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Risk analysis of project groups based on improved fuzzy comprehensive evaluation

Sun Yu[a], Wu Hongxin

Department of Management Science and Engineering, Hebei University of Engineering, Handan, 056038, China
[a]1091273788@qq.com

Abstract: *In order to increase their market competitiveness, construction companies have started to undertake multiple projects simultaneously. Project management is not suitable for managing multiple projects. In order to achieve benefits that cannot be obtained from a single project, construction companies have started to form project groups and use project group management methods to manage them. The project group management model not only brings more benefits to construction enterprises, but also increases many problems. Taking the project group of a certain construction enterprise as an example, a hierarchical structure model is established from four aspects: information, environment, management, and cooperation. 12 secondary indicators are selected, and an improved Analytic Hierarchy Process (AHP) three scale method is used to establish a judgment matrix. The weight vector is calculated and fuzzy comprehensive evaluation is carried out. The results indicate that the fuzzy comprehensive evaluation of the project group of the construction enterprise is safe.*

Keywords: *construction enterprises, project group risk analysis, iahp capability, Fuzzy comprehensive evaluation*

1. Introduction

With the continuous development of the construction industry, competition among construction enterprises is also deepening. In order to increase their industry competitiveness, construction companies have started to increase the number of construction projects to increase the benefits they can obtain. However, with the increase in the number of construction projects, project management technology can no longer meet the needs of construction companies. In order to better manage multiple projects, construction companies have also begun to explore new management models. Construction companies have explored three management models, namely multi project management, project portfolio management, and project group management. Gao Peng studied the management framework of project clusters and the management standards of construction enterprises from a strategic perspective [1]. Zeng Yucheng proposed a strategic led project portfolio management model [2]. Hu Changming explored the organizational structure of multi project management by analyzing the orderly changes in organizational structure [3]. The three management modes focus on different contents. Project group management focuses on achieving overall benefits greater than the sum of the benefits of each project, project portfolio management focuses on project screening and priority determination, and multi project management focuses on resource allocation. Overall, the project group management mode is more suitable for the development needs of construction enterprises. Therefore, construction enterprises will construct suitable projects and form project groups according to strategic needs to increase their own profits [4].

Although the project group management model can bring more benefits to construction enterprises, it also brings more problems. The increase of projects has increased the difficulty of management. Projects are not independently completed by construction enterprises, but are jointly cooperated by construction enterprises and project group owners and subcontractors. Once a problem occurs in a certain link, it may lead to the occurrence of project group risks, causing construction enterprises to face unnecessary risks. Therefore, construction enterprises should fully identify and timely evaluate the uncertain risks in the project group management process, continuously strengthen the risk management intensity of the project group, predict uncertain risks to the maximum extent, and take corresponding measures in a timely manner to reduce the possibility of risk occurrence, ensuring the normal operation of project group management. This article aims to study the management of project group risks. Firstly, it elaborates on the definition and classification of project group risks. Secondly, it points out how

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construction enterprises identify and evaluate project group risks. Finally, practical risk prevention measures are proposed, hoping to help construction enterprises avoid unnecessary risks.

