Research on the risk assessment method of power grid engineering cost based on grey correlation analysis

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Abstract. Power grid engineering is an organic component of national infrastructure, which provides strong support for national economic and social development, and cost control is one of the core contents of power grid engineering construction, which has an important impact on the investment efficiency of power grid engineering. Based on practical factors such as large investment scale, complex procurement plan, and long construction period, power grid engineering cost control faces certain challenges and pressures. Especially under the urgent need to reduce cost and improve accuracy in power grid engineering construction, it is necessary to analyze the relevant factors that lead to cost deviation, explore ideas and methods to optimize power grid engineering cost management, and effectively improve management effectiveness as well as the cost management level of power grid engineering. Therefore, combined with the needs of power grid engineering cost control and control, this paper constructs a cost risk assessment index system from five dimensions: technology, management, policy, economy, and natural environment, and constructs a risk assessment model based on analytic hierarchy-entropy weight method-grey management analysis, which provides a reference for power grid enterprises to carry out engineering cost risk assessment reasonably.

Keywords: power grid engineering, cost management, deviation analysis, control effect, evaluation method, optimization suggestions

1 Introduction

Facing the new situation of increasing government supervision, stricter social supervision standards, and a lean enterprise investment management level, the power grid project cost management has been paid more and more attention. Therefore, combined with the cost analysis results of the power grid project, carrying out the cost and risk assessment of the power grid project is of great significance to improve the efficiency of enterprise cost control and improve the level of enterprise operation efficiency.

By clarifying the indicators adapted to the life-cycle cost verification of power grid engineering, a dynamic model of power grid engineering life cycle cost is constructed, and a new control method is proposed based on Gaussian- fitted power

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grid engineering repair rate solving and cost control [1]. A cost risk grading method for power grid engineering is proposed based on fuzzy worst indicators, which can optimize the cost evaluation logic and support settlement review, cost analysis, verification, and early warning [2]. Taking capital chain factors, material and equipment factors, monetary policy, natural environment, and financial financing as statistical variables, the fuzzy feature mapping model is used to analyze the quantitative characteristics of power grid engineering cost, the analytic hierarchy method is used to realize the quantitative recursive analysis of key factors of power grid engineering cost control, and the identification of key factors of power grid engineering cost control is realized according to the quantitative recursive analysis results [3]. The problems existing in the cost management process of power grid engineering are analyzed from the three main stages of bidding, design, and construction, and relevant suggestions are put forward [4]. The cost management of power grid engineering is analyzed and puts forward the control strategy of power grid engineering cost is put forward [5]. The safety risk factors affecting the cost management of the whole process of the project are analyzed, preventive measures for the safety risk factors are formulated, and countermeasures are put forward [6], to further improve the safety management level of project cost.

To sum up, current scholars pay more attention to the research of power grid engineering cost and cost risk management but lack corresponding risk assessment methods, which cannot effectively guide power grid enterprises to carry out the risk assessment of power grid engineering cost.

2 Research on the risk assessment of power grid project cost control

2.1 Construction of risk assessment index system for power grid project cost control

By reading many pieces of literature and consulting with project site owners and supervision experts, this paper identifies the cost risk factors that are easy to occur in the construction of power grid engineering and will bring large losses according to the risk identification process and establishes the corresponding cost risk assessment index system, the specific index system is shown in Table 1.

Table 1. Power grid engineering cost risk assessment index system.

Power grid project cost risk	Technical risk	Survey risk
		Design quality risk
		Quantities and valuation risk
		Construction risk
	Manage risk	Management personnel professional quality risk
		Organize and manage risks
		Information management risk
	Policy risk	Legal policy risks

	Land policy risk
	Tax policy risk
	Labor cost and price fluctuation risk
Economic risks	Equipment and material price fluctuation risk
	Interest fluctuation risk
	Risk of geological conditions
Natural risk	Climate risk
	Natural disaster seal letter

As can be seen from Table 1, the cost risk is mainly divided into 5 first-level indicators and 16 second-level indicators of technical risk, management risk, policy risk, natural risk, and economic risk.

