Research on the Analysis of Influence Factors of Power Grid Engineering Cost Based on Cluster Analysis-Interpretation Structure Model

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Abstract. With the continuous expansion of the investment scale of the power grid project, strengthening the project cost management is one of the important means to improve the investment efficiency and efficiency of enterprises. However, the current research on the influence of market factors for the cost is mainly focused on taking passive control means to eliminate or use the change of market factors, however, for the background of the national unified market factors change of power grid engineering construction cost disturbance mechanism is not clear, need further study national unified market factors of the evolution of the developing market characteristics and monitoring methods, and clear the market factors change of power transmission and transformation project cost, conduction and evolution.

Keywords: Power grid engineering, cost factor analysis, cluster analysis, explanatory structural model

1. Introduction

With the acceleration of the construction of a unified national market, the internal and external factors that trigger the cost fluctuation of power transmission and transformation projects have been studied and judged, and the cost transmission mechanism adapted to low-carbon construction has received widespread attention.

Literature [1] on the basis of analyzing the cost control process of the whole process of power transmission and transformation engineering, the grounded theory is used to identify a total of 9 key influencing factors in three categories: early bidding and bidding, construction process control and market environment that lead to project cost deviation, and the ANP-entropy weight method is used to quantitatively analyze the weight of key factors, and then put forward suggestions to control the cost deviation of power transmission and transformation projects and improve the quality and efficiency of cost control. Literature [2] uses the DEMATE method to comprehensively analyze the influencing factors of power grid engineering cost, and reasonably divides the influencing factor levels. Literature [3] identifies the influencing factors of the whole process of cost management by principal component analysis method, determines the factors affecting the cost management of power transmission and transformation projects, and finally gives corresponding countermeasures and suggestions from the perspective of the whole process cost management of power transmission and

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transformation projects based on key elements. Literature [4] expands the cost management of power transmission and transformation projects to the management dimension of all factors, whole life cycle, all-round and full risk, so as to provide reference for the construction of resource-saving and environment-friendly power grids. Literature [5] briefly analyzes the influencing factors of the cost of power transmission and transformation projects, and explains the effective measures of cost control from the decision-making stage, design stage and construction stage. Literature [6] introduces the application methods of system dynamics theory in the analysis of influencing factors. Reference [7] combines factor analysis theory to systematically analyze the main factors that affect the equipment status.

In summary, the current comprehensive analysis of the impact of China's agreed large-market construction on the cost of power transmission and transformation projects is relatively weak, so this paper has the necessity of research.

2. Identification technology of influencing factors of power grid engineering cost based on cluster analysis method

2.1 Basic principles of the cluster analysis method

Clustering is a technique for finding the intrinsic structure between data. Clustering organizes all instances of data into similar groups, and these similar groups are called clusters. Data instances in the same cluster are identical to each other, and instances in different clusters are different from each other.

The basic steps of clustering are as follows:

1) Think of n factors as n classes. Standardize data.

2) Calculate the distance between classes, the class relationship with small distance is close, and the class relationship with large distance is more distant. The distance is calculated as follows:

Euclidean distance:

$$d=\sqrt{\sum(x_i-y_i)^2} \tag{1}$$

3) Repeat steps 2, 3 until all factors are combined into one class.

This step can be easily implemented with the help of SPSS software. Enter data in SPSS, click "Analysis" - "Classification" - "System Clustering", select "Variable" in the "Clustering" box, determine the method in the "Method" option box, click OK to get the result, generally select the output treemap.

2.2 Case analysis

The cost of 220kV overhead line engineering was taken as the research object. The influencing factors have been preliminarily identified as the amount of earth and rock X_1 (cubic meter/foundation), the amount of foundation concrete X_2 (cubic meter/foundation), the amount of tower material X_3 (tons/km), the amount of wire X_4 (tons/km), the amount of foundation steel X_5 (tons/km), the price of tower materials X_6 (10,000 yuan/ton), the price of conductors X_7 (10,000 yuan/ton) and the altitude X_8 (m). The basic data for the 10 samples are shown in Table 1.

Table 1. Data of influencing factors of 220 KV overhead line engineering.

Order number	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8
1	162.18	80.18	42.35	8.54	92	0.8401	16190	300
2	217.56	85.50	0.00	6.88	6	0.0000	14790	9
3	146.97	122.92	35.61	9.73	1244	0.7659	16161	150
4	195.73	261.00	94.01	12.66	130	0.7500	15480	10
5	486.60	329.40	64.28	11.38	106	0.6612	15993	10
6	763.57	246.88	72.51	8.82	60	0.7444	16630	10
7	663.88	159.35	45.43	9.15	297	0.8028	16346	10
8	101.70	53.68	26.47	9.07	288	0.7315	16191	27
9	94.27	36.97	47.10	4.10	80	0.7417	15665	21
10	513.13	268.75	75.59	6.93	190	0.7500	15480	15

SPSS was used for systematic clustering. The Pearson coefficient is chosen for the metric, and the clustering method is intergroup join. The clustering process is shown in Table 2. First, X_2 and X_3 merge into one class. Then, X6 and X7 merge into one class. X_1, X_2, and X_2 then merge, and so on, until all the factors merge into one class. Through the dendrogram, you can clearly understand the clustering process of these 8 factors.

