Combination forecasting model of equipment and material prices for power grid production technological transformation projects based on unary linear regression and grey theory

He Lin¹, Rong Gaosheng¹, Ma Ning¹, Chen Li¹, Huang Bo¹, Guo Xiaofan²*
¹ Economic and Technological Research Institute, State Grid Xinjiang Electric Power Co., Ltd., Wulumuqi, Xinjiang Uygur Autonomous Region, China
² Powerchina Sichuan Electric Power Engineering CO., LTD., Chengdu, Sichuan Province, China
*Corresponding author’s e-mail: 1182306191@ncepu.edu.cn

Abstract: The purchase cost of equipment and materials occupies a large proportion in the cost of power grid production technological transformation projects, and has a greater impact on project cost control. Therefore, strengthening the management of equipment and material price forecasts and improving the scientificity and accuracy of forecasting methods are important for improving production technology. It is of great significance to improve the cost management of the whole process of the project and improve the lean management level of the investment of power grid enterprises. In this paper, combined with the current situation of equipment and material price forecasting for the production technological transformation projects of power grid enterprises, a combination forecasting model based on unary linear regression and grey theory is constructed, and the validity of the model is verified through empirical analysis.

1. Introduction
At present, most of the forecast methods for the price of power grid equipment materials are mainly based on the published prices of power grid equipment materials regularly released by State Grid Corporation, supplemented by the experience of technical personnel[1]. Forecasting methods are divided into traditional forecasting methods such as trend extrapolation, linear regression and intelligent forecasting methods such as neural networks. Traditional forecasting methods use different mathematical formulas to fit and study the historical changes in the price of power grid equipment materials[2]. The intelligent prediction method is to make predictions through the simulation of historical data with the help of machine learning algorithms. These forecasting methods have their own drawbacks. For example, traditional forecasting methods cannot fit complex nonlinear relationships, neural networks converge slowly and easily fall into local optimal solutions, and cannot obtain global optimal solutions. Support vector regression machines perform kernel functions and penalty factors[3]. The dependence of parameters is high, and the inaccurate selection of parameters has a great influence on the prediction results. At present, in view of the shortcomings of power grid equipment material price forecasting, on the one hand, equipment material price forecasting is mainly based on the actual work experience of technicians, and lacks a certain degree of scientificity; secondly, there are many factors influencing the price of power grid equipment and materials, and scientific research is required. Method for forecasting; finally, because there are many types of
equipment and materials required for power grid construction projects, traditional forecasting methods have drawbacks in data collection and data analysis, and cannot cope with the high-speed and intelligent development trend of power grid construction projects.

2. Analysis of the current situation of equipment and material price forecasts
At present, the forecast of equipment material prices by power grid companies is mainly determined by trend analysis based on historical data of past prices. This method has a certain degree of reliability in short-term equipment material price forecasting[4]. However, in the medium and long term, due to the influence of national economic policies, market supply and demand, and fluctuations in the price of raw materials of the tower itself, this trend prediction has certain limitations and is prone to deviations, which is not conducive to the project cost management in Xinjiang. Long-term development of work. The main forecasting principles are as follows:

(1) Collect and sort out the information on the winning bid prices of equipment and materials in the past. First, multi-stage, cluster sampling is used. Through the sampling method, the corresponding data is found in the six batches of the winning bid prices of the annual State Grid Corporation's centralized bidding. Then use the stratified sampling method to divide the price of each batch of winning bids according to voltage grade, rated capacity, number of phases, transformation ratio, voltage regulation method, structure type, etc.

The price of equipment and materials of the same batch and the same model will be included in the information alternative price of this quarter at the average price; if there is only one batch of bids, and the price is unique, it will be directly used as the information reference price. For example: 750kV single-phase oil-immersed non-excitation autotransformer (500MVA, 750/220/66, horizontal split), this equipment only won the fifth batch of the year, and the same manufacturer won the bid, the price is 13,899,600 yuan. The reference price of this equipment information is 13,899,600 yuan.

(2) After stratified sampling, the equipment materials of the same model and different batches are measured according to the method of percentage weight; taking the 110kV main transformer 50MVA as an example, first compare the price batches won in this year with those in the previous year. Compare the price of batches, as shown below:

It can be seen from the price trend chart of the bid prices of the two-year equipment that the equipment prices are the highest in the first batch, and the fifth batch is the lowest in the whole year. At the same time, it is predicted that the price in the first quarter of this year and the fourth quarter of the previous year will not deviate much from the prices of equipment in the current year, the supply-demand relationship in the equipment market, and the advancement of production technology. The final ratio is 5:3:2, the most recent batch of prices accounted for 50% of the proportion, and so on. If there are only two batches of winning bid prices, they will be charged as 50% of each.

(3) Information reference price after screening
1) The equipment and materials that are more frequently selected have not been tendered this year, and the information prices released by the State Grid Economic Research Institute in the current period are used as a reference.
2) Only a batch of equipment and materials of the same model were recruited this year, and the price is single, which is directly used as the information price.
3) The final price obtained by the calculation method of percentage weight.
4) The information reference price determined after screening is reported to the State Grid Xinjiang Electric Power Company for review and approval at the end of the month of calculation to form a price list of major equipment and materials. The release date is mid-February in the first half of the year and mid-August in the second half of the year.

