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Research on Dynamic Monitoring and Analysis Technology of Substation Engineering Cost Fluctuation Based on Index Theory

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Abstract: Scientific and reasonable project cost forecasting is one of the important means for power grid companies to improve the investment efficiency of power transmission and transformation projects. Based on the analysis of the factors affecting the cost of power transmission and transformation projects, this paper constructs a particle swarm optimization-based power transmission and transformation project cost prediction model, and selects actual engineering cases for empirical analysis to verify the accuracy and effectiveness of the model prediction. The method for predicting the cost of power transmission and transformation projects has good prediction accuracy. It is a reference and reference for improving the cost control level of power transmission and transformation engineering enterprises of the power grid.

Keywords: power transmission and transformation engineering, cost prediction, particle swarm optimization

1. Introduction

As one of the important state-owned backbone enterprises related to the national energy security and the lifeline of the national economy, the power grid enterprises undertake the basic mission of ensuring the safe, economic, clean and sustainable power supply. In recent years, with the deepening of the power system reform, with the change of the international and domestic environment, the new situation of energy development, the rapid development of China's economy and the improvement of people's living standards, higher requirements are put forward for the safety and stability of the power grid, power supply quality and power supply service. The internal and external changes in the operation and management environment of power grid enterprises have undergone great changes, and the investment and construction of power grid power transmission and transformation projects have put forward higher development requirements for cost control. Relevant scholars have conducted more research on the cost management of power transmission and transformation projects.

(1) Analysis of cost influencing factors

Xie Xifei et al. [1] combined the literature analysis method to construct an index system for the influencing factors of each participant in the comprehensive cost management of transmission and transformation projects, and established a structural equation model of the influencing factors of the comprehensive cost management of transmission and transformation projects, and quantitatively analyzed the participation of the parties. The degree of influence of project cost management. Sun Anli et al.[2-3]systematically identified the main factors affecting the project cost from the various stages of the construction of the entire transmission and transformation project, and proposed relevant measures to control the project cost.

(2) cost control and evaluation

Chen Jie et al.[4] first used the multiple regression method to identify the main factors affecting the cost of power transmission and transformation projects; then divided the factors into four categories: scale factors, market factors, project external environmental factors, design technology and construction standard factors; and finally From the three aspects of space, time, concentration, etc., the construction cost rationality evaluation index system is constructed. Yang Yali[5]took the

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Xinjiang power transmission and transformation project as the research and analysis object, combed and analyzed the key influencing factors and cost control points of the Xinjiang power transmission and transformation project in the decision-making, design, bidding, construction and completion stages. The needs of the whole process cost management evaluation of regional projects, combined with the fuzzy analytic hierarchy process, screened and refined the cost management evaluation indicators at various stages, and constructed a set of cost management evaluation index systems for the entire process of power transmission and transformation projects in Xinjiang.

(3) Cost risk control

Ye Jue[6] analyzed the characteristics of the cost management of power transmission and transformation projects based on actual typical cases, and made a reasonable assessment of the risk of cost management and control. Li Guowen et al. [7] collected data in the form of questionnaire survey, used directed clustering analysis method, clustered various risk factors of power transmission and transformation project cost through empirical analysis, and summarized relatively prominent risk factors. Lu Zhongwei et al. [8] first comprehensively identified the cost risk factors of transmission and transformation projects from the three links of decision-making, implementation, and operation, designed a transmission and transformation project cost risk early warning indicator system, introduced the ANP method, and constructed an ANP network with the interaction of early warning indicators. Structure, and determine the index weight. Secondly, use extension theory to build a risk early warning model for the cost of power transmission and transformation projects, determine the risk levels of various indicators and the entire project, and issue early warning signals. Finally, corresponding countermeasures are proposed for the cost risks of different warning levels.

To sum up, the current relevant scholars mainly pay attention to the analysis of cost influence factors, cost risk identification and assessment of cost of power transmission and transformation projects, while the study of cost prediction methods is relatively weak. Based on this paper, the identification method based on fish bone mapping method, determines the influence of the cost, and verifies the effectiveness of the model.

