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Research on Neural Network of Enterprise Raw material production and Transportation based on Multi-objective programming

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Abstract: *This paper mainly studies how to make an order plan and arrange a transfer plan when the future supply capacity of the supplier is uncertain. On the basis of reasonably using the neural network algorithm to predict the future supplier supply capacity, a single objective optimization model based on 0-1 programming is established. First of all, this paper selects ten representative indicators from four aspects: the supply capacity of suppliers, the demand intensity of enterprises for materials, the supply sustainability of suppliers and the relationship between the company and suppliers, and carries on the principal component analysis. 402 suppliers were ranked. Then, based on the neural network algorithm, the maximum supply capacity of the supplier in the next 24 weeks is predicted according to the supplier's supply data in the past 5 years, and the regression accuracy is more than 90%. A 0-1 programming model aiming at the minimum weekly supply is established, with the weekly production capacity as the lower limit and the supplier's maximum supply capacity as the upper limit. The minimum number of suppliers per week is as follows: at least 44 suppliers are selected to supply raw materials. Considering the distribution of the specific order number of each supplier, the ratio method is used to determine the weight of the supplier, so as to define the weight production function, and order according to the way of maximizing the weight production function.*

Keywords: *Principal component analysis, Neural network prediction, 0-1 programming model*

1. Introduction

The ordering and transportation of raw materials in manufacturing enterprises start from the purchase of materials. In practice, enterprises usually select high-quality suppliers with stable supply and demand according to the index of material price, order delivery capacity and so on. Select the transporters with good transport performance according to the maximum transport volume and the degree of material loss [1], and then work out the ordering and transshipment plan to effectively reduce the enterprise cost, ensure the enterprise production and improve the enterprise production capacity, in order to enhance the competitive advantage, it is of great strategic significance to achieve complementary interests and win-win cooperation.

2. Construction of evaluation index system

2.1. Model building

In this paper, eight evaluation indicators are extracted, and then principal component analysis is used to transform the variables with high correlation into independent or unrelated variables to achieve the effect of dimensionality reduction. Finally, according to the selected indicators, the 402 suppliers were scored and ranked, and the target suppliers were selected [2].

Set the variable of the indicator of the supplier as x_{ij} , and now standardize the value of each indicator.

$$x_{ij} = \frac{x_{ij} - \bar{x}_j}{s_j} \left(i = 1, 2, \ldots\ldots, 12,\ j = 1, 2, \ldots\ldots, 402\right) \tag{1}$$

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$$\bar{x}_j = \frac{1}{n}\sum_{i=1}^{n} x_{ij}, s_j = \sqrt{\frac{1}{n-1}\left(x_{ij} - \bar{x}_j\right)^2} \left(j = 1, 2\ldots\ldots, 402\right)$$

Calculate correlation coefficient matrix $R = \left(r_{ij}\right)_{12*12}$.

$$r_{ij} = \frac{\sum_{k=1}^{n} \tilde{x}_{ki} - x_{kj}}{n-1} \left(i, j = 1, 2, \ldots\ldots, 12\right) \tag{2}$$

$r_{ii} = 1, r_{ij} = r_{ji}, r_{ji}$ is the correlation coefficient between the first indicator and the first indicator.

Calculate the eigenvalues of the correlation coefficient matrix $\lambda_1 \geqslant \lambda_2 \geqslant \lambda_3 \geqslant \ldots\ldots \geqslant \lambda_{12} \geqslant 0$, and corresponding eigenvectors, where $u_j = \left(u_{1j}, u_{2j}, \ldots\ldots, u_{nj}\right)^T$ .The new m index variables are composed of feature vectors. Calculate the eigenvalues $\lambda_j \left(j = 1, 2, \ldots\ldots, m\right)$ [3], the information contribution rate and cumulative contribution rate are called the information contribution rate of the main component. Formula is as follows:

$$b_j = \frac{\lambda_j}{\sum_{k=1}^{m} \lambda_k} \left(j = 1, 2, \ldots\ldots, m\right) \tag{3}$$

The cumulative contribution rate of main components is defined as follows:

$$\alpha_p = \frac{\sum_{k=1}^{P} \lambda_k}{\sum_{k=1}^{k} \lambda_k} \tag{4}$$

The overall score is calculated:

$$Z = \sum_{j=1}^{P} b_j y_j \tag{5}$$

2.2. Solution of model

After the principal component analysis of the initial 10 indexes by using MATLAB software, the eigenvalues, contribution rate and cumulative contribution rate of the correlation coefficient matrix are obtained[4][5]. According to the above data, six indexes are selected, and the variable coefficients are calculated respectively, and then 402 enterprises are scored by using the above model, and finally the score ranking of 402 enterprises is solved.

