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Research on Cost risk Warning Technology of Distribution Network Based on Subjective Empowerment-Object Extension Method

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Abstract. Strengthening the risk control of the distribution network project cost plays an important role in ensuring the project quality, saving the project investment and improving the operating efficiency of enterprises. Therefore, this paper first combines the characteristics of distribution network construction, from the four aspects of technology, management, policy, nature, reasonably constructs the risk early warning and evaluation index system, and then constructs the evaluation model based on subjective empowerment-object element extension method, and combined with empirical analysis, to verify the effectiveness of the model. The risk early warning technology proposed in this paper can guide the power grid enterprises to carry out the cost risk assessment work reasonably, and improve the efficiency and quality of the project cost control.

Keywords: distribution network; cost risk; sequential relationship analysis method; material element extension model; early warning technology.

1. Introduction

Power grid engineering construction has the characteristics of many uncertain factors, long recovery cycle and large amount of investment. Therefore, the whole process cost risk management of power grid engineering is very important for project construction [1]. To this end, relevant scholars have carried out the following research work on how to carry out the power grid cost risk management:

Zuo Meng [2] uses the hierarchical analysis method to determine the weight of each risk factor to reduce the adverse impact of experts subjective factors on the evaluation results. At the same time, the fuzzy comprehensive evaluation operation results are obtained by combining the fuzzy mathematical algorithm. Through the analysis of the matrix calculation results, the influence level of various risk factors of NH power grid project is determined, and the rectification direction of the project should be determined according to the analysis results and the rectification scheme can be determined. Zhang Fujun [3] analyzed and studied the statistical analysis of power grid production technology transformation project, and put forward some suggestions, hoping to improve the effectiveness of the cost risk assessment of production technology transformation project of power grid enterprises. Gou Ruixin and other [4] build an analysis model of the cost of power grid line project, calculate the influence degree of various factors on the cost of power grid line projects, and point out the key link of the risk control of power grid line project cost, which can provide reference for the cost control of other power grid line projects. Liu Jie and other [4], combined with the inevitable requirements of the development goal of "one body and four wings" of power grid enterprises, put forward the specific cost risk management method of power grid projects.

To sum up, current scholars mainly use statistical analysis and fuzzy mathematics to build conventional evaluation models, and lack systematic method application in the evaluation index selection and weight determination. Therefore, the study in this paper is a good necessity.

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2. Evaluation Index Construction

The risk assessment index system constructed in this paper combined with the construction process and characteristics of distribution network and the key points of project cost control is shown in Table 1 as follows:

Table 1. Distribution network project cost risk assessment index system.

Evaluation target	Level 1 indicators	Secondary indicators
Distribution network project cost risk assessment	Technical risk	Survey risk
		Design level and design change risk
		Engineering calculation and valuation risk
	Manage risk	Construction risk
		Professional quality of management personnel
		Organize management and coordinate risks
		Information management risk
	policy risk	Laws, regulations and technical specifications
		Land policy risk
		Tax policy risk
	economic risks	Labor cost, raw material price fluctuation risk
		Equipment and material price fluctuation risk
		Loan interest rate change risk
		Risk of geological and hydrological conditions in construction areas
	natural risk	climatic conditions
		natural calamities

3. Literature References

3.1 Index Weight Calculation Based on the Order Relationship Analysis Method

Sequence relationship analysis is a subjective empowerment method, which to some extent avoids the disadvantage that hierarchical analysis (AHP) is difficult to determine weights due to too many indicators and too large data statistics. In contrast, order relationship analysis has the advantages of strong order preservation and intuitiveness. The calculation steps are as follows:

(1) Determine the order relationship of the evaluation indicators

The hypothesis $x_1, x_2, ..., x_n (n \geq 2)$ is n indicators (primary or secondary indicators). When the importance of the indicator i is greater than the importance of the indicator j, it is denoted as $x_i > x_j (i = 1,2,...,n; j = 1,2,...,n; i \neq j)$, and the ordinal relationship between the evaluation indicators is established accordingly.

(2) Experts judgment of the importance of adjacent indicators

The expression of the degree of importance between adjacent indicators is:

$$r_a = w_{a-1} / w_a (a = n, n-1, n-2, ..., 3, 2) \tag{1}$$

Therefore, the relative importance of each indicator is obtained, r_a is the importance between the a-th indicator x_a and the neighboring indicator x_{a-1}, and w_a is the weight of the a-th indicator.