2. Literature Review

2.1 Programme management

Li Dongping proposed the "regional chain+project group" management model, and introduced the organizational goals, framework, and operational management processes of construction enterprises using this management model through practical cases. At the same time, he elaborated on the achievements of this model from multiple aspects, providing solutions for construction enterprises to solve cross regional and multi project project group management problems [5]. Han Erdong elaborated on the characteristics of conflict games between sub projects in construction enterprise project groups, as well as the impact of conflict games on sub project benefits and comprehensive project group benefits, based on the characteristics of project groups. He proposed reasonable project group optimization suggestions for construction enterprises in response to the conflict games of sub projects [6]. Yan Hongyan et al. analyzed the elements of multi subject collaborative management in construction enterprise project groups through the McKinsey 7S framework. Based on the Hall three-dimensional structural framework, they constructed a four-dimensional institutional framework including knowledge dimension, logic dimension, spatial dimension, and time dimension. Through this framework, suggestions were provided for the construction enterprise to construct a multi subject management system for project groups [7]. Yang Chao analyzed the definition, characteristics, and difficulties of construction enterprise project groups, and distinguished project groups from single project management. Through an example of an EPC project group in Saudi Arabia, they elaborated on the innovation in organizational mode, design control mode, logistics procurement mode, and construction management mode, providing a good case for construction enterprises to contract international project groups [8]. Peng Wuliang considered the constraints of tight relationships and limited shared resources among construction enterprises, and proposed a decentralized resource constrained multi project scheduling problem. A two-stage algorithm was designed from both the single project layer and the project group layer, and the optimal combination of project group duration and resource allocation was obtained through simulation. This helped construction enterprises achieve single project optimization and global project group optimization [9].

2.2 Programme risk

Based on the statistical and self-evaluation data of the meteorological support engineering project for mountain flood geological disaster prevention and control, as well as the construction situation of project units through field research, Yang Yanhong applies project group risk management theory and methods to identify and analyze meteorological support engineering risks from key aspects of project group risk management such as target control, project tracking, and information management. She summarizes the methods and implementation processes of meteorological support engineering risk management, Provide a detailed introduction to the risk identification, analysis methods, and preventive measures that are gradually being accepted and applied. The above conclusion can serve as both an accumulation of experience and a certain degree of universality, and can be used to guide major meteorological engineering projects or similar "small and wide" engineering projects. By selecting the most appropriate risk prevention measures, we can maximize the prevention and control of risks, and reduce the losses caused by risks to the project [10]. In order to reduce the potential losses of hydroelectric engineering caused by project coordination risks, Wen Yuanqing used the weighted multi-level smoothing method to effectively predict the coordination risks of a hydroelectric engineering project. Then, by analyzing the feasibility of coordinating risk prediction, the risk value was used as a parameter indicator that can reflect the degree of risk loss. Based on this, a set of time series prediction samples were constructed, and the sample data was calculated and analyzed using exponential smoothing method. Calculate the accuracy of the results based on each sample data and assign corresponding weights to obtain the final risk prediction result and the degree of risk controllability. The results show that there is a high coordination risk in the hydropower project group, and the weighted multi-level smoothing method used can better reflect the actual situation of coordination risk in hydropower projects. This method has good feasibility and applicability [11].

2.3 Fuzzy comprehensive evaluation

Wang Yike use the pressure state response model to construct a risk assessment index system for river type water source areas, including 22 indicators, from four aspects: water quality pollution, water shortage, ecological environment, and management protection, and analyze and determine the corresponding indicator risk threshold; The entropy weight analytic hierarchy process is used to weight the combination of indicators, and the traditional fuzzy evaluation method is improved based on the principle of effectiveness and weighted average. An improved fuzzy comprehensive evaluation model is established to evaluate the risk level of water sources. The results show that they are consistent with the actual situation, verifying the applicability of the model. [12]. Jiang Feng pointed out that the risk factors of crude oil storage tanks on offshore platforms are complex and fuzzy, and the weights of each factor are difficult to allocate. He proposed to use the three scale AHP method for safety evaluation, briefly describing the advantages and method steps of the three scale AHP. Based on specific cases, safety evaluation indicators were constructed, and the weights of each factor were determined using the three scale AHP method. A two-level fuzzy comprehensive evaluation model was used for safety evaluation, based on the evaluation results, propose key points for prevention and management [13]. Huang De, in response to the various influencing factors, strong arbitrariness, and uncertainty in the evaluation process of gas extraction standards, combined with the on-site evaluation process of gas extraction standards and existing research results, divided the evaluation levels of gas extraction standards based on evaluation indicators and relevant regulations. Using the improved Analytic Hierarchy Process (IAHP), as well as the theory of matter elements and fuzzy extension, a gas extraction standard evaluation model based on the Improved Analytic Hierarchy Process Fuzzy Extension Model (IAHP FE) is established. Establish a gas drainage compliance evaluation system based on the compliance evaluation standards and expert opinions. Taking a production mine as an example, a systematic 3-scale Analytic Hierarchy Process was used to determine the evaluation weights, and the feasibility and rationality of the gas extraction standard evaluation model were verified. Based on this, the impact of each evaluation index on the gas extraction standard evaluation was analyzed [14].