Table 1: Ranking of the top 50 suppliers

S007	S307	S139	S067	S247
S114	S329	S140	S076	S268
S123	S348	S308	S080	S284
S143	S352	S330	S086	S294
S150	S031	S338	S129	S306
S229	S040	S340	S151	S314
S266	S055	S346	S194	S356
S275	S098	S364	S213	S361
S282	S108	S367	S218	S365
S291	S131	S003	S244	S374

3. Construction of optimal order quantity Model

The 0-1 variable was introduced to quantitatively analyze whether the company chose the i_{th} supplier in week j. According to the question, at least one supplier should be selected in week J to meet the

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production demand:

$$F(x)_j = \min \sum_{i=1}^{50} A_{ij} \tag{6}$$

The objective function is:

$$F(x) = \max\left\{F(x)_j\right\} \quad (j = 1, 2, \ldots, 24) \tag{7}$$

In this paper, the neural network model fitting regression is carried out by MATLAB software. On this basis, the supply capacity of 50 suppliers in the next 24 weeks is obtained

Let S_{ij} be the quantity of product that can be produced from the material supplied by the supplier in week J of the ordering scheme. According to the forecast, let S_{ijmax} be the maximum quantity of products that can be produced by the material provided by the supplier in week J. Since the quantity of the material ordered by the ith supplier in week J shall not exceed the maximum quantity of the product predicted, then the constraint conditions S_{ij} shall be as follows:

$$S_{ij} \leqslant S_{ij\max} \tag{8}$$

4. The Construction of the Model of loss rate

In addition, due to the loss in the process of transport, the actual receiving quantity of the enterprise is always less than the supply quantity of the supplier. Different carriers have different attrition rates. In order to determine the minimum number of suppliers while ensuring the normal and continuous production of the enterprise, this paper considers the worst transshipment situation.

Using statistical knowledge, the maximum of the past attrition rate of 8 carriers was used to represent the maximum attrition rate $B = 1 - M_{\max}$.

Then, after the material arrives in week j, the product that can be produced by the material in week j is

$$P = \sum_{i=1}^{50} A_{ij} S_{ij} B \tag{9}$$

There is a second constraint

$$P_j = \sum_{i=1}^{50} A_{ij} S_{ij} B \geqslant 28800 \tag{10}$$

Constraints exist two: one is because of the levels is usually less than the quantity of goods and loss, so the company receives the materials to produce the number of products is not lower than the enterprises weekly capacity requirement is 28800 cubic meters, the second is every materials provided by the supplier shall not be greater than the number of material suppliers can afford a maximum of, namely model as constraint conditions

$$\left\{\begin{array}{l} P_j = \sum_{i=1}^{50} A_{ij} S_{ij} B \geqslant 28200 \\ S_{ij} \leqslant S_{ij\max} \end{array}\right. \tag{11}$$

By ergodic method, $F(x)_j$ can be obtained. This article selects the maximum number of suppliers from the minimum number required per week:

$$F(x) = \max\left\{F(x)_j\right\} \quad (j = 1, 2, \ldots, 24) \tag{12}$$

For the suppliers obtained above, we might as well set the order as 1~J+K+L, and stipulate that Class A suppliers are the first J, Class B suppliers are J + 1~J+K, and Class C suppliers are J+K+1~J+K+L. S_{ijmax} is used to express the quantity of products that can be produced according to the materials provided by the predicted I supplier in week j, which is called the upper limit of the quantity of products produced.

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For the above-mentioned J+K+L suppliers, the enterprise will place orders to the above-mentioned suppliers every week in the next 24 weeks. However, the order quantity of week J is still limited by the upper limit supply capacity of the supplier in week J

$$S_{ij} \leqslant S_{ij\max} \tag{13}$$

The order cost formula of week j is:

$$W = YC_A y_{Aj} + YC_B y_{bj} + YC_C y_{cj} \tag{14}$$

The ratio of the three is 1.2:1.1:1.

5. Optimization model of supplier allocation

Define the weighted production function. Let F_i be the weighting coefficient for the ith supplier to be selected

$$F_i = P_i / P_{total} \tag{15}$$

The weighted production function is

$$f(x)_j = \sum_{i=1}^{J+K+L} F_i S_i \tag{16}$$

The objective function is to minimize cost:

$$\min W = \min\left(YC_A y_A + YC_B y_B + YC_C y_C\right) \tag{17}$$

The second objective function is the maximum weight production function

$$\theta(x) = Max \sum_{i=1}^{J+K+L} F_i S_{ij} \tag{18}$$

6. Model solution

In this paper, MATLAB is used to solve the problem and it is found that at least 44 suppliers are needed to meet the production needs.

This paper considers the ordering scheme to be the most economical with the transhipment scheme (see Annex A).In this paper, the substitution analysis is carried out between the result data and random extraction of 9 groups of data, and it is found that the results of random extraction of several groups of data within the constraint conditions are not optimal. Only the first group of result data can reach the "most economic" as required by the title, and the transport cost is the least. Therefore, this paper believes that this kind of transshipment scheme is the best.

