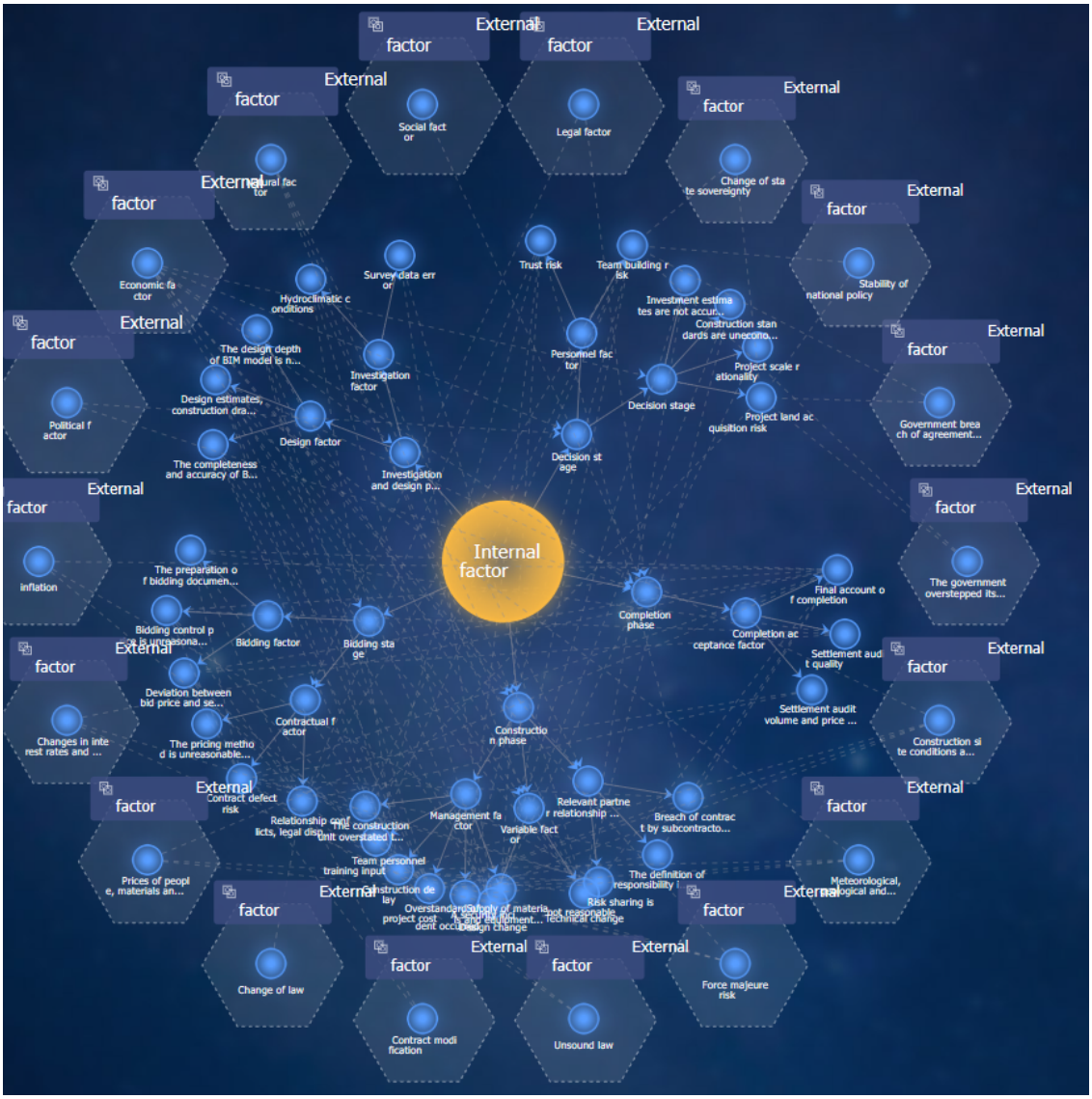

Figure 1. Knowledge map of influencing factors of project cost in different execution stages

3.1. Monomer extraction: influencing factors

Monomer extraction aims to identify various objects within the BIM model that impact costs throughout the project's lifecycle, akin to network nodes in the knowledge graph.

A knowledge graph functions as a structured semantic network, utilizing nodes, relationships, attributes, and other fundamental elements to delineate connections between objects in the physical world [7]. Addressing the actual requirements of construction cost factors, this study synthesizes and incorporates research findings from relevant scholars.

Construction cost factors are categorized into two distinct levels: the execution process and the execution subject. Factors affecting the execution process encompass two categories: external risks, such as political, social, legal, natural, and economic risks prevalent in unstable regions within the contracting market, and internal risks encountered across various project execution stages, including decision-making, survey and design, bidding, construction, and completion.

At the primary level of implementation, influential factors include government bodies, designers, and builders. These factors at both levels interact and are interconnected, collectively influencing fluctuations in

construction costs.

3.2. Semantic extraction: attribute information of influencing factors

Semantic extraction is a method used to transform natural language text data into structured knowledge, effectively integrated through progressive disambiguation.

Based on the identified object set of influencing factors, the information database of the BIM model is utilized to associate, extract, and map relevant information and attributes of the influencing factors. This process links the project's execution subject, working conditions of the execution stage, construction specifications, and experiences from failed project cost controls.

