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Supplier Production Importance Evaluation Model Based on RSR Comprehensive Evaluation Method and TOPSIS Method

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Abstract: This paper studies the production plan of an enterprise and the historical data of many suppliers, and puts forward a reasonable ordering and transportation prediction scheme for the enterprise according to different situations. Firstly, we standardized the data of 402 suppliers to calculate the total value, square error and normalized value of supply quantity and order quantity. Then select five indicators: supply stability capacity, total supply quantity, supplier supply capacity, raw material consumption and raw material unit price, and score the importance of suppliers respectively by RSR rank sum ratio comprehensive evaluation method and TOPSIS method. Finally, calculate the average value of the two scores and select the top 50 with the highest score as the result.

1. Introduction

The purchase and transportation cost of raw materials is a direct factor affecting the production efficiency of an enterprise. According to the purchase data records of an enterprise with 402 material suppliers in five years, through the quantitative analysis of the supply data records of each supplier, a mathematical model is established to reflect the importance of each supplier to ensure the production of the enterprise, so as to determine the most important 50 raw material suppliers.

First, integrate the data: normalize the raw material consumption, unit price, total demand, variance of demand, total supply and variance of supply in Python. The ratio between the total supply quantity and the order quantity is calculated to represent the supply capacity of the supplier. The greater the ratio, the higher the supply capacity. Then, the supply stability capacity (supply variance), total supply capacity, supplier supply capacity, raw material consumption and raw material unit price are selected as indicators, and the importance of suppliers is scored by RSR (rank sum ratio comprehensive evaluation method) and TOPSIS (good and bad solution distance method). Finally, the average score of the two is taken as the final score to rank 402 suppliers, the top 50 suppliers are the most important suppliers.

2. Model Establishment and Solution

2.1 Model Preparation

For this problem of multi index and multi unit evaluation at the same time, we choose to use RSR (rank sum ratio comprehensive evaluation method) and TOPSIS (good and bad solution distance method) in the comprehensive evaluation method to evaluate the importance of suppliers.

Because the units of various indicators are different, the data should be normalized before establishing the required mathematical model, and then the comprehensive indicators should be calculated. Therefore, we set the consumption of raw materials A, B and C per cubic meter of product as 0.60, 0.66 and 0.72 respectively, and set the unit price of raw materials A, B and C per cubic meter as 120, 110 and 100 respectively according to the proportion given in the title stem.

(1) Variance R1 of order quantity calculation:

$$R_1 = \frac{\sum_{i=1}^{N}(X_i - \bar{X})^2}{N} \tag{1}$$

Where X_i represents the order quantity of the enterprise in week i; $\bar{X}$ represents the average order quantity in these 240 months.

Variance R2 of calculated supply quantity:

$$R_2 = \frac{\sum_{i=1}^{N}(X_i - \bar{X})^2}{N} \tag{2}$$

Where X_i represents the supply volume of a supplier in week i; $\bar{X}$ represents the average value of supply in these 240 months.

(2) Normalization r:

$$r = \frac{(X - X_{min})}{(X_{max} - X_{min})} \tag{3}$$

(3) Entropy weight method for weight [1]:

Step 1: standardization of indicator data

We selected five factors as indicators: total supply (sum_2), ratio of supply to order (rate), variance of total supply (r_2), material demand (use) and material cost (money). Standardize them respectively.

Step 2: calculate the information entropy of each index

$$p_{ij} = \frac{Y_{ij}}{\sum_{i=1}^{n} Y_{ij}} \tag{4}$$

$$e_j = \frac{-\sum_{i=1}^{n} p_{ij} \ln p_{ij}}{\ln(n)}, j = 1,2,\cdots 5 \tag{5}$$

The information utility value is:

$$d_j = 1 - e_j \tag{6}$$

Step 3: determine the weight of each index:

$$w_j = \frac{1 - e_j}{m - \sum_{j=1}^{m} e_j} \tag{7}$$

Table 1: Processed data

Item	Information entropy(e_j)	Information utility value(d_j)	weight
sum_2	0.85415957	0.14584043	0.33858804
rate	0.97821232	0.02178768	0.05058302
r_2	0.99520792	0.00479208	0.01112546
money	0.87022044	0.12977956	0.30130058
use	0.87146857	0.12853143	0.29840290

2.2 Model Solution

(1) RSR (rank sum ratio comprehensive evaluation method)

Step 1: rank the original data table

In this paper, the whole rank sum ratio method is used to rank the evaluation object. The benefit index in the original data is ranked from small to large, the cost index is ranked from small to large, and the same index data is ranked as the average rank. Among the five indicators we selected in this paper, the cost indicators are variance of total supply (r_2), material demand (use) and material cost (money); Benefit indicators include total supply (sum_2) and ratio of supply to order (rate). Accordingly, we rank the index data R_{ij}.