3. Theoretical basis and research hypothesis

3.1 Definition of project group risk

Project group risk refers to the occurrence of risks due to certain uncertainties in time, location, and other conditions, resulting in the inability of the project group to operate normally. Specifically, project group risks can be understood as the risks that may arise during the process of construction companies providing services to owners. The occurrence of project group risks not only hinders the normal operation of the entire project group, but may also affect the performance of the construction enterprise, inevitably causing a certain degree of loss to the construction enterprise.

3.2 Classification of project group risks

Project group risks can be classified into different categories according to different standards. This article selects four risk factors that cause frequent occurrence of project group risks: information risk, environmental risk, management risk, and cooperation risk.

(1) Information risk

Most construction enterprises with large and numerous project clusters will use management information systems for overall operation monitoring and coordination. Due to the large structure of the project group, it may lead to complex management systems owned by construction enterprises, resulting in problems such as information asymmetry, information distortion, information delay, information leakage, and insufficient communication between enterprises. Therefore, in order to better connect the information sharing among the participating parties in the project group, losses caused by information issues should be avoided. This risk analysis divides information risk into: information asymmetry risk, information technology risk, and information transmission risk.

(2) Environmental risk

The deterioration of the natural environment caused by various factors and the inability of construction companies to monitor and predict natural phenomena through existing means are a major source of risk for external project groups. Extreme weather and natural disasters, which cannot be controlled and prevented in advance, can pose unavoidable risks to the project team. In severe cases, they may lead to the paralysis of the project team and the inability to resume operation in the short term. This risk analysis divides environmental risks into natural environmental risks, economic environmental risks, and policy and legal risks.

(3) Manage risk

The regional expansion and structural extension of project clusters not only bring profits to construction enterprises, but also increase the difficulty of project cluster management. It is also difficult for construction enterprises to formulate management models and action standards suitable for their future development to solve all problems. Once the relevant management system designated by the construction enterprise cannot be implemented normally in various regions, the management system will be like a sham, leading to problems in the operation of the entire project group system, and even slow development and poor coordination, which is not conducive to the future development of the construction enterprise. This risk analysis divides management risks into operational risks, human resource risks, and business decision risks.

(4) Cooperative risk

The enterprises in the project group system do not exist independently and need to cooperate with other enterprises to ensure the stable operation of the project group and form a mutually beneficial and win-win situation. However, multiple risks may arise during this process. The following lists the possible risk situations that may arise in the project group during the cooperation process: due to the inability to coordinate with each other between construction companies and subcontractors, there may be mutual distrust between companies, and one party may pursue their own interests without ignoring the overall interests of the project group; Both parties in the cooperative project need to reach a fair and reasonable agreement on the distribution of benefits, in order to avoid uneven distribution of benefits. Unclear responsibility causes unnecessary trouble; The quality and ability cultivation of employees in construction enterprises are an indispensable part of the construction enterprise culture construction. Construction companies should assign employees to suitable job positions based on their work abilities and strengths. At the same time, an appropriate reward and punishment system should be established to stimulate the work enthusiasm of employees and reduce the operational risks of construction enterprises caused by talent loss. This risk analysis divides cooperation risks into credit risk, partnership risk, and contract risk.