2. Analysis of Factors Affecting the Cost of Power Transmission and Transformation Projects

2.1 Identification of Cost Impact Factors Based on the Fish Bone Mapping Method

(1) Fundamental

The fishbone diagram was invented by Dr. Ishikawa Kain of Japan, so it is also called the Ishikawa diagram. The basic idea is to extract factors from the structure and process of the analyzed object, and then draw each factor into a clearly structured and well-organized graph according to the correlation between the factors. Because the graphics look like fish bones, they are vividly called fish bone diagrams. Fishbone diagram method is a qualitative research method, which is widely used in management, technical and economic analysis and other fields. In actual operation, factors are generally divided into three levels: large, medium, and small. The basic model is as follows:

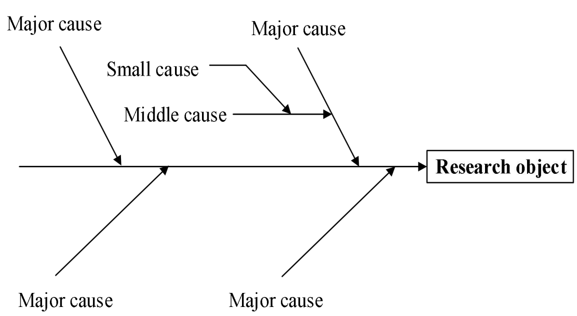

Figure 1. Fish bone map model.

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(2) Application steps

The application of fish bone map is divided into two steps: analysis factors and fish bone map.

1) analytical factor:

For the research subjects, choose the classification method, that is, the main reason.

Use the brainstorming method, the Delphi method and so on to identify all the possible factors in each category.

Organize the factors and clarify the attributes of each factor.

2) draws the fish bone map:

Much current specialized software can now be used to draw fish bone maps, such as visio, XMind et al. Simple fish bone maps can also be drawn in Word and Excel. The drawing is as follows:

The question to be studied is identified on the fish head.

Draw a big bone, fill in the big reason.

On the large bone extension out of the medium bone, small bone, respectively to fill in the cause, small to cause.

Note: When identifying the factors, the better, and then streamline it; in the drawing, the angle with the horizontal line is 60°, the level or 60° according to the clarity and beauty of the overall drawing, for observation and recording.

2.2 Practical Application of Fishbone Diagram Method

When applying the fishbone diagram method to identify the factors affecting the cost of power transmission and transformation projects, factors such as the construction characteristics of different regions and different types of projects should be considered. In this paper, a 110kV overhead line in a transmission and transformation project in a certain area is taken as an example to analyze the practical application of the fishbone diagram method. The identified influencing factors are shown in Figure 2 below.

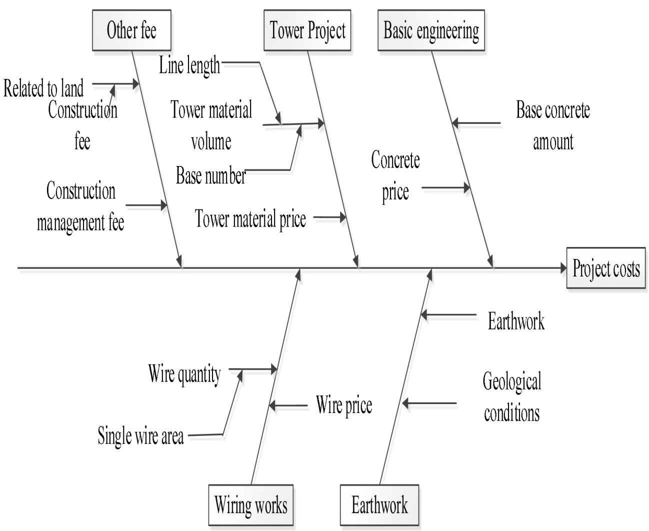

Figure 2. Factors affecting overhead line project cost.