2.2 Calculation of index weights based on hierarchical analysis-entropy weight method

According to the nature and general goal of the multi-objective decision-making problem, the problem itself is decomposed hierarchically to form a bottom-up hierarchical structure. The highest level is the overall goal to solve the problem, called the target layer; several middle layers for the realization of the overall goal of the intermediate measures, criteria, called the criterion layer; and the lowest level to solve the problem of various solutions, called the solution layer.

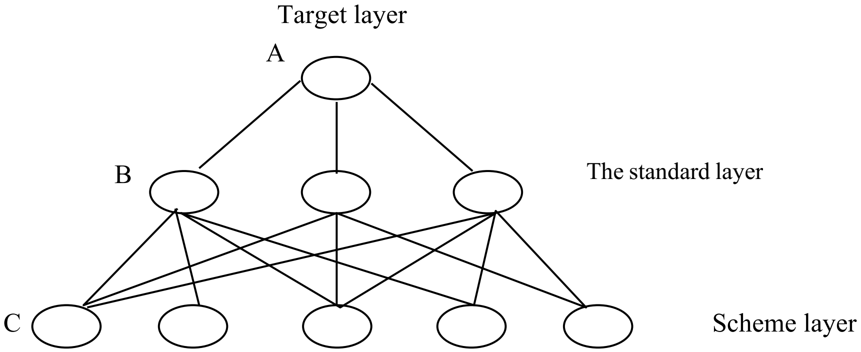

Fig. 1. The hierarchical hierarchy.

Figure 1 shows the hierarchical hierarchy of the analytic hierarchy method, which organizes and hierarchically constructs the factors involved in the problem into a hierarchical structural model. In this model, the complex problem is decomposed into several elements, and each level has a certain relationship between each level. The elements of the previous level have a dominant effect on the elements of the next level, and the level can be divided into the following three categories: the highest layer, the middle layer, and the lowest layer.

(2) The basic steps of the hierarchical analysis method

Now to compare the influence of n factors $X=\{x_1,...,x_n\}$ on a factor Z, the method of comparing the factors in pairs can be used to establish a pairwise comparison matrix. That is, two factors x_i and x_j are taken each time, and a_{ij} is used to represent the ratio of the influence of x_i and x_j on Z, and all comparison results are represented by a matrix $A=(a_{ij})_{n\times n}$, which is called the pairwise comparison judgment matrix between $Z-X$ (referred to as the judgment matrix). It is easy to see that if the ratio of the influence of x_i and x_j on Z is a_{ij}, then the ratio of the effect of x_j and x_i on Z should be $a_{ji}=\frac{1}{a_{ij}}$.

(2) Determination of the weight of the power grid project cost risk index

Based on the basic principle of hierarchical analysis, the weight of the risk index of power grid engineering is calculated as shown in the following table:

Table 2. Calculation results of the risk assessment index weight of the power grid project cost.

Power grid project cost risk	Technical risk 0.287	Survey risk
		Design quality risk 0.357
		Quantities and valuation risk 0.178
		Construction risk 0.287
	Manage risk 0.180	Management personnel professional quality risk 0.477
		Organize and manage risks 0.387
		Information management risk 0.136
	policy risk 0.152	Legal policy risks 0.257
		Land policy risk 0.285
		Tax policy risk 0.358
	economic risks 0.237	Labor cost and price fluctuation risk 0.285
		Equipment and material price fluctuation risk 0.571
		Interest fluctuation risk 0.144
	natural risk 0.144	Risk of geological conditions 0.384
		Climate risk 0.397
		Natural disaster risk 0.219

Table 2 is the calculation result of the weight calculation of the power grid engineering cost risk indicators at all levels calculated according to the basic principles of the analytic hierarchy method.

2.3 Construction of the risk assessment model based on the grey association analysis (GRA)

Gray association analysis requires the following steps:

Step 1: To determine the analyzed sequence.