(3) Calculate the weight coefficient

If the ideal assignment of r_a given by the expert satisfies:

$$r_{a-1} > \frac{1}{r_a} \tag{2}$$

The weight w_n of the n-th indicator is.:

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$$w_n = (1 + \sum_{a=2}^{n} \coprod_{i=a}^{n})^{-1} \tag{3}$$

$$w_{a-1} = r_a w_a \, (a = n, n-1, ..., 3, 2) \tag{4}$$

In the formula: w_{a-1} is the weight of the $a-1$ -th indicator, w_a is the weight of the a -th indicator, and r_a is the project assignment given by experts, which is also a preset value.

3.2 Matter-Element Extension Model

The matter-element extension model is based on the theory of matter-element theory, extension set, correlation function, and correlation degree, which is a method to quantitatively evaluate each index and can systematically reflect the comprehensive evaluation results. The calculation steps for the comprehensive evaluation of power grid construction projects using the matter-element extension model are as follows:

(1) Determine the Classical Domain Matter Element Matrix

The matter element matrix consisting of the matter N, the feature c_n of the matter N and the standard range of its features is the Classical Domain Matter Element Matrix, denoted as R_j. Then there are:

$$R_j = \begin{bmatrix} & c_1 & (a_{j1}, b_{j1}) \\ & c_2 & (a_{j2}, b_{j2}) \\ N_j & c_3 & (a_{j3}, b_{j3}) \\ & \vdots & \vdots \\ & c_n & (a_{jn}, b_{jn}) \end{bmatrix}. \tag{5}$$

In the formula, N_j denotes the j -th evaluation level ($j = 1, 2, \cdots, m$) of the target matter N; c_i is the i -th evaluation index ($i = 1, 2, \cdots, n$); $V_{ji} = (a_{ji}, b_{ji})$ denotes the range of values of the index i in level j.

(2) Determine the evaluation district matter-element matrix

The matter element matrix consisting of the thing N, the characteristic c_n of the thing N, and the expansion range of its characteristic is the evaluation district matter-element matrix, denoted as R_p, and there are:

$$R_p = \begin{bmatrix} & c_1 & (a_{p1}, b_{p1}) \\ & c_2 & (a_{p2}, b_{p2}) \\ N_p & c_3 & (a_{p3}, b_{p3}) \\ & \vdots & \vdots \\ & c_n & (a_{pn}, b_{pn}) \end{bmatrix}. \tag{6}$$

In the formula, N_p denotes the whole of the evaluation level of the matter; c_i is the i-th evaluation index ($i = 1, 2, \cdots, n$); $V_{pi} = (a_{pi}, b_{pi})$. denotes the range of values taken by the index on the whole of the level, and it is obvious that $V_{pi} \subset V_{ji}$.

(3) Determine the matter element matrix to be measured

For a certain matter N to be evaluated, the i -th evaluation index c_i takes the value v_i, then the matrix to be measured is:

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$$R_0 = \begin{bmatrix} & c_1 & v_1 \\ & c_2 & v_2 \\ N & c_3 & v_3 \\ & \vdots & \vdots \\ & c_n & v_n \end{bmatrix} \tag{7}$$

(4) Calculate the degree of correlation according to the correlation function

The correlation function represents the extent to which a matter element meets the required range when its quantitave value takes t value of a point on the real axis. The correlation function is a transformational tool for quantitative changes in matters and can represent qualitative problems quantitatively. The relevant formulas for calculating the degree of association $K_j(v_i)$ are as follows:

$$K_j(v_i) = \begin{cases} -\dfrac{\rho(v_i, V_{ji})}{|V_{ji}|} v_i \in V \\ \dfrac{\rho(v_i, V_{ji})}{\rho(v_i, V_{pi}) - \rho(v_i, V_{ji})} v_i \in V_{ji} \end{cases} \tag{8}$$

$$\rho(v_i, V_{ji}) = \left| v_i - \frac{a_{ji} + b_{ji}}{2} \right| - \frac{b_{ji} - a_{ji}}{2} \tag{9}$$

$$|V_{ji}| = (b_{ji} - a_{ji}) \tag{10}$$

In the formulas, $\rho(v_i, V_{ji})$ denotes the distance from each index value v_i to the classical domain interval V_{ji}, while a_{ji} and b_{ji} are the two endpoints of the interval; $\rho(v_i, V_{pi})$ denotes the distance from the index value v_i. to the section domain interval V_{pi}. a_{pi} and b_{pi}. are the two endpoints of the interval.

