

# Neural network-based logistics and distribution cost prediction of maintenance equipment

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**Abstract.** Accurate prediction of maintenance equipment logistics and distribution costs can help enhance the competitiveness of enterprises. In order to obtain higher accuracy prediction results, a neural network logistics and distribution cost prediction method of maintenance equipment was proposed, based on historical data, the learning sample of maintenance equipment logistics distribution cost prediction was established through transformation technology, and the BP neural network was introduced to train the learning sample. The change characteristics of maintenance equipment logistics and distribution cost were fitted, so as to realize the cost prediction. The results show that the prediction accuracy of the BP neural network is not only more than 5% higher than that of the gray model on average, but also the prediction stability is better.

**Keywords:** Maintenance equipment; Cost forecasting; Neural networks; Logistics cost.

## 1. Introduction

Maintenance equipment refers to all devices and materials used for equipment maintenance, which is the basis for equipment maintenance<sup>[1]</sup>. The logistics and distribution cost control helps enterprises improve economic benefits and improve their competitiveness, so it is of great significance to study the prediction of logistics and distribution costs of maintenance equipment. Many factors are involved in the logistics and distribution cost of maintenance equipment, which has significant nonlinear change characteristics, and the prediction accuracy of the traditional model is poor. The scope of application is not broad<sup>[2-4]</sup>. The BP neural network is typically applied to predict the logistics cost, and scholars at home and abroad have made a lot of attempts and achieved specific results. Wang et al.<sup>[5]</sup> introduced particle swarm optimization to optimize the logistics distribution cost estimation model, improve the prediction accuracy, and provide reference value for logistics distribution cost management. Sun<sup>[6]</sup> used the activity costing method and BP neural network to predict the railway freight cost, and the results were better than the gray system prediction method. The PCA-EBP neural network model proposed by Wang Lijuan et al.<sup>[7]</sup> has high accuracy in the exact prediction of coal logistics costs, and can better meet the actual needs of coal logistics cost prediction. Zhang et al.<sup>[8]</sup> predicted the logistics cost in the region based on the improved gray BP neural network, and achieved satisfactory results.

## 2. Cost forecasting methodology

### 2.1 Factors influencing the logistics and distribution cost of maintenance equipment

There are many factors that affect the prediction results of maintenance equipment logistics and distribution costs, mainly including: inventory costs, transportation costs, management costs, number of vehicles, weather factors, etc. In this paper, six main factors are selected as the input vectors of the logistics and distribution cost prediction model of BP neural network, as shown in Table 1.

Tab.1 Factors influencing logistics and distribution costs

Influencer number	name
$x_1$	Inventory cost

$x_2$	Unit shipping cost
$x_3$	Shipping distance
$x_4$	Manage cost
$x_5$	Number of vehicles
$x_6$	The total amount of equipment distributed

## 2.2 BP Neural Network

The BP neural network, known as the backpropagation neural network, is a multi-layered forward propagation neural network that is divided into three layers: the input layer, the hidden layer, and the output layer<sup>[9]</sup>. Each layer contains a certain number of neurons, with the neurons between the adjacent layers connected and the neurons in the same layer not connected. Based on this, a neural network system is formed, as shown in Figure 1.

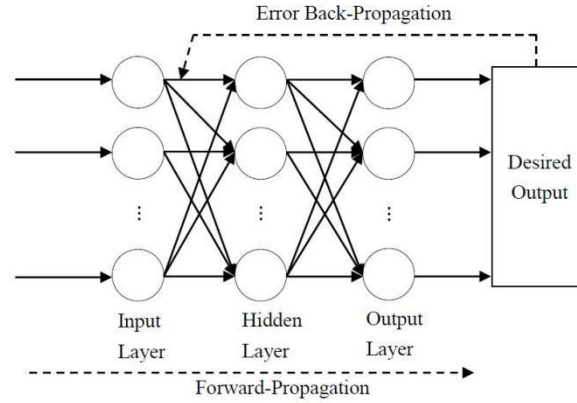


Fig.1 BP neural network model

In general, there is an inevitable error between the actual output value of the neural network and the expected output value, and the error  $E_k$  expression is