The aim is to identify factors affecting the cost of BIM entity objects throughout the project execution process, establishing a structured data format. Semantic and logical expressions are then employed to obtain a unified dataset of the BIM model.

3.3. Structuralization: semantic network of influencing factors

The structure of the object refers to the adjacency and connectivity between the two different levels of the execution process and the execution subject, as well as the relationship between the project implementation subject and the node, and the relationship between the influencing factors.

Relationship extraction involves identifying connections between entities from the text to discover potential associations among influencing parameters. These relationships serve as the connecting edges linking nodes in the graph. Together with nodes, they form a semantic multi-layered interwoven network structure, illustrating the relationships, mutual influence, and cooperation among influential factors.

3.4. Relationship between influencing factors

Under this two-tier knowledge graph, the hierarchical relationships between different types of influencing factors are clear, as are the relationships between influencing factors at different stages. Additionally, there is a clear correlation and direction between the executive body and various influencing factors. The logical relationships between different types of influencing factors are well demonstrated. This effectively resolves issues such as multiple types of influencing factors, overlapping concerns, and unbalanced distribution of content gaps. The aim is to achieve high-speed and effective control of project costs throughout the entire construction process.

However, during the actual project implementation process, it is crucial to align and optimize all parameters of the above model according to the specific circumstances of the proposed project. This ensures that the model's effectiveness is fully realized.

4. Summary

Through the analysis of construction cost influencing factors based on BIM, this paper primarily accomplishes two objectives:

(1) In consideration of the entire project process, the analysis delves into the influencing factors at each implementation stage. External factors encompass influences across all stages of the project, categorized into 11 factors across five categories: social, political, legal, natural, and economic. Internal factors, on the other hand, are involved in different project stages, categorized into six stages: decision-making, survey and design, bidding, construction, and completion and acceptance. These factors span ten categories, totaling 31 types. Additionally, the analysis examines influencing factors from the

perspective of the executing body, which includes government departments, owner units, design firms, construction companies, and their collaborative departments.

(2) Building upon the analysis of different influencing parameters, a knowledge graph of influencing parameters across different dimensions is established at two levels. These entities are interconnected with influencing factors, collectively influencing the overall project cost direction within a three-dimensional space.

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Disclosure statement

The authors declare no conflict of interest.

References

[1] Zhang H, Gu M, 2018, Research and Application of Intelligent BIM Model Checking Tools. Journal of Information Technology in Civil Engineering and Architecture, 10(2): 1–6.

[2] Mu L, Wang J, Li J, et al, 2019, Research on Fire Intelligent Drawing Review based on BIM and Knowledge Graph. Fire Science and Technology, 2019, 38(12): 1765-1768.

[3] Su W, Wang C, 2023, Research on Key Technologies of Highway Model and Cost Correlation Based on BIM. Highway, 68(2): 189–194.

[4] Miao ZN, 2023, Research on Cost Control Method of Electric Power Engineering Based on BIM Technology. Enterprise Reform and Management, 2023(21): 135–137.

[5] Ke Y, Li W, Hu HB, 2023, Application of BIM Technology in Cost Management of Water Transport Engineering Design Phase. Construction Economy, 44(S2): 332–335.

[6] Xu J, 2010, Conceptual Framework and Representation of Geographic Knowledge Map. Journal of Geo-Information Science, 12(4): 496–502.

[7] Zhou C, 2021, Geoscience Knowledge Graph in the Big Data Era. Scientia Sinica (Terrae), 51(7): 1070–1079.

[8] Liang W, 2021, Application of Knowledge Map Technology in Joint Operation of Water Conservancy Projects in Beijiang River Basin. Heilongjiang Water Science and Technology, 49(12): 187–190.

[9] Qian Q, Shen Y, Liu Z, 2023, Modeling and Evaluation of Cost Risk in the Whole Process of Power Transmission and Transformation Project Based on Grey Theory. Microcomputer Applications, 39(11): 111–113.

[10] Zhou M, Zhao S, Zhu J, 2016, Cost Risk Evaluation of Power Transmission and Transformation Project Based on Support Vector Machine. Journal of Wuhan University of Technology (Information & Management Engineering): 38(2), 187–191.

[11] Lin H, Hu N, He Q, et al, 2024, Construction of a Multi-Modal Knowledge Graph for Railway Equipment Operation and Maintenance Based on Building Information Model Data-Driven Approach. Journal of Tongji University (Natural Science): 52(2), 166–173.

[12] Xie Y, Wang L, Dong C, et al, 2021, Research on the Construction Method of Earthquake Disaster Prevention Knowledge Graph. Science of Surveying and Mapping, 46(10): 219–226.

[13] Liu Y, Wu LT, Liang X, et al., 2020, Research on the Application of Knowledge Graph in BIM Model Review. The Sixth National BIM Academic Conference, 2020: 122–126.

[14] Su P, Huang J, 2023, The Application of BIM Technology in the Field of Engineering Cost Based on Knowledge Graph. Journal of Guangdong University of Technology, 40(2): 103–110 + 119.

[15] Wu Q, Wang W, Hu C, 2023, A Visualization Analysis into the Full Life Cycle Researches of Buildings in China based on Knowledge Graph. Housing Science, 43(4): 50–55.