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Estimation of Manpower Cost Difference of Transmission Line Based on PSO-SVM

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Abstract*:* The rapid and large-scale development of power grid construction puts forward higher requirements for the construction and management of transmission line engineering projects. Implementing refined cost management and cost management will help improve the quality of power engineering infrastructure and avoid engineering cost risks. The pricing model currently used in China still operates around the quota model, resulting in a price difference between the labor fee quota and the market price, which poses a challenge to the cost work. Therefore, this paper establishes different prediction models and uses the transmission line engineering to conduct empirical research. The conclusion confirms that the selected key influencing factors have a strong influence on the total price difference of labor costs. By properly controlling key influencing factors, the gap between fixed labor costs and market labor costs can be reduced. In addition, through the comparative analysis of different prediction models, it is concluded that the PSO-SVM prediction model has the highest prediction accuracy for the total price difference, and the total price difference predicted by this model is the most accurate. The research provides a strong support for strengthening the construction of power grid projects, accurately measuring project cost, controlling labor costs, and achieving lean management.

Keywords Transmission line engineering, PSO-SVM, Labor fee

INTRODUCTION

Power grid construction is critical to the fundamental role of national economic development. [Taylor, *et. al.*, 1987] With the development of social economy and the advancement of science and technology, the demand for electricity is also increasing sharply, and the requirements for power quality are getting higher and higher.[Aylor, 2004] This also promotes the large-scale development of transmission line engineering construction activities to a certain extent. "Since the 11th Five-Year Plan, China State Grid Corporation has increased its investment in power grids, and its power grid construction has achieved remarkable results. From 2005 to 2015, the cumulative investment in power grid infrastructure was 2.77 trillion yuan. The cross-regional transmission capacity during the 13th Five-Year Plan period is expected to reach 370 million kilowatts. [Hu, *et. al.*, 2019] The total investment of the project will reach 3.3 trillion yuan. [L. Hao, *et. al.*, 2018] rge-scale development of power grid construction puts forward higher requirements for the construction and management of power grid projects.[R. Wang, et. al., 2018] He implementation of refined cost management and cost control will help improve the quality of power engineering infrastructure and avoid engineering cost risks.

In recent years, with the increase of labor costs, the proportion of labor costs to total project costs has increased, and engineering cost management faces new challenges. With the continuous reform of China's construction cost, the pricing model has changed from fixed pricing to engineering quantity list pricing. However, regardless of the pricing model, the essence still runs around the quota model. Due to the difference between the quota standard and the market price, there will still be cases where the budget estimates are overestimated, the budget is over budgeted, and the final accounts are over budgeted. There are many factors such as time, space and market conditions change between the labor cost quota of transmission line construction and the market price of labor expense. It is unavoidable to form more or less differences.[Lan, *et. al.*, 2019] At present, the existing treatment methods are to solve this problem by repairing the quota of power construction projects and issuing quota adjustment factors in time. However, compared to the ever-changing labor market, the existing methods cannot fully solve the impact of the spread problem.

Therefore, based on the current research on the causes of labor cost changes in the power industry, this paper accurately identifies the factors affecting the labor cost spread, proposes the exact quantitative indicators, and builds the calculation model of the labor line price difference of the transmission line. The research on the difference between the labor cost quota and the labor cost market price of transmission line construction is helpful to improve the refined management level of transmission line engineering investment, and has reference value for transmission

project management theory research and engineering cost management practice.

RELATED LITERATURE REVIEW

At present, domestic and foreign research on the price difference of labor costs is relatively lacking. Most scholars analyze and discuss the overall project cost or labor cost.

In terms of engineering cost pricing: Singly G,etc.[1] explores the problems in the application process of engineering construction and optimizes the engineering pricing model. LawC ,etc.[2] studied the calculation of the total contract amount and the model of the measurement pricing. He believed that the optimized engineering quantity list pricing model had many benefits for the calculation of the total contract amount. Wood ,etc.[3] believe that the optimization of the price index is affected by the cost management of the contractor and subcontractors at the construction site. Taylor ,etc.[4] believes that the construction price index can be used to predict the project cost index and control the trend of project cost macro, and he believes that the price index forecast is particularly important in the future construction industry. In a study of the engineering price index, Taylor ,etc. [5] pointed out that demand changes can have a guiding effect on the price index, but changes in supply have an impact on the price index over time. For the first time, Fellows ,etc.[6] analyzed the leading variables that can affect the project cost level by regression method. He found that the factors that can have a major impact on the cost level include the industry investment amount, the bank interest rate, the number of contracts awarded, and the production within the industry. Model and construction costs. Paul Bowen ,etc. [7] studied the UK's factors in terms of bid quotation indices and macroeconomic variables. By analyzing the macroeconomic variables and the correlation between the construction industry's cyclical turning point in the price level of change, a series of leading economic variables that can influence the construction price level in the UK are screened out. By studying the trend of the bidding quotation level and the influencing factors of the cost of the cost, Mc Coffer,etc.[8] believes that the mathematical model established by regression analysis using data from the past period of time is closer to reality than the model established by the same analysis using the predicted data.