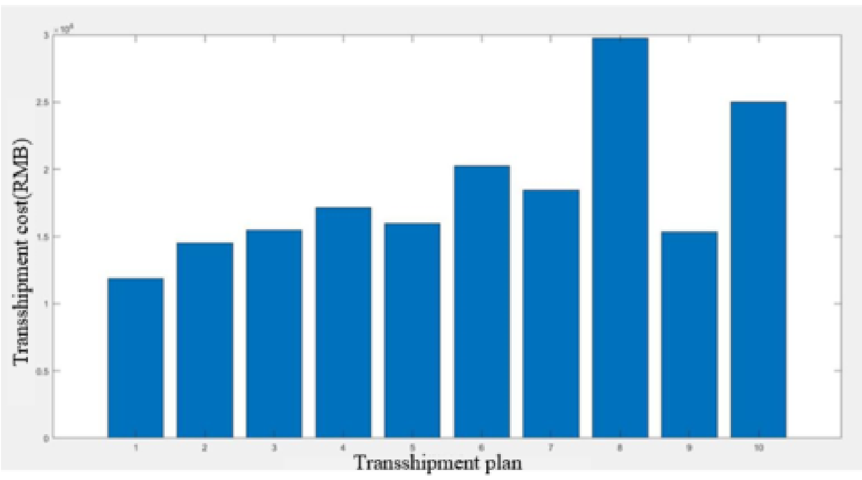

Figure 1: Optimal transfer scheme

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After BP neural network prediction and solution by MATLAB, figure below is obtained. It can be seen that R value is 0.9532, with good fitting degree and reference value.

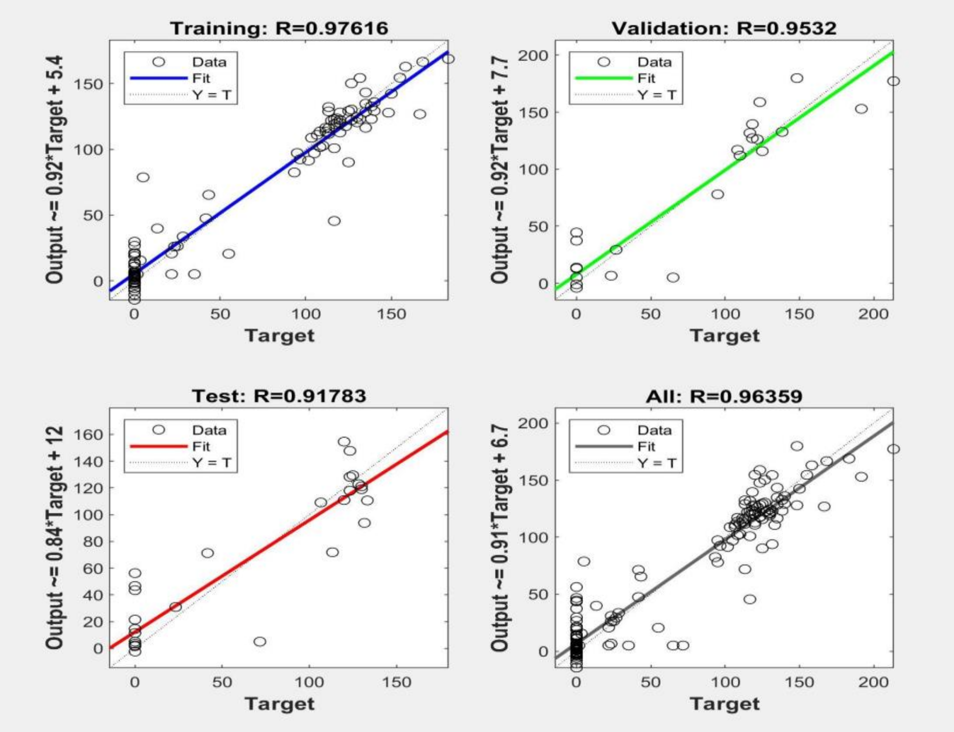

Figure 2: The result of R value of BP neural network prediction

7. Conclusion

In order to select the most important supplier to ensure the normal production of the enterprise, this paper selects ten representative indicators from four aspects: the supplier's supply capacity, the enterprise's demand for materials, the supplier's supply sustainability and the relationship between the company and the supplier, and carries on the principal component analysis. 402 suppliers are graded and sorted. Then the neural network sour rice is used to solve the single-objective programming problem, and the maximum supply capacity of the supplier in the next 24 weeks is predicted according to the supplier's supply data in the past 5 years, and the regression accuracy is more than 90%. And through the 0-1 planning method, taking the weekly production capacity as the lower limit and the maximum supply capacity of suppliers as the upper limit, the minimum number of suppliers per week is as follows: at least 44 suppliers are selected to supply raw materials.

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