Based on the qualitative analysis of the studied question, one dependent variable factor and multiple independent variable factors were determined. Let the dependent variable data constitute the reference sequence X0, the respective variable data constitute the comparative sequence Xi′ (I = 1, 2, ..., n), n + 1 data series from the following matrix:

$$(X'_0, X'_1, \ldots, X'_n) = \begin{bmatrix} x'_0(1) & x'_1(1) & \ldots & x'_n(1) \\ x'_0(2) & x'_1(2) & \ldots & x'_n(2) \\ \ldots & \ldots & \ldots & \ldots \\ x'_n(N) & x'_n(N) & \ldots & x'_n(N) \end{bmatrix}_{N*(n+1)} \tag{1}$$

Where $X'_i = (x'_i(1), x'_i(2), \ldots, x'_i(N))^T, i = 0, 1, 2, \ldots, n$, N is the length of the variable sequence.

Step 2: To determine the sequence of variables.

$$(X_0, X_1, \ldots, X'_n) = \begin{bmatrix} x_0(1) & x_1(1) & \ldots & x_n(1) \\ x_0(2) & x_1(2) & \ldots & x_n(2) \\ \ldots & \ldots & \ldots & \ldots \\ x_n(N) & x_n(N) & \ldots & x_n(N) \end{bmatrix}_{N*(n+1)} \tag{2}$$

The commonly used dimensionless methods include a mean method, an initial value method, and so on.

$$x_i(k) = \frac{x'_i(k)}{\frac{1}{N}\sum_{k=1}^{N} x'_i(k)}, i = 0,1,\ldots,n; k = 1,2,\ldots,N \tag{3}$$

$$x_i(k) = \frac{x'_i(k)}{x'_i(1)}, i = 0,1,\ldots,n; k = 1,2,\ldots,N \tag{4}$$

Step 3: To find the difference sequence, maximum difference, and minimum difference.

The absolute difference between the first column (reference sequence) and the other columns (compare sequence) is calculated to form the following absolute difference matrix:

$$\begin{bmatrix} \Delta_{01}(1) & \Delta_{02}(1) & \dots & \Delta_{0n}(1) \\ \Delta_{01}(2) & \Delta_{02}(2) & \dots & \Delta_{0n}(2) \\ \dots & \dots & \dots & \dots \\ \Delta_{01}(N) & \Delta_{02}(N) & \dots & \Delta_{0n}(N) \end{bmatrix}_{N*n} \tag{5}$$

Among:

$$\Delta_{0i}(k) = |x_0(k) - x_i(k)|, i = 1,2,\dots,n; k = 1,2,\dots,N \tag{6}$$

The maximum and minimum numbers in the absolute difference array are the maximum difference and minimum difference:

$$\max_{\substack{1 \le i \le n \\ 1 \le k \le N}} \{\Delta_{0i}(k)\} \underline{\underline{\Delta}} \Delta(\max) \tag{7}$$

$$\min_{\substack{1 \le i \le n \\ 1 \le k \le N}} \{\Delta_{0i}(k)\} \underline{\underline{\Delta}} \Delta(\min) \tag{8}$$

Step 4: To calculate the correlation coefficient.

The data in the absolute difference array are transformed as follows:

$$\xi_{0i}(k) = \frac{\Delta(\min) + \rho\Delta(\max)}{\Delta_{0i}(k) + \rho\Delta(\max)} \tag{9}$$

To obtain the correlation coefficient matrix:

$$\begin{bmatrix} \xi_{01}(1) & \xi_{02}(1) & \dots & \xi_{0n}(1) \\ \xi_{01}(2) & \xi_{02}(2) & \dots & \xi_{0n}(2) \\ \dots & \dots & \dots & \dots \\ \xi_{01}(N) & \xi_{02}(N) & \dots & \xi_{0n}(N) \end{bmatrix}_{N*n} \tag{10}$$

In the formula, the resolution coefficient ρ is taken within (0,1), and the data is usually 0.1 to 0.5. The smaller the ρ, the higher the difference between the correlation coefficients. The correlation coefficient $\xi_{0i}(k)$ is a positive number not exceeding 1, and the smaller $\Delta_{0i}(k)$ is, the larger $\xi_{0i}(k)$ is, which reflects the degree to which the $i-th$ comparison sequence X_i is related to the reference sequence X_0 at the k period.

Step 5: To calculate the correlation degree.

The degree of correlation between the comparative sequence X_i and the reference sequence X_0 is reflected by N correlation coefficients, and the correlation degree between X_i and X_0 can be obtained by averaging.

$$r_{0i}=\frac{1}{N}\sum_{k=1}^{N}\xi_{0i}(k) \tag{11}$$

Step 6: To sort by correlation degree.

