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Research on the Evaluation of Risk Control Schemes for Engineering Projects under Uncertain Environments

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Abstract: To effectively select risk control schemes in uncertain environments, this paper has proposed an analysis and evaluation method based on the fuzzy comprehensive evaluation method. Firstly, enterprises have adopted the brainstorming method and the Delphi method to identify risks in engineering projects, and organized the identified risks in the form of checklists to facilitate further analysis. Secondly, the fuzzy comprehensive evaluation theory was introduced to determine the comparison matrix of each risk factor and its weight. Furthermore, the top five risk factors in terms of weight ranking were taken as the evaluation factors for the selection of risk control plans. The plans were scored through the weighted scoring method, and the optimal risk control plan was determined based on the score. Finally, the feasibility of the proposed selection technology was verified through A research example of the risk control plan assessment for the construction project of Enterprise A.

Keywords: Engineering projects; Fuzzy comprehensive evaluation method; Uncertain environment; Risk control schemes

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1. Introduction

Engineering projects in the construction industry need to go through stages such as design, planning, construction, and completion acceptance. However, the uncertainty and complexity of the situation have increased the difficulty of risk control in construction projects. During this process, how to effectively carry out risk control before the commencement of engineering projects and how to select the best risk control plan are the key procedures, which are of great significance for the smooth completion of the subsequent stages. The fuzzy comprehensive evaluation method can quantify the identified risks of engineering projects. By constructing a judgment matrix through the fuzzy comprehensive evaluation method, the maximum eigenvalue and eigenvector were calculated as the weights of each risk factor. The risk danger was ranked according to the size of the weights, and the evaluation factors are determined for the selection of risk control plans. Therefore, this paper has proposed the research on the assessment of project risk control schemes based on the fuzzy comprehensive evaluation method in an uncertain environment, further provided enterprises with a risk control scheme centered on project quality and offering a new idea for each enterprise to select the optimal risk control scheme.

Risk management was referred to the need to formulate corresponding contingency plans for the constantly changing risks in the risk prevention process during the management process, ensuring timely response. In the face of new risk issues, timely assessment and evaluation should be conducted, so as to make appropriate adjustments to the risk management emergency plan and ensure that the new plan can be effectively implemented during the construction process. Ensure that there is a complete risk monitoring plan for each stage of the entire project construction to maintain the dynamic and continuous nature of risk prevention throughout the project construction period, thereby achieving the predetermined prevention effect. Risk identification for large-scale projects and classified the risks were conducted, dividing them into technical and non-technical risks, which is of positive significance for the implementation of risk identification [1]. The content of engineering risk quantification and quantified the relevant risks were proposed, which is helpful for identifying the related risks [2]. The inquiry method was adopted to make the risk list by consulting relevant experts [3]. The checklist method was used to confirm the risk factors of actual cases, that is, risk identification [4]. The Analytic Hierarchy Process (AHP) and fuzzy analysis method was employed to assess and analyze project risks [5]. Its advantage lies in the fact that when evaluating project risks, it can meticulously analyze the impact degree of each risk factor on the entire project, enabling targeted measures to be taken.

The main research content of this article is as follows: Firstly, it has analyzed the positive significance of the selection of risk control schemes in enterprise construction projects. Secondly, from the perspective of risk identification, combined with the common risk contents of enterprise construction projects, the common risks in enterprise construction projects were summarized and sorted out by using methods such as brainstorming, Delphi method and checklist method. Furthermore, based on the identified risks, various risks were evaluated and analyzed from different perspectives using the fuzzy Analytic Hierarchy Process, and specific evaluation results were provided. Finally, for the identified risks, as the evaluation factors of the risk control plan, the weighted scoring method was adopted in combination with the actual case A enterprise construction project risk management research. Through the application of the above risk identification, evaluation and analysis as well as the selection of risk control plans, the above research was improved.

2. Selection methods for risk control plans in engineering projects

The main focus in this article was on the assessment of risk control plans during the construction process of ongoing engineering projects. The objective was to adopt scientific and reasonable methods to identify the main risk factors of construction projects, assess and analyze them, and take appropriate control decisions to reduce risks. The existed risks were unable to be completely avoided. Hence, new strategies were required to control them within an acceptable range through scientific management methods [6]. Based on this, a method for selecting risk control schemes for engineering projects was proposed (refer **Table 1**).

(1) In the process of risk identification for construction projects, the brainstorming method was first adopted to have relevant experts and practitioners identify related risks based on the current situation, and then the identified risks were made into a table, which is the risk checklist. Through this checklist, relevant risks were relatively well identified.

