Research on Supplier Selection Based on Supply Characteristics

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Abstract. Aiming at the decision of raw material ordering and transportation of building materials manufacturing enterprises, this paper deeply excavates data and analyzes the construction model. The model is based on five secondary indexes: default rate, undersupply rate, supply deviation degree, relative supply capacity and sufficient supply rate.Finally, the supplier importance evaluation model is constructed based on TOPSIS method, and the suppliers are ranked according to the score. Then, the supplier supply quantity estimation model and the transport operator attrition rate estimation model are established based on the progressive weighted average, and the estimated quantities of supply quantity and attrition rate in the next 24 weeks are given. Considering ordering decision and transportation decision step by step, this paper calculates the number of suppliers needed by enterprises under the guarantee of weekly capacity demand.The supplier evaluation and selection model proposed in this paper can provide better solutions for related enterprises and has practical application value.

Key words: TOPSIS method, supplier selection, 0-1 planning

1. Introduction

Suppliers transport raw materials, ordering process will produce large economic costs, research on the supply model and ordering strategy is helpful to reduce operating costs[1].Based on the supply information of suppliers, this paper establishes a mathematical model reflecting the importance of ensuring the production of enterprises. Using 240 weeks of actual operational data from a company for analysis and modeling.According to the actual operation data of a company, it gives the minimum number of suppliers that can meet the production needs, and makes the ordering scheme with the lowest weekly cost and the transport scheme with the least loss in the future. Through data analysis to analyze the periodicity of the supplier's supply plan to solve the enterprise's optimal transport plan, and on this basis to determine the number of suppliers to choose[2].

2. Indicator selection and description

2.1 Basis for index selection

In order to weigh the importance of building materials suppliers more comprehensively and objectively, when selecting the evaluation indicators of the importance of suppliers, we should build an index system based on the principles of scientificity[3], comprehensiveness and comparability, and comprehensively consider all aspects of evaluating the supply capacity of suppliers[4].Based on this, after comparing the research results of some scholars, the supplier evaluation index system is shown in Figure 1 according to the number of citations and application breadth.

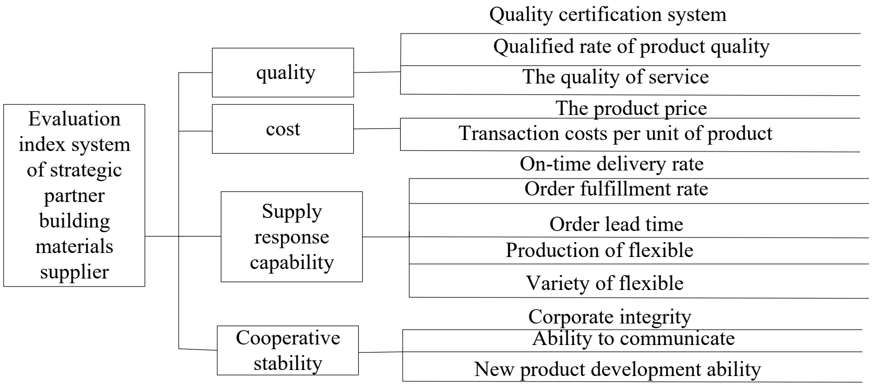

Figure 1 Supplier evaluation index system

2.2 Screening and quantification of indicators

Based on the requirements of supplier selection, this paper selects supplier importance score as the dependent variable.In this case, the difference in raw material quantity and price is not considered. Based on the evaluation index system shown in the figure above, this paper selects supply response ability and cooperation stability as the first-level