The degree of association is similar to the degree of affiliation in the fuzzy comprehensive evaluation, according to the criterion of maximum degree of association:

$$K_j(v_i) = maxK_j(v_i), j = 1, 2, \cdots, m \tag{11}$$

Based on this, the evaluation grade of indicator c_i is identified as j. The final comprehensive evaluation grade K_j can be obtained by synthesizing the correlation degree of each indicator with the weight of the indicator to achieve the overall evaluation of the power grid project:

$$K_j = \sum_{i=1}^{n} w_i K_j(v_i), i = 1, 2, \cdots, n, j = 1, 2, \cdots, m \tag{12}$$

In the formula, w_i is the indicator weight, $K_j(v_i)$ is the correlation degree of indicator i on grade j, and K_j is the correlation degree of evaluation target.

4. Empirical Analysis

In this paper, the whole construction process of a 110kV distribution network construction of NX province power grid company is selected as an example to carry out empirical analysis. Combined with the suggestions of relevant experts, the index weight calculation results of the order relationship analysis method are shown in the following table:

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Table 2. Index weight calculation results

Evaluation target	Level 1 indicators	Secondary indicators
Distribution network project cost risk assessment	Technical risk (0.287)	Survey Risk (0.357)
		Design Level and Design Change Risk (0.178)
		Engineering calculation and valuation risk (0.287)
		Construction Risk (0.178)
	Manage risk (0.180)	Professional quality of management personnel (0.0.477)
		Organize and manage coordination risks (0.0.387)
		Information Management Risk (0.0.136)
	policy risk (0.152)	Laws, regulations and technical specifications (0.257)
		Land policy risk (0.385)
		Tax policy risk (0.358)
	economic risks (0.237)	Risk of labor cost and raw material price fluctuation (0.285)
		Risk of equipment and material price fluctuation (0.571)
		Risk of loan interest change (0.144)
		Geological and hydrological condition risk of construction site (0.384)
	natural risk (0.144)	Climate conditions (0.397)
		Natural disaster (0.219)

Based on the extension model, the calculation results of the project cost risk level are as follows:

Table 3. Risk level calculation results

metric	risk grade				Determine the risk level
	N1	N2	N3	N4	
Technical risk	-0.07147	-0.06669	-0.02506	-0.03576	N3
Manage risk	-0.05834	-0.02084	-0.03047	-0.05821	N2
policy risk	0.0441	0.01071	-0.02512	-0.04369	N2
economic risks	-0.09296	0.08672	-0.07235	-0.02908	N4
economic risks	-0.04102	0.02348	-0.01707	0.03617	N3

The comprehensive risk matrix and comprehensive risk value of the first-level indicators of the project is $\{-0.0657, -0.0485, -0.0361, -0.0395, -0.0361\}$, and we can get the comprehensive risk warning level of the cost of the project is N3, which is in a moderate state of early warning in which the technical risk and natural risk is in a moderate state of early warning, the economic risk is in a heavy state of early warning, and the management and policy risk is in a light state, and the managers should attach great importance to the loss of the project's cost caused by the technical, natural, and economic risks.

5. Conclusion

This paper the distribution network engineering cost risk early warning technology based on order relationship-element extension method, Including: first, the distribution network with the construction characteristics of the framework risk assessment index system; Then, the order relationship analysis was used to calculate the weight of each first-level index and each second-level index, Set the risk characteristics and risk levels; Then, to establish the classical domain, Area element and the element to be evaluated; And calculate the single-factor attribution degree of any secondary index to any risk level; Thus, the correlation degree of each secondary index to each risk level is calculated based on the weight of each secondary index, Final calculated correlation for each risk level to be evaluated, Thus, the risk level of the power grid engineering project to be evaluated is obtained.

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