(2) Five managers, five technical engineers and five supervision experts with over 10 years of experience in the industry were selected. The Delphi method was used to have the relevant experts evaluate the identified risks. The opinions of the experts were summarized and the risk factors that the experts all

considered to constitute risks were recorded. After the opinions of the experts tend to be consistent, the relevant factors that the experts consider to have a relatively high risk were scored. The scoring was mainly focused on the occurrence probability of the relevant risk factors. Let the above-mentioned experts score the relevant indicators and take the average value to represent it using the 9-level scaling method. After scoring, a first-level comparison matrix was obtained. Through calculation, the first-level comparison matrix yields the scores of relevant risk factors. After meeting the consistency test, the relative importance levels of each risk factor were obtained.

Table 1. Comprehensive evaluation matrix $\boldsymbol{R}=\left(r_{ij}\right)_{N\times M}$ of alternatives

Plan	G_1	G_2	…	G_M
S_1	r_{11}	r_{12}	…	r_{1M}
S_2	r_{21}	r_{22}	…	r_{2M}
…	…	…	…	…
S_N	r_{N1}	r_{N2}	…	r_{NM}

$$b_{ij}=ln\left(1/a_{ij}\right)\ (i=1,2,\dots,N,\quad j=1,2,\dots,M) \tag{1}$$

$$Z_i=\sum_{j=1}^{M}\rho_{\text{nom}j}b_{ij}\ (i=1,2,\dots,N,\quad j=1,2,\dots,M) \tag{2}$$

(3) The standard scale scoring method was used to determine S. This method has usually provided different standard scoring values, such as 1–5 or 1–10 points, and used the size of the score to determine the degree to which the scheme meets the evaluation objective. Based on the weights obtained from the expert evaluation team information, the comprehensive information volume of the alternative plans was calculated, and its calculation formula was shown below.

$$R_i=\sum_{j=1}^{M}Z_i s_{ij}\ (i=1,2,\dots,N,\quad j=1,2,\dots,M) \tag{3}$$

Risk identification was conducted for engineering projects by adopting the brainstorming method. After risk identification, the Delphi method was used to reanalyze the previously determined risks, that is, to quantify the risks. Then, the fuzzy analytic Hierarchy process was used to create a judgment matrix. Finally, the weights were processed to determine the risk level. The optimal risk control plan was selected through the weighted scoring method.

3. Examples and analysis of results

Although the construction project of Company A has involved in the expansion of the company's factory buildings and dormitories, the main project was still a building project. It has similar characteristics to general construction projects and thus has a certain degree of universality. Then, during the risk analysis of the construction project of Company A, general construction project cases was referred to. Meanwhile, the analysis and evaluation research of the risk control plan of the construction project of Company A have provided a reference for the relevant analysis of other construction projects to a certain extent. In accordance with the content of the risk control plan selection method, starting from risk identification, evaluation and analysis. A further analysis of this project was conducted. Based on the relevant contents of risk identification and evaluation analysis, the risk control plan for the construction project of Enterprise A was selected.

(1) From the risk checklist of the engineering project design stage, it was known that during the design stage of the construction project of Company A, this study has focused on identifying the risks of process and flow, technical and usage risks, the rationality of design, the accuracy of background information, and risks related to the working environment. On the basis of these identified risk factors, this study has further refined the analysis.

(2) Due to the excessive number of risk factors proposed by the project team of Company A during the brainstorming session, this study has identified and analyzed these risk factors. By re-analyze the contents of the risk checklist mentioned above through the Delphi method, and select managers, technicians, and supervisors with over 10 years of experience in this industry, risks have been identified. The risk factors that all experts consider to constitute risks have been identified, as shown in **Table 2**.

Table 2. The main risks of engineering projects and the weights

The main risks	Contents of risks	The weights
Materials of equipment	The quality, progress and personnel safety of construction projects are affected due to the substandard construction machinery and building materials	C1 (0.147)
Safety risk	The prevention measures are inadequate and the risk control plan is incomplete	C2 (0.196)
Personnel risk	Insufficient safety awareness among on-site construction workers	C3 (0.657)
Policy risk	Refers to changes in relevant government policies	C4 (0.122)
Financial risk	The risk caused by excessively high procurement costs of materials	C5 (0.558)
Quality management	Materials and equipment were substandard	C6 (0.320)
Contract risk	Risks arise due to loopholes in the contract	C7 (0.494)
Supplier management	Risks arising from suppliers' non-compliance with contracts	C8 (0.266)
Design plan	Implemented in accordance with laws and regulations	C9 (0.240)
Technology	Technologies cannot be utilized	C10 (0.230)
Economic risks	The overall situation of the financial market	C11 (0.648)
The working environment	The climate, water quality and other conditions at the construction site	C12 (0.122)

Based on the relevant analysis of the weight ranking of risk factors, it was concluded in the first-level risk factor indicators that management risk was higher than technical risk, technical risk was higher than construction risk, and construction risk was higher than environmental risk. According to Equation (1) and (2), the most significant risk factors for Company A's construction projects were: technical and operational risks, political risks, contract management, equipment and materials, supplier management, and safety risks.