Table 2. Cluster table of influencing factors.

steps	Cluster combination		coefficient	Order clusters appear for the first time		The next order
	Cluster 1	Cluster 2		Cluster 1	Cluster 2	
1	2	3	.757	0	0	3
2	6	7	.734	0	0	6
3	1	2	.529	0	1	4
4	1	4	.385	3	0	7
5	5	8	.296	0	0	6
6	5	6	.273	5	2	7
7	1	5	.052	4	6	0

As for when systematic clustering should stop and classify, it is best to divide factors into several categories, and there is no unified understanding in the academic community. The common method is to classify according to the degree of jumping of the dendrogram and the subjective judgment of the researcher.

Finally, the number of clusters is set as 4, and the factor classification results are:

The first category: foundation concrete, tower material, earth square, wire quantity;

The second category: tower material price, wire price;

The third category: the basic steel volume;

The fourth category: altitude.

The first type of factors are related to the scale of construction and can be regarded as quantity factors; The second type of factor is price factors, which are related to market price fluctuations; The third type of factors is the amount of basic steel, indicating that compared with other engineering quantity factors, the amount of basic steel should be paid special attention, or it may be due to the small sample size, and no typical law of the amount of basic steel has been found; The fourth type of factor is altitude, which is related to the geographical location of the project.

3. Analysis technology of influencing factors of power grid project cost based on explanatory structure model

3.1 Basic principles of the model

Interpretation structure modeling technique (interpretative structural modeling, ISM) was developed by the American scholar J. Warfield Put forward in 1973, is for the analysis of complex social and economic system and develop a system method, its characteristic is to use the correlation matrix principle in graph theory to analyze the overall structure of the complex system, combined with people's practical experience and knowledge, the help of the computer, eventually constitute a multilevel hierarchical structure model, make the status and relationship between the elements within the system is clear at a glance.

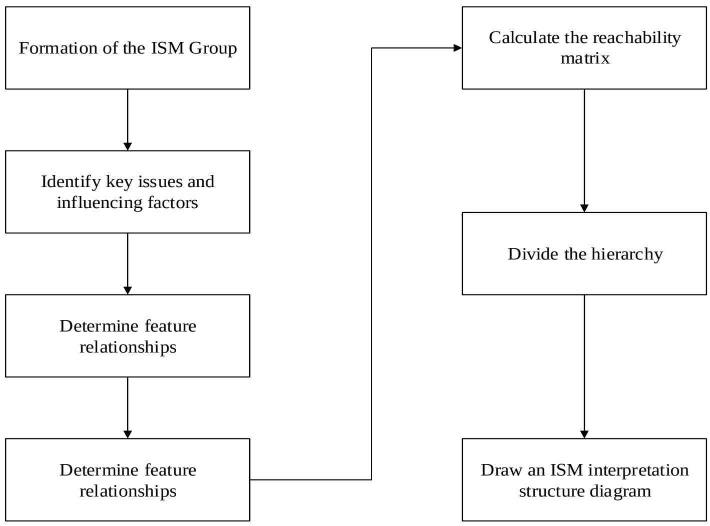

Figure 1. Explains the implementation steps of the structural model.

As shown in Figure 1, ISM should follow the following steps: (1) determine the factors affecting the key problems of the system; (2) list the correlation of various factors; (3) establish the adjacent matrix and accessible matrix according to the correlation of each factor; (4) decompose the accessible matrix and establish the structural model; (5) establish the explanatory structure model according to the structural model and analyze it. The specific implementation steps of explaining the structural model are shown in the figure below:

3.2 Model construction

The adjacency matrix $L = L_{n*n}$ is established based on the system feature association, where n is the number of system features identified, so the value of L_{ij} is used to indicate whether there is an association between the system features, as shown in Equation (1):

$$L_{ij} = \begin{cases} 0, \text{element i has no effect on element j} \\ 1, \text{element i has an impact on Element J} \end{cases} \tag{2}$$

(1) Neighborhood matrix of cost factors influencing the whole process of power grid project

A represents the estimate, B the budget, C the budget, D the cost of the bidding stage, E the cost of the construction stage, and F the cost of the completion stage. Through the discussion among the expert members of the ISM group, the interaction relationship between the six elements is judged. Based on the theory and method of explaining the structural model, the direct effect is recorded as "1", otherwise "0". Building the adjacency matrix can obtain the interaction relationship of the six variables, which is represented by the elements of the adjacency matrix.