The correlation degree of the compared sequence and the reference sequence is ranked from large to small, and the greater the correlation degree, the more consistent the trend between the compared sequence and the reference sequence changes.

3 Empirical analysis

This paper selects a power grid project in the Xinjiang region as an example to carry out empirical analysis and research.

Table 3. Risk judgment table of a power grid project in a certain area of Xinjiang.

Index	Risk level				Determine the level of risk
	N1	N2	N3	N4	
Survey risk (A1)	-0.0973	-0.0922	-0.0103	-0.0512	N3
Design quality risk (A2)	-0.0466	-0.0422	-0.0089	-0.0255	N3
Engineering takeoff and valuation risk (A3)	-0.0718	-0.0665	-0.0507	-0.0317	N4
Construction risks (A4)	-0.0439	-0.0404	0.0296	0.0215	N4
Professional quality of managers (B1)	-0.0726	-0.0133	-0.0429	-0.0757	N2
Organize management and coordinate risks (B2)	-0.0570	-0.0348	-0.0199	-0.0498	N3
Information management risk (B3)	-0.0122	-0.0075	-0.0170	-0.0208	N2
Legal and technical specifications (C1)	-0.0303	-0.0195	-0.0160	-0.0231	N3
Land policy risks (C2)	-0.0465	-0.0120	-0.0292	-0.0500	N2
Tax policy risk (C3)	-0.0514	-0.0030	-0.0272	-0.0517	N2
Artificial price fluctuation risk (D1)	-0.0610	-0.0578	-0.0480	-0.0196	N4
Risk of fluctuations in equipment and material prices (D2)	-0.1243	-0.1188	-0.1022	-0.0332	N4
Risk of changes in loan interest (D3)	-0.0320	-0.0171	-0.0024	-0.0317	N3
Geological condition risk (E1)	-0.0465	-0.0277	-0.0130	-0.0423	N3
Climatic conditions risk (E2)	-0.0448	-0.0286	-0.0217	-0.0354	N3
Risk of natural disasters (E3)	-0.0246	-0.0069	-0.0158	-0.0267	N2

It can be seen from Table 3 that the comprehensive risk matrix and comprehensive risk value of the first-level index of the project are {-0.0657, -0 .0485, -0 .0361,

-0.0395, -0.0361}, and it can be obtained that the cost comprehensive risk early warning level of the project is N3, which is in a medium warning state. Combined with the results of risk assessment, it is recommended that managers should pay great attention to the loss of technical, natural, and economic risks to project costs.

4 Conclusion

This paper is based on the theory of project comprehensive evaluation system and the development of present situation analysis, combined with the characteristics of power grid construction, power grid project evaluation basic requirements, and power grid project evaluation classification standard. Through the study of the traditional evaluation index system and evaluation method, the power grid project cost risk evaluation index system is established, and finally, a comprehensive evaluation method for the power grid project is recommended.

References

1. Zhou Haozhen. Research on cost control of power grid engineering based on whole life cycle cost [J]. Engineering and Construction, 2022, 36 (06): 1850-1852.
2. Chen Jia, Cheng Cong, Qian Hua. Cost risk grading method of power grid engineering based on fuzzy worst index [J]. Electric Power Equipment Management, 2021 (03): 132-134.
3. Li Chengyin, CAI Xia. The identification method of the key factors of the cost control of power grid engineering is based on the hierarchical analysis method [J]. Microcomputer applications, 2020, 36 (11): 111-113 + 122.
4. Xie Yongguang. Analysis of the problems and countermeasures existing in the process of power grid engineering cost management [J]. Technology and Enterprise, 2013(13):70. DOI: 10.13751/j.cnki.kjyqy.2013.13.220
5. Huang Wei. Analysis of the cost management and control strategy of power grid engineering [J]. New Chinese new technology and new products, 2014(22):121. DOI: 10.13612/j.cnki.cntp.2014.22.095.
6. Guo Zhenxin. Analysis of risk factors and countermeasures of power grid engineering cost management [J]. Technology wind, 2014(21):138. DOI: 10.19392/j.cnki.1671-7341.2014.21.120.