3. Construction of Cost Prediction Model of Power Transmission and Transformation Engineering Based on Particle Group Algorithm

3.1 Basic Principles of the Particle Group Algorithm

The Particle Group Optimization Algorithm (Particle Swarm Optimization, for PSO), an algorithm in population intelligence, first proposed by Kennedy and Eberhart in 1995, is a

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population optimization-based heuristic search algorithm that originated from the simulation of a simple social model.

The proposal of this algorithm is inspired by group phenomena such as birds, colonies, ants, etc. It has a obvious connection to the artificial life theory and the clustering of birds or fish. For example, the colony foraging phenomenon, the random colony, after many round trips, the colony will eventually be able to find the shortest foraging route, which is the inspiration of the colony algorithm. Similarly, the particle swarm algorithm was derived from the study of bird predation behavior, and the location of a food source is only necessary to know the location of the bird closest to this food source. Particle group algorithm is inspired from this model and used to solve the optimization problem. In the PSO algorithm, the potential solution to each optimization problem is a bird in the search space, calling it a "particle". Each particle has an adaptive value (Fitness Value), determined by the objective function to be optimized, and each particle also has a velocity vector, which determines the distance and direction that the particle flies in the search space. In each iteration, the particle updates itself by tracking the individual and global maxima, where it is the optimal value searched by the particle itself to the current number of iterations, and the optimal value searched for the entire population to the current iteration.

Suppose that in a D-dimensional target search space, there are K particles forming a community, and the position of the $i-th$ particle is represented as a vector $x_i = (x_{i1}, x_{i2}, \cdots x_{iD})\ i = 1, 2 \cdots K$.

That is, the position of the $i-th$ particle in the D-dimensional search space is x_i. Each particle is a potential solution, and the fitness value of x_i can be calculated by bringing x_i into an objective function, and the quality of x_i can be measured according to the size of the fitness value. The velocity of the $i-th$ particle is also a D-dimensional vector, denoted as $v_i = (v_{i1}, v_{i2}, \cdots v_{iD})\ i = 1, 2 \cdots K$, and the velocity determines the displacement of the particle per iteration in the search space.

If the optimal position searched so far for the $i-th$ particle is recorded as:

$$Pbest_i = \left(pbest_{i1}, pbest_{i2}, \cdots pbest_{iD}\right), i = 1, 2 \cdots K \tag{1}$$

The optimal position searched so far for the entire particle group is recorded as:

$$Gest_i = \left(Gest_{i1}, Gest_{i2}, \cdots Gest_{iD}\right), i = 1, 2 \cdots K \tag{2}$$

Particles update their speed and position according to the following formula:

$$v_{i+1} = \omega v_i + c_1 rand(0,1)(Pbest_i - x_i) + c_2 rand(0,1)(Gbest_i - x_i) \tag{3}$$

$$x_{i+1} = x_i + v_{i+1} \tag{4}$$

3.2 Method steps

(1) PSO initialization. Set the parameters, determine the particle group size, initialize the position and speed of each particle, and form the matrix.

(2) The optimal position of the group of the particles is assumed. For example, record the optimal position searched for the $i-th$ particle as:

$$Pbest_i = \left(pbest_{i1}, pbest_{i2}, \cdots pbest_{iD}\right), i = 1, 2 \cdots K \tag{5}$$

The optimal position searched so far for the entire particle group is recorded as:

$$Gest_i = \left(Gest_{i1}, Gest_{i2}, \cdots Gest_{iD}\right), i = 1, 2 \cdots K \tag{6}$$

(3) Iterate according to the formula. Find the optimal position through iteration, that is, the optimal solution. The iteration starts from the original position, and the most common one is classification iteration.

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(4) Analysis of the final prediction results. The particle swarm algorithm also needs to be solved on the basis of historical data, and predict the project cost result that you want to know based on the historical data.