In terms of cost forecasting: Teicholz Paul ,etc.[9]uses a variety of methods to combine the prediction of the full-life engineering cost process, and the prediction results are very good. Therefore, it is indispensable to predict the project cost reasonably in the control project cost stage. Bulli ,etc.[10] forecasts the total investment in total life projects considering the scope and design changes of the project cost impact.

It can be seen that scholars have researched and improved the engineering cost pricing model and tried to predict the project cost. In this paper, a new forecasting model is proposed for the labor cost in the transmission line engineering cost, combined with the frontier artificial intelligence learning method, to accurately measure the labor cost in the transmission line project, and to control the overall project cost.

METHODOLOGY

GA-BP

"If the holism is correct, then the theory of truth-co BP neural network can theoretically approximate any nonlinear continuous function under the condition of reasonable structure and appropriate weights. It makes use of error gradient descent algorithm to minimize the mean square error between the output value of the network and the actual output value.

The BP neural network consists of input layer, hidden layer and output layer. BP neural network distinguishes itself by the presence of hidden layers, whose computation nodes are correspondingly called hidden neurons of hidden units. The functions of hidden neurons are to connect the input and the network output. Given a training set of input-output data, the most common learning rule for multi-layer perceptron neural networks is the back-propagation algorithm which involves two following phases: the first one is a feed-forward phase in which the external input information at the input nodes are propagated forward to compute the output information signal at the output unit; the second one is a backward phase in which modifications to the connection weights are made based on the differences between the computed and observed information signals at the output units.

In this paper, genetic algorithm is applied to optimize the connection weights of neural networks. GA algorithm is used to optimize the initial weight and search the better solution in the solution vector. BP neural network is used to search for the optimal solution. Firstly, GA is used to generate the optimized value in a certain point, which is taken as the initial weight of BP algorithm, and then trained by BP algorithm, and then controlled by BP neural network. This is the basic principle of GA-BP algorithm. And this method can solve the problem that BP neural network is trapped in local optimum.

PSO-SVM

The support vector machine (SVM) was proposed by Vapnik[11] (1995) . It is a statistical learning algorithm based on VC (Vapnik-Chervonenkis) dimension theory[12] (1971) and structural risk minimization (SRM) principle. SVM has a strong capacity for processing nonlinear data. The basic principle of support vector machines is to find a nonlinear mapping function $\phi(x)$ to make the linear

inseparable data x in the low-dimensional feature space projected into the high-dimensional feature space F to make it a linear separable problem. Then carry out linear regression in the high-dimensional feature space F.

Particle swarm optimization (PSO) is used in this paper. In the optimization process, according to the actual situation of the adaptive particle, the optimal parameters of the support vector machine can be found quickly and accurately by balancing its global search and local search capability dynamically, so as to carry out effective identification. By optimizing the penalty parameter cbest and the kernel function radius parameter gbest with the smallest SVM error, the optimized SVM can be better classified and judged.

EMPIRICAL STUDY

In this paper, the total labor cost difference between the estimated labor cost and the completion settlement of the transmission line engineering is selected as the target variable. The data comes from the transmission line project that has been completed in the provinces of Shanxi, Shaanxi and Henan from 2015 to 2018. The list of items is shown in the figure. According to the calculate formula of quota labor cost: Labor cost = Quota labor consumption * Quota Labor unit price, combined with the relevant literature research, the key influencing factors affecting the engineering quantity and the artificial unit price are selected. The selection criteria are as follows: indicators can well represent and reflect the corresponding factors, the source of indicator data is real and reliable, and the access to indicator data is reliable and feasible. Finally, three factors were selected as explanatory variables: labor cost, line length and construction difficulty. By using neural network and support vector machine to process the variables, the labor cost difference of transmission line construction is measured and the correlation of these factors to the labor cost of transmission line construction is analyzed separately.

Table 1: Spread calculation result

Item	Observed value	GA-BP Predicted value	PSO-SVM Predicted value
1	600629	717172.459	467570.6344
2	1601327	1454183.11	1070107.253
3	783569	760613.379	574146.9087
4	539519	382542.945	434738.9639
5	91896	-974928.81	115231.896
6	16106.44	76243.0307	39733.08131
7	250079	156896.66	229999.9049
8	173392	94679.2202	191470.4674
9	5000	55095.3899	29001.53598
10	6580	168211.541	30711.09916
11	287980	357023.852	264745.609
12	45362	-797487.98	68362.03578
13	301371	114505.085	277676.7156
14	137128	166559.72	158437.6312
15	73404	111483.152	49446.64936
16	54563	55902.6705	77657.29971
17	43321	79103.8159	65998.0974
18	-737588	348819.584	-355348.2161
19	-52861	51053.77	-16675.5