4. Principles and Methods of Evaluation

4.1 Principles of Analytic Hierarchy Process

Analytic Hierarchy Process (AHP) is a qualitative and quantitative hierarchical weight decision analysis method that decomposes objectives into target layer, criterion layer, and scheme layer. The Analytic Hierarchy Process (AHP) belongs to the field of operations research and was proposed by American operations researchers. The Analytic Hierarchy Process (AHP) can be used for method selection and evaluation of research content, with flexible application. Based on the final weight ranking, it can not only select the optimal solution for the target layer, but also sort the execution order of several solutions. The Analytic Hierarchy Process (AHP) analyzes the essence, influencing factors, and interrelationships of large-scale decision-making problems, and uses less quantitative information to mathematize the thinking process of decision-making, thereby providing a simple decision-making method for complex decision-making problems with unstructured characteristics.

4.2 Questionnaire design and data collection

Fuzzy comprehensive evaluation is a comprehensive evaluation method based on fuzzy mathematics, which transforms qualitative evaluation into quantitative evaluation and makes a comprehensive evaluation of objects constrained by multiple factors. The most significant feature of the fuzzy comprehensive evaluation method is that it can be compared with each other, and the membership function relationship between the evaluation value and the evaluation factors can be determined based on the characteristics of various evaluation factors.

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4.3 Improving the Analytic Hierarchy Process and Its Steps

Improving the Analytic Hierarchy Process by using the Three Scales method can make judgments simpler and more intuitive. The specific steps to improve the Analytic Hierarchy Process are as follows:

(1) Based on the principle of Analytic Hierarchy Process, analyze various limiting factors and establish an evaluation index system, consisting of the target layer, criterion layer, and scheme layer.

(2) Construct the corresponding comparison matrix using the three scale method. Compare various factors pairwise to obtain A.

(3) Use the three scale method, namely 0, 1, and 2, to construct the judgment matrix. And construct the true judgment matrix B according to equation (1).

$$\begin{cases} a_{ij} = \dfrac{r_i - r_j}{r_{\max} - r_{\min}}(b_m - 1) + 1, (r_i \geq r_j) \\ a_{ij} = 1, (r_i = r_j) \\ a_{ij} = \left[\dfrac{\left| r_i - r_j \right|}{r_{\max} - r_{\min}} \times (b_m - 1) \right]^{-1}, (r_i \leq r_j) \end{cases} \tag{1}$$

In the formula, a_{ij} is the element of the judgment matrix B; r_i and r_j represent the importance level of the judgment element; r_{max} and r_{min} are the maximum and minimum values for determining the importance of factors; The ratio of the maximum value to the minimum value of the importance level of the judging factor is represented by b_m.

(4) Calculate the optimal transfer matrix C according to the following equation.

$$C_{ij} = \frac{1}{n}\sum_{k=1}^{n}(\lg\frac{a_{ik}}{a_{jk}}), \forall i, j, k = 1, 2, \cdots n \tag{2}$$

In the formula, C_{ij} is the element of the transfer matrix; a_{iK} and a_{JK} are the judgment elements.

(5) Calculate the judgment matrix A* obtained after consistency adjustment.

$$A_{ij}^{*} = 10^{C_{ij}} \tag{3}$$

In the formula, A_{ij}^{*} is the element of the judgment matrix.

(6) By substituting the above calculation results into the following equation, the weight vector W for each indicator can be obtained.

$$W_j = \frac{1}{\sum A_{ij}^{*}} \tag{4}$$

In the formula, W_j is the element of the weight vector.

4.4 Fuzzy comprehensive evaluation and its steps

Fuzzy comprehensive evaluation is a comprehensive evaluation method suitable for fuzzy indicator boundaries, which uses fuzzy mathematics to determine the quality of things and provides quantitative values qualitatively to achieve the goal of comprehensive evaluation of things. The specific steps for fuzzy comprehensive evaluation are as follows:

(1) Establish an effective set of evaluation factors. Generally represented by the capital letter U, U= $\{U_1, U_2, ..., U_n\}$, $U_i \in U$ (i=1, 2, ..., n)

(2) Calculate weight vectors.