(5) The predicted value and the actual value of the fitting analysis, to determine the error. The fitting comparison between the predicted and actual values was made to determine whether the model selected is suitable for such engineering and whether the accuracy of the model meets the requirements.

4. Empirical analysis

This paper takes 40 110kV substation projects in a certain area of our country as an example for empirical analysis. First, combining the fishbone diagram method and the actual characteristics of the sample project, the main factors affecting the cost of the 110kV substation project in the area are identified, including: galvanized steel beams, the sum of the main transformer and the concrete frame of the incoming and outgoing lines, and the sum of the main transformer and the total amount of concrete for the incoming and outgoing lines. Equipment purchase fees. The original data of the sample project is shown in Table 1 below.

Table 1. The data sheet of raw sample engineering.

sample book	Galvanized steel beam （t）	Total of main transformer and access line concrete frame (m^3）	Total amount of concrete of main transformer and incoming and outgoing line foundation (m^3）	original equipment cost (Wan Yuan)	static investment (Wan Yuan)
1	7800	43.6	74.5	2151	3721
2	8000	47.48	66.916	1363	2330
3	8760	54.76	69.53	1711	3095
4	7200	6.782	30.145	797	1054
5	6520	3.4946	18.75	683	904
6	8000	41.97	89.71	1054	1924
7	8000	51.01	76.79	976	2109
8	8000	47.71	90.41	1147	2112
9	8700	10.036	40.528	832	1091
10	7000	5.25	18.75	96	203
11	7200	5.22	20.16	620	800
12	6500	6.15	44.013	803	1053
13	7200	4.25	18.56	893	1181
14	7000	6.41	15.41	547	751
15	7202.32	6.23	18.75	47	70
16	8000	65.107	97.898	929	1650
17	8000	55.415	82.822	916	1844
18	7800	50.79	112.206	1218	2135
32	7800	46.21	76.5	1008	1586
33	7800	55.62	61.93	1073	2024
34	8000	49.31	69.58	911	1944
35	6947	5.78	29.48	60	113
36	7500	46.582	88.487	1250	2109
37	7500	49.78	89.59	913	1800
38	7500	53.913	72.76	1266	2119
39	6800	5.23	70.7406	713	1023
40	7000	4.11	36.4526	531	814

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Combining the sample engineering data, first select the first 35 engineering samples for training, and obtain the applicable particle swarm algorithm prediction model.

It can be seen from the above figure 3 that the actual value of the sample static investment basically coincides with the sample forecast data, and the fitting effect is better, indicating that the model is more accurate and effective. Then predict the remaining 5 samples, compare the prediction results with the actual values, and judge whether the prediction model is accurate and reliable according to the error. The comparison between the predicted results and the actual values is shown in Table 2 and Figure 4:

Table 2. Preast sample data.

sample book	Galvanized steel beam （t ）	Total of main transformer and access line concrete frame (m^3）	Total amount of concrete of main transformer and incoming and outgoing line foundation (m^3）	original equipment cost (Ten thousand yuan)	real investmen t (Ten thousand yuan)	Forecast, investment (Ten thousand yuan)	Predictiv e deviatio n （%）
36	7500	46.582	88.487	1250	2109	2053	-2.66%
37	7500	49.78	89.59	913	1800	1885	4.72%
38	7500	53.913	72.76	1266	2119	2045	-3.49%
39	6800	5.23	70.7406	713	1023	1056	3.23%
40	7000	4.11	36.4526	531	814	786	-3.44%

It can be seen from Table 2 that the model prediction deviation rate is within 5%, and the prediction accuracy is better.

5. Conclusion

Based on the analysis of the factors affecting the cost of power transmission and transformation projects, this paper constructs a particle swarm optimization-based power transmission and transformation project cost prediction model, and verifies the effectiveness of the model through actual cases. The prediction model can provide better prediction accuracy, can effectively guide power grid companies to make investment decisions for power transmission and transformation projects, and can also provide reference and reference for power grid companies to formulate reasonable cost control measures.

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