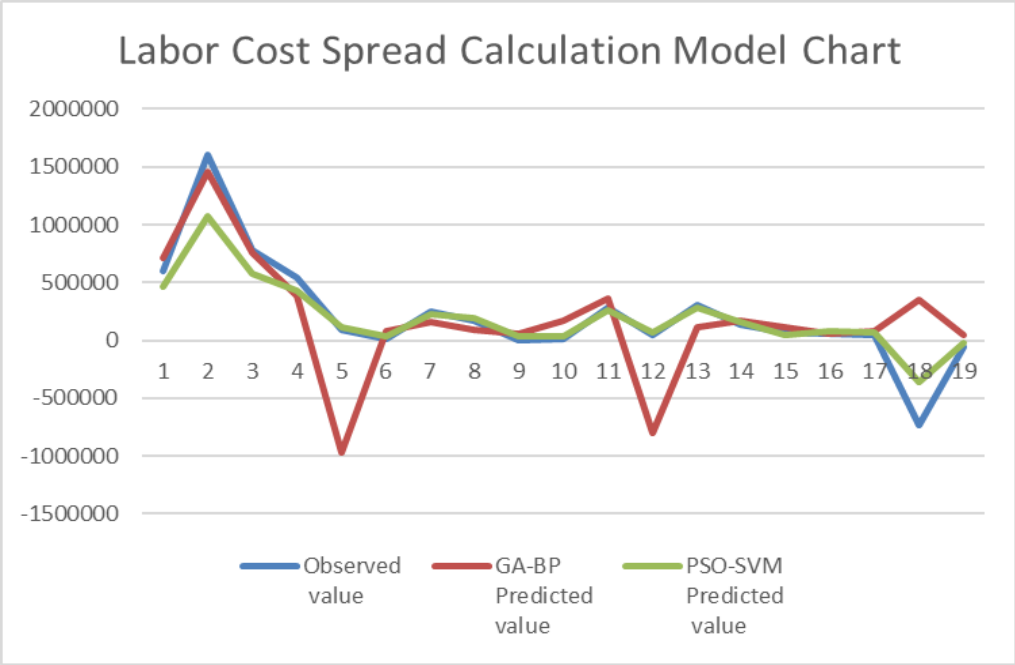

Fig. 1. Labor Cost Spread Calculation Model Chart

Table 2: Error analysis of measurement results

Item	GA-BP	PSO-SVM
1	0.194035684	0.284573829
2	0.09188872	0.496417294
3	0.029296235	0.364753495
4	0.290955563	0.241018277
5	11.60904508	0.202512471
6	3.733699738	0.594634113
7	0.372611615	0.08730045
8	0.453958544	0.094419091
9	10.01907798	0.827595338
10	24.56406391	0.785745213
11	0.239752247	0.087761195
12	18.58052959	0.336444571
13	0.620052742	0.085330469
14	0.214629545	0.134498547
15	0.518761267	0.484509081
16	0.024552729	0.297387365
17	0.82599238	0.34360229
18	1.472919277	1.075676664
19	1.965811642	2.169982005
MAEP	**3.990612341**	**0.473376935**
RMSE	**409775.7322**	**163650.6448**

Therefore, by comparing and analyzing the total price difference of the transmission line construction labor cost with the three variables and two different measurement models established in this paper, the following conclusions can be obtained:

① By comparing the two different calculation models of cost difference, it can be seen that the predicted value of the two kinds of price difference

shows the same change trend as the observed value. The predicted value of GA-BP and PSO-SVM calculation models basically conforms to the observed value, which proves that the key factors extracted in this study have a strong influence on the labor cost of transmission line construction, and these key factors can have a strong influence on the labor cost of transmission line construction；

②Mean absolute percentage error (MAEP) and root mean square error (RMSE) are indicators that characterize the accuracy of the model. The optimal measurement model is tested by comparing the two models MAEP and RMSE. From the above figure, it can be seen from the fluctuation predicted by the model, that is, the stability, that the error fluctuation of pso-svm model is much lower than that of ga-bp model, so its prediction results are relatively stable and of more practical value, which can achieve better prediction effect.

CONCLUSIONS

By establishing different prediction models, this paper conducts empirical research on transmission line projects of different regions, different time periods, different voltage levels, different line sizes and different construction difficulties, and confirms that the three key factors of labor cost unit price, line length and construction difficulty have a strong impact on the total labor cost price difference.

Through reasonable control of key influencing factors, the gap between quota labor cost and market labor cost can be narrowed. In addition, through analysis and comparison of different prediction models, it is concluded that the PSO-SVM prediction model has the highest prediction accuracy for the total spread, and the total spread predicted by this model is the most accurate.

It provides a basis for the establishment of labor costs in transmission line engineering, and provides a strong support for strengthening the construction of power grid engineering, accurately calculating the project cost, controlling labor costs and realizing lean management.

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