Step 2: calculate the rank sum ratio and sort it

When calculating the rank sum ratio, only the relative size and weight of the data are considered without using specific values. The calculation formula is:

$$RSR_i = \frac{1}{n}\sum_{j=1}^{m} w_j R_{ij} \tag{8}$$

Where w_j is the weight of the j-th index. According to the calculated RSR value, 402 suppliers are evaluated and ranked, and the top 60 suppliers are obtained.

(2) TOPSIS (good and bad solution distance method)

Step 1: construct normalization matrix

There are 402 evaluation objects in total, and each object consists of 5 evaluation indexes. The original matrix is constructed as follows:

$$\begin{bmatrix} X_{11} & X_{12} & X_{13} & X_{14} & X_{15} \\ X_{21} & X_{22} & X_{23} & X_{24} & X_{25} \\ \cdots & \cdots & \cdots & \cdots & \cdots \\ X_{n1} & X_{n2} & X_{n3} & X_{n4} & X_{n5} \end{bmatrix} \tag{9}$$

Construct weighted gauge matrix:

$$z_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{n} x_{ij}^2}} \tag{10}$$

The normalized matrix is:

$$Z = \begin{bmatrix} Z_{11} & Z_{12} & Z_{13} & Z_{14} & Z_{15} \\ Z_{21} & Z_{22} & Z_{23} & Z_{24} & Z_{25} \\ \cdots & \cdots & \cdots & \cdots & \cdots \\ Z_{n1} & Z_{n2} & Z_{n3} & Z_{n4} & Z_{n5} \end{bmatrix} \tag{11}$$

Step 2: determine the positive ideal solution and negative ideal solution

The positive ideal solution Z^+ is composed of the maximum value of each column element in the normalized matrix Z; $Z^+ = (Z_1^+ Z_2^+ \cdots Z_5^+)$

Negative ideal solution Z^- consists of the minimum value of each column element in Z:

$$Z^- = (Z_1^- Z_2^- \cdots Z_5^-)$$

Step 3: calculate the proximity of each object to the two schemes

$$D_i^+ = \sqrt{\sum_{j=1}^{m} w_j \left(Z_j^+ - z_{ij}\right)^2} \tag{12}$$

$$D_i^- = \sqrt{\sum_{j=1}^{m} w_j \left(Z_j^- - z_{ij}\right)^2} \tag{13}$$

Step 4: calculate the relative proximity between each object and positive ideal solution and negative ideal solution

$$C_i = \frac{D_i^-}{D_i^+ + D_i^-} \#(14)$$

$C_i \to 1$ means that the better the evaluation object is.

By judging the advantages and disadvantages of 402 suppliers respectively, the final scores are sorted and the top 60 are selected.

Finally, the ranking is obtained by combining the two evaluation methods of RSR and TOPSIS. Because the ranking of the two methods is not important or not, we take the average score of the two methods of the same supplier as the final ranking basis to obtain a new ranking and take the top 50.

3. Model Evaluation

3.1 RSR comprehensive evaluation model

Advantages: Based on the nonparametric method, there are no special requirements for the selection of indicators, which is suitable for all kinds of evaluated objects; The numerical value used in this method is rank, which can eliminate the interference of outliers. It integrates the method of parameter analysis. The result is more accurate than the simple nonparametric method. It can be sorted directly or by grades, and has a wide range of applications.

Disadvantages: the main basis for sorting by this method is the selected rank of the original data. The final calculated RSR value reflects the gap of the comprehensive rank, which has nothing to do with the gap degree between the ranking of the original data. In this way, some information of the original data will be lost when the index is transformed into rank, such as the size difference of the original data.

3.2 TOPSIS Model

It can supplement the problem that the RSR rank sum ratio comprehensive evaluation model can not reflect the gap between the rank and the original data, and make more full use of the original data given in the title.

Therefore, the above two evaluation models are more reasonable and objective, and the selected 50 suppliers are also the most important and representative.

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