(3) Determine the security level V= $(V_1, V_2, ..., V_n)$. The final result of fuzzy comprehensive

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evaluation is to obtain the corresponding evaluation result from the evaluation set.

(4) Fuzzy evaluation comprehensive processing. Perform fuzzy transformation in two levels to obtain the final weight, from which the impact of each factor on the target layer can be seen.

5. Case analysis

Taking the project group of a certain construction enterprise as an example, a fuzzy comprehensive evaluation is conducted on the project group of the company. The steps are as follows.

5.1 Weight determination

The project team selects four types of risks: information risk, environmental risk, management risk, and cooperation risk. Based on the principles of improved Analytic Hierarchy Process Fuzzy Comprehensive Evaluation and the construction of evaluation system indicators, the project group of construction enterprises is taken as the evaluation object. The first level evaluation indicators are information risk, environmental risk, management risk, and cooperation risk, while the second level evaluation indicators comprehensively consider the specific risks of each type of risk. The project team risk assessment system is shown in Table 1.

Table 1: Project group risk assessment system

Project Group Risk Analysis	Information Risk	Information asymmetry risk
		Information technology risk
		Information transmission risk
	Environmental risks	Environment risk
		Economic and environmental risk
		Policy and legal risk
	Manage risk	Operational risk
		Human resource risk
		Business decision risk
	Cooperative risk	Credit risk
		Partnership risk
		Contract Risk

5.2 Calculation of weight indicators

Based on the project group examples of construction enterprises, relevant literature was consulted, and a survey questionnaire was conducted. Combined with the opinions of technical personnel and experts, the first level evaluation indicators were comprehensively valued using the "three scale method". The results are shown in Table 2.

Table 2: Value of primary evaluation indicators

Index	B_1	B_2	B_3	B_4	r_i
B_1	1	2	2	2	7
B_2	0	1	2	2	5
B_3	0	0	1	1	2
B_4	0	0	1	1	2

Calculate the result from equation (1) to construct the evaluation matrix as follows:

$$B=\begin{bmatrix} 1 & 2 & 7/2 & 7/2 \\ 1/2 & 1 & 5/2 & 5/2 \\ 2/7 & 2/5 & 1 & 1 \\ 2/7 & 2/5 & 1 & 1 \end{bmatrix}$$

The optimal transfer matrix C is determined by equation (2). Calculate the judgment matrix A* according to equation (3). Calculate the weight vector W of the first level evaluation index using equation (4).

$$C=\begin{bmatrix} 0 & 0.8943 & 2.3312 & 2.3312 \\ -0.8943 & 0 & 1.4369 & 1.4369 \\ -2.3312 & -1.4369 & 0 & 0 \\ -2.3312 & -1.4369 & 0 & 0 \end{bmatrix}$$

$$A^* = \begin{bmatrix} 1 & 1.6734 & 3.8265 & 3.8265 \\ 0.5976 & 1 & 2.2867 & 2.2867 \\ 0.2613 & 0.4373 & 1 & 1 \\ 0.2613 & 0.4373 & 1 & 1 \end{bmatrix}$$

$$W = (0.4716, 0.2818, 0.1233, 0.1233)$$

The calculation process of the weights of the secondary evaluation indicators is the same as that of the primary evaluation indicators. The values of the evaluation indicators B1 to B4 are determined using the "three scale method", and the results are shown in Tables 3 to 6.