$$E_k = \frac{1}{2} \sum_{i=1}^q (d_i - y_i)^2 \quad (1)$$

thereinto,  $E_k$  Indicates the error value,  $q$  indicates the number of neurons in the output layer,  $d_i$  represents the expected output value of the  $i$ th neuron in the output layer,  $y_i$  represents the actual output value of the  $i$ th neuron in the output layer.

The expression of the function between the layers of the BP neural network is

$$y_i = f \left( \sum_j w_{ji} x_j + \theta_i \right) \quad (2)$$

## 2.3 Learning sample setup

Firstly, the logistics and distribution cost data of maintenance equipment is converted into a form recognized by the neural network. Let the influencing factor of maintenance equipment logistics distribution cost be  $n$ , and the number of maintenance equipment logistics distribution cost value is  $m$ , that is, the logistics distribution cost of maintenance equipment and the influencing factors can form the following mapping relationship.

$$\begin{bmatrix} x_{11} & \cdots & x_{1n} \\ \vdots & \ddots & \vdots \\ x_{m1} & \cdots & x_{mn} \end{bmatrix} \rightarrow \begin{bmatrix} c_1 \\ \vdots \\ c_m \end{bmatrix} \quad (3)$$

Taking the influencing factors of maintenance equipment logistics distribution cost as the input vector and the maintenance equipment logistics distribution cost as the output vector, the BP neural network uses the input and output sample sets to learn and correct the weights and thresholds of the network, fits the mapping relationship between the logistics distribution cost of maintenance

equipment and the mapping of influencing factors, and establishes a prediction model of maintenance equipment logistics distribution cost.

## 2.4 Determination of BP neural network structure

Before creating a model for predicting the cost of logistics and distribution of maintenance equipment, it is necessary to determine the structure of the BP neural network, where the number of neural nodes in the input layer is determined by the number of factors affecting the cost of logistics and distribution of maintenance equipment, i.e.,  $n=6$ , and the number of neural nodes in the hidden layer is usually determined by equation (4), since the output value is the value of the logistics distribution of maintenance equipment, i.e.,  $m = 1$ .

$$j = \sqrt{n + m} + \alpha \quad (4)$$

The essential expression of the neural network activation function is

$$f(x) = \frac{1}{1+e^{-x}} \quad (5)$$

## 2.5 Prediction steps

Step 1 Select the influencing factors of maintenance equipment logistics and distribution cost and discrete them;

Step 2 Collect historical data on the logistics and distribution cost of maintenance equipment and establish a learning sample;

Step 3 initialize the corresponding parameters according to the BP neural network structure determined by the learning sample;

Step 4 The BP neural network is trained. When the error reaches the expectation, a prediction model for the logistics and distribution cost of maintenance equipment is established, as shown in Figure 2.

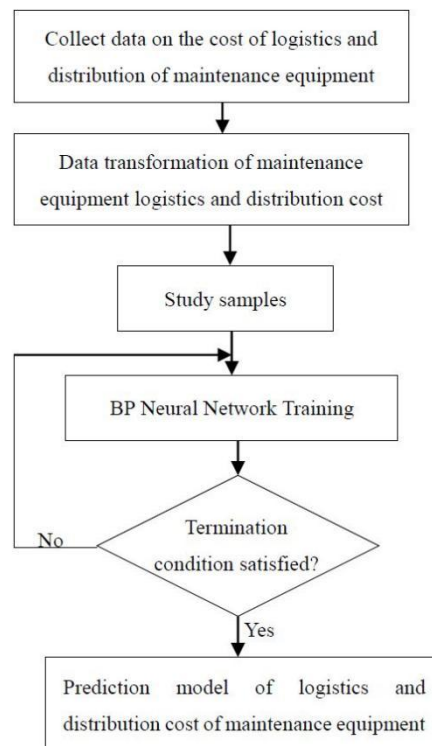


Fig.2 BP Neural Network Repair Equipment Logistics Distribution Cost Prediction Process