3. Construction of a combination model of equipment and material price prediction

3.1. Unary linear regression model
Regression Analysis refers to the use of statistical data to analyze the quantitative changes of various variables, and to reflect and describe this relationship in the form of regression equations. Regression analysis is divided into linear regression and nonlinear regression. This section only introduces the commonly used linear regression analysis. If there is only one independent variable involved in the regression analysis, it is a one-variable linear regression analysis, and the result obtained is a linear regression equation. The mathematical model of unary linear regression is:

\[ Y = a + bx \]  

(1)

3.2. Construction of equipment material price prediction model based on gray system theory

The research object of gray system theory is the uncertainty system of "part of the information is known, part of the information is unknown, small sample, poor information". Through the analysis and processing of a small amount of raw data, the development and change law of the generated data is studied, and the gray prediction model is established. To make predictions. This method has simple calculation and high prediction accuracy, and solves the problems that could not be studied in the past due to the lack of data and uncertain information. As one of the important contents of gray system theory, the gray GM(1,1) model does not look for statistical laws, not probability distributions, but treats random variables as gray quantities, searches for laws between data, and makes up for the lack of data processing methods. Is currently the most widely used predictive model for predicting a variable and first-order differential equation.

3.3. Combination model construction

The unary linear regression model and the gray GM (1,1) model are weighted and combined, and the variance-covariance method is used to calculate the combined weight of each method model; the relative value of the combined model and the combined model error is:

\[ f_c = w_1 f_1 + w_2 f_2 \]  

(2)

\[ e_c = w_1 e_1 + w_2 e_2 \]  

(3)

Among them, \( f_c \) is the predicted value corresponding to the combined model, \( e_c \) is the absolute error corresponding to the combined model; \( f_1 \) and \( f_2 \) are the price prediction values of the same equipment and materials at the same time node, respectively, \( e_1 \) and \( e_2 \) are the unary linear regression model and the gray prediction model, \( w_1 \) and \( w_2 \) to predict the absolute error value of the predicted values of the two models; \( w_1 \) and \( w_2 \) are the weight coefficients of the combined model, and \( w_1 + w_2 = 1 \), the combined model is:

\[ f_c = w_1 f_1 + w_2 f_2 \]  

(4)

4. Empirical analysis

This paper takes the iron tower (Q345) as the research object, and selects the tower prices (average price) of the six purchase batches in 2016 and the four purchase batches in 2017 as the original sample data; the steel price index at the same time point of purchase is a linear unity Dependent variables of the regression model construction, carry out the construction of the tower price (Q345) grid combination forecasting model. The basic data is shown in the following table:

| Purchase year | Purchase batch | Average purchase price | Steel price index in the same period |
|---------------|----------------|------------------------|--------------------------------------|
| 2019          | A batch        | 6177                   | 2542.35                              |
|               | Second batch   | 6412                   | 2648.00                              |
Combined with the basic data, the unitary linear regression model, gray prediction model and combination model are respectively used to predict the equipment price. The prediction results are shown in the following table.

Table 2. Model prediction result table.

| Purchase year | Purchase batch | Predicted value of unary linear regression model | Grey model predictive value | Combination model prediction value |
|---------------|----------------|-----------------------------------------------|----------------------------|-----------------------------------|
| 2019          | A batch        | 6177                                         | 6177                       | 6177                              |
|               | Second batch   | 5946.13                                      | 6786.24                    | 6366.185                          |
|               | Three batches  | 6077.52                                      | 6512.52                    | 6295.02                           |
|               | Four batches   | 5911.67                                      | 6511.67                    | 6211.67                           |
|               | Five batches   | 6248.64                                      | 6848.64                    | 6548.64                           |
|               | Six batches    | 6788.5                                       | 7188.5                     | 6988.5                            |
|               | A batch        | 6931.3                                       | 7331.3                     | 7131.3                            |
|               | Second batch   | 6977.1                                       | 7277.1                     | 7127.1                            |
|               | Three batches  | 7225.97                                      | 7225.97                    | 7225.97                           |
|               | Four batches   | 7077.97                                      | 7577.97                    | 7327.97                           |

It can be seen from the above table that the average deviation of the predicted value of the unary linear regression model is about 3.17%; the average deviation of the predicted value of the gray model is about 3.64%; the deviation of the predicted value of the combined model is about 0.82%, indicating that the predicted result of the combined model is determined to be better.

5. Conclusion
In this paper, combining with the current situation of the management of equipment and material prices in power grid enterprises, a combined prediction model based on unary linear regression and gray theory is constructed, and the effectiveness of the combined model is verified through empirical analysis. The combined forecasting model can improve the accuracy of equipment and material price forecasts for power grid enterprises, thereby improving the cost control level of production technological transformation projects.

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