Table 3: Value of Level 2 Evaluation Indicator B1

Index	B_{11}	B_{12}	B_{13}	Weight
B_{11}	1	2	2	0.5174
B_{12}	0	1	2	0.3435
B_{13}	0	0	1	0.1391

Table 4: Value of Level 2 Evaluation Indicator B2

Index	B_{21}	B_{22}	B_{23}	Weight
B_{21}	1	1	2	0.4444
B_{22}	1	1	2	0.4444
B_{23}	0	0	1	0.1112

Table 5: Value of Level 2 Evaluation Indicator B3

Index	B_{31}	B_{32}	B_{33}	Weight
B_{31}	1	2	2	0.5556
B_{32}	0	1	1	0.2222
B_{33}	0	1	1	0.2222

Table 6: Value of Level 2 Evaluation Indicator B4

Index	B_{41}	B_{42}	B_{43}	Weight
B_{41}	1	2	1	0.3781
B_{42}	0	1	2	0.3568
B_{43}	1	0	1	0.2651

5.3 Fuzzy comprehensive evaluation

This article divides the risk assessment system results of the project group into 5 levels, V={safe, relatively safe, average, relatively dangerous, dangerous}. Through long-term on-site research, combined with technical personnel and expert scoring, the summary of enterprise supply chain risk assessment is shown in Table 7.

Table 7: Summary of project group risk assessment

	Criterion layer	weight	Indicator layer	weight	Security level				
					1	2	3	4	5
Project group risk assessment system	Information Risk	0.4716	Information asymmetry risk	0.5174	0.42	0.30	0.18	0.10	0
			Information technology risk	0.3435	0.28	0.16	0.32	0.12	0.12
			Information transmission risk	0.1391	0.38	0.22	0.16	0.10	0.14
	Environmental risks	0.2818	Environment risk	0.4444	0.34	0.26	0.14	0.16	0.10
			Economic and environmental risk	0.4444	0.44	0.22	0.12	0.12	0.10
			Policy and legal risk	0.1112	0.24	0.36	0.12	0.16	0.12
	Manage risk	0.1233	Operational risk	0.5556	0.38	0.16	0.24	0.12	0.10
			Human resource risk	0.2222	0.32	0.44	0.12	0.12	0
			Business decision risk	0.2222	0.26	0.34	0.16	0.14	0.10
	Cooperative risk	0.1233	Credit risk	0.3781	0.18	0.42	0.30	0.10	0
			Partnership risk	0.3568	0.30	0.26	0.28	0.16	0
			Contract Risk	0.2651	0.22	0.34	0.44	0	0

According to the formula Ui=Wi * Ri, the results of the second level fuzzy comprehensive evaluation are as follows:

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U1= (0.3363, 0.2408, 0.2253, 0.1069, 0.0907)

U2= (0.3733, 0.2533, 0.1289, 0.1422, 0.1023)

U3= (0.3400, 0.2622, 0.1956, 0.1244, 0.0778)

U4= (0.2334, 0.3418, 0.3299, 0.0949, 0)

According to E=W * U calculation, the first level fuzzy comprehensive evaluation results are as follows:

E=(0.3487,0.2594,0.2074,0.1175,0.0670)

According to the principle of maximum membership, the project group risk assessment level of the construction enterprise is safe. Through the Analytic Hierarchy Process Fuzzy Comprehensive Evaluation of the construction enterprise, it can be concluded that the project group risk prediction system of the construction enterprise is relatively complete. The construction enterprise should attach certain importance to information and environmental risks, strengthen risk response measures, and improve corresponding risk response capabilities.

6. Research conclusions and suggestions

The current market competition is becoming increasingly fierce, and modern information technology is constantly developing, making project group management gradually become the key for construction enterprises to steadily move forward in market competition. Construction enterprises should strive to improve themselves according to the trend of the times, strengthen their adaptability to the constantly changing market environment, increase information sharing among subcontractors and owners, and build deepening strategic cooperation between enterprises. At the same time, construction enterprises should continuously strengthen the construction and improvement of their own project group management system, strengthen timely identification of project group risks, and enhance risk prevention and control and risk response capabilities. Construction enterprises need to implement the concept of project group management into every aspect of project group management in order to fundamentally strengthen their ability to respond to project group risks and enable the enterprise to continuously develop steadily.

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