(2) Calculation of the accessible matrix

The accessible matrix R is solved according to the adjacency matrix L. The meaning of the accessible matrix is whether there is a direct or indirect influence relationship between the two elements, and if present, the accessible. As shown in the figure below, there is A direct influence between elements A and B, and an indirect influence between elements A and D, so elements A can reach elements B and D.

In the accessible matrix, the value of Rij is used to indicate whether the two elements are accessible, as shown in Equation (3):

$$L_{ij} = \begin{cases} 0, \text{feature i is unreachable and feature j is not reachable} \\ 1, \text{feature i can reach feature j} \end{cases} \tag{3}$$

The accessibility matrix is designed to show the indirect relationship between more intuitive and perfect factors. Reachable matrix refers to whether the interconnected path can reach from one node to another node, indicating the direct or indirect relationship between elements.

(3) The hierarchical division of influencing factors

In this study, the results of huang Wei ISM online computing obtained.

Table 3. Hierarchical division table of influencing factors of power grid project cost.

Level	Influencing factor number
Tier 1	A12,A16,A20
Tier 2	A5,A9,A14,A17,A19
Tier 3	A7,A15,A18
Tier 4	A2,A4,A6,A8,A11,A13
Tier 5	A1,A3,A10,A21,A24
Tier 6	A22,A23
Tier 7	A25,A26,A27

As shown in Table 3, the prime hierarchy operation can make the messy system layout appear in the form of hierarchical ladders according to its binary relationships. So that the "cause-effect" of the system can be displayed in the form of a hierarchical structure diagram at a glance, which is easy to understand and convenient for observing and analyzing the entire system.

4. Empirical analysis

This paper, a power grid project of FJ provincial power grid company is selected as the research object to carry out empirical analysis. Known power grid engineering project: there are 5 single projects, including 110kV substation construction project, opposite side 220k V substation expansion 110kV interval engineering, 110kV line engineering, related OPGW optical cable line engineering and optical transmission system communication engineering. Among them, the total investment of the project feasibility study is 25.8 million yuan, the estimated total investment is 31.4 million yuan, and the total settlement investment is 30.18 million yuan. Based on the analysis of the influencing factors of the whole process of the project, the table of the structure model is shown in Table 4 below:

Table 4. Classification table of the cost influencing factors in each stage of the project.

Serial number	Stage model	Surface factors	Deeper factors	Deep factors
1	Feasibility stage ISM model	First layer:A12,A16,A20 Second layer:A5,A9,A14,A17,A19	Third layer:A7,A15,A18 Fourth layer:A2,A4,A6,A8,A11,A13 A1,A3,A10,A21,A24	Sixth layer:A22,A23 Seventh layer:A25,A26,A27
2	Initial ISM model	First layer:B13,B21,B24 Second layer:B10,B11,B18,B23,B27	Third layer:B9,B12,B14,B17,B22,B25 Fourth layer:B3,B4,B5,B6,B8,B15,B19	Fifth floor:B2,B7,B16,B20 Sixth layer:B1 Seventh layer:B26
3	ISM model during the construction drawing design phase	First layer:C16,C18,C24 Second layer:C14,C17,C23	Third layer:C11,C19,C21 Fourth layer:C2,C6,C8,C9,C12,C22 Fifth floor:C15,C20 Sixth layer:C7,C10	Seventh layer:C3,C5 Eighth layer:C1,C4,C13
4	ISM model at the tender stage	First layer:D8,D12,D14	Second layer:D3,D7,D10 Third layer:D1,D6,D9,D11	Fifth floor:D2,D4,D5 Sixth layer:D13,D15
5	ISM model during the construction	First layer:E9,E13,E16 Second layer:E12,E15,E17,E18	Third layer:E3,E8,E11,E14 Fourth layer:E7,E10 Fifth floor:E2,E4	Seventh layer:E5,E22 Eighth

	phase		Sixth layer:E1,E6,E23	layer:E21,E24 Ninth floor:E19,E20
6	Completion phase ISM model	First layer:F8	Second layer:F6,F7,F9 Third layer:F1,F3	Fifth floor:F2,F4,F5
7	ISM model of the factors influencing the cost of the whole process	First layer:F Second layer:B	Third layer:D Fourth layer:C	Fifth floor:B Sixth layer:A

It can be seen from Table 4 that the factors influencing the cost of power grid engineering at different stages can be divided into different levels, which is convenient for power grid enterprises to formulate targeted control measures and improve the level of cost control and control.

5. Conclusion

Based on the actual situation of power grid engineering construction, this paper constructs the identification technology of cost influence factors based on cluster analysis, which helps power grid enterprises to identify the influencing factors of power grid cost to further help power grid enterprises to determine the level of cost influence factors.

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