### 3. Simulation analysis

#### 3.1 Data set

In order to test the performance of the maintenance equipment logistics distribution cost prediction model proposed in this paper, 100 historical data of maintenance equipment logistics distribution cost were selected as the test objects, the variation curve is shown in Figure 3. At the same time, the gray model of the logistics distribution cost prediction method of maintenance equipment was selected for comparative experiments.

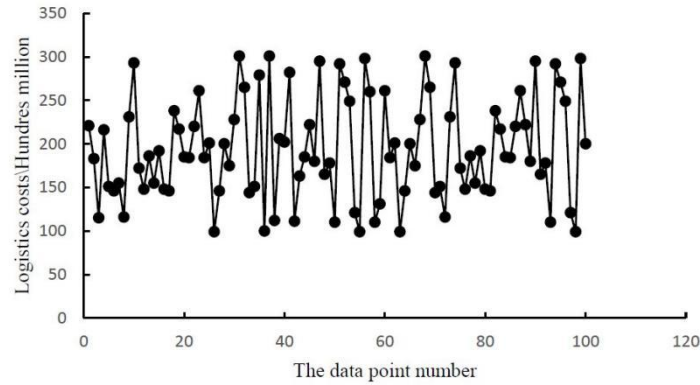


Fig.3 Repair equipment logistics distribution cost data set

#### 3.2 Comparison of prediction accuracy

90 data were randomly selected as test samples, and 5 test experiments were carried out by 2 methods, and the statistical results of the prediction accuracy of logistics and distribution cost of maintenance equipment are shown in Figure 4.

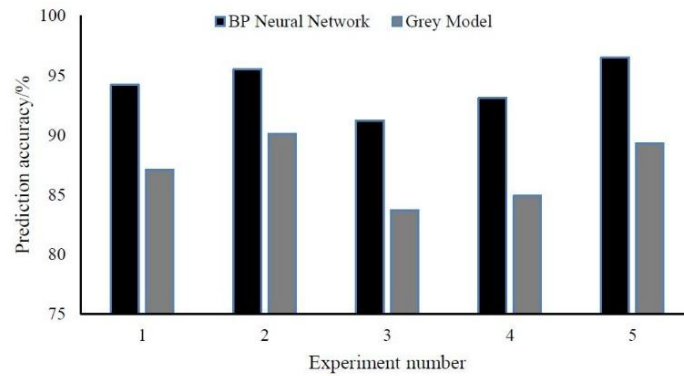


Fig.4 Comparison of prediction accuracy

By observing the comparison chart of the prediction accuracy of the two methods, it can be found that the prediction accuracy of BP neural network is generally better than that of the gray prediction model, and the prediction error is effectively reduced by using BP neural network to predict the logistics and distribution cost of maintenance equipment.

#### 3.3 Predict efficiency

Table 2 shows the two methods of BP neural network and grey model to predict consumption time. Obviously, BP neural network maintenance equipment logistics and distribution cost prediction is more efficient.

Tab.2 Predict consumption time

Number of trials	BP Neural Network	Gray model
1	13.5	33.5
2	12.9	26.9
3	15.8	24.6
4	13.7	23.8
5	14.2	24.1

#### 4. Summary

This paper uses the PB neural network model to make a preliminary attempt to predict the logistics and distribution cost of maintenance equipment, because there are many factors involved in the logistics cost of maintenance equipment, and there is no separate accounting and recording of the logistics cost of maintenance equipment in the financial system, many factors cannot be quantified, and it is difficult to obtain sample data. Further research is needed on how to introduce more variables and improve the logistics cost prediction index system of maintenance equipment.

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