(3) Considering the actual situation of the engineering project, the expert team has determined three alternative risk control plans for the construction project of Company A and has selected five employee representatives (D1 to D5) from among the numerous employees of Company A to evaluate the three alternative plans. Based on the risk factor analysis and evaluation of the construction project of Enterprise A, it was concluded that the risk factors affecting the project was divided into two layers. The first layer was the project layer, and the second layer was the criterion layer, mainly the specific factors that have an impact on the project. The weight ranking was obtained by the fuzzy comprehensive evaluation method. Select the top five as the key evaluation index factors for the weighted scoring method. Factor set F = {F1: Technology and Application, F2: Policy Risk, F3: Contract Management, F4: Equipment and Materials,

F5: Supplier Management}. The normalized index weight vector was obtained by using the improved weighted average method as $\tilde{\boldsymbol{n}}_{\text{norm}} = (0.20,\quad 0.14,\quad 0.22,\quad 0.31,\quad 0.13)$.

(4) The expert team thoroughly analyzed the existing scheme information. Five experts have reviewed the initial design values of the scheme to obtain the evaluation values. The experts have obtained the relative weights of each expert through voting. Based on the expert weights, the comprehensive evaluation values were obtained to construct the evaluation matrix (**Table 3**).

Table 3. The evaluation information of five alternatives

	R_1	R_2	R_3
D_1	0.46	1.00	0.76
D_2	1.00	1.00	0.77
D_3	0.38	1.00	0.73
D_4	0.63	1.00	0.83
D_5	0.00	0.00	1.00

Based on Equation (11), the comprehensive assessment values of the alternative risk control plan for this project were obtained as: $R_1 = 2.57$, $R_2 = 3.54$, $R_3 = 3.53$. Therefore, R_2 was the optimal risk control scheme.

To further verify the effectiveness of the method, after the enterprise applied the results and analyzed the feedback information from the project implementation department, the results were recognized. The application of this method also indirectly brought the following benefits to the enterprise: It has reduced problems such as project delays, cost overruns, and substandard quality, lowered economic losses and resource waste, safeguarded the rights and interests of all parties involved in construction, operation, and supervision, and avoided disputes. At the same time, by optimizing processes and standardizing operations, the project management level was enhanced to accumulate reusable experience for subsequent projects and ensure the smooth fulfillment and delivery of the projects.

4. Conclusions

Based on domestic and international research and in accordance with the actual situation of engineering enterprises in China, this paper has analyzed the main influencing factors of digital transformation of engineering enterprises, and has constructed an evaluation index system for the maturity of digital transformation of engineering enterprises from four aspects, by using the G_1 method to obtain the index weights, and finally applied the cloud model to evaluate the maturity of digital transformation of engineering enterprises.

(1) Based on current standards and norms, this paper has analyzed the influencing factors of digital transformation in engineering enterprises by establishing index principles and bases, and uses principal component analysis to screen the influencing factors of digital transformation in engineering enterprises, eliminating secondary indicators An evaluation index system for the maturity of digital transformation of engineering enterprises has been established, which includes four first-level indicators: digital operation technology, digital system guarantee and digital foundation, and digital performance, nine second-level indicators, and 24 third-level indicators.

(2) By using G_1 to calculate the weights of the evaluation indicators for the digital transformation maturity of engineering enterprises, it can be understood that the degree of influence of intelligence level, total factor productivity, digital strategy formulation, digital strategy matching, and management decision-

making efficiency on the digital transformation maturity of engineering enterprises is relatively large. Corresponding measures can be taken during the digital transformation process. Accelerate the digital transformation of engineering enterprises.

(3) This paper has employed a cloud model to evaluate the maturity level of digital transformation in engineering enterprises, which can effectively address the ambiguity and randomness of the evaluation, complete the conversion between qualitative expression and quantitative values of maturity evaluation, and make the evaluation more objective and reasonable.

Disclosure statement

The author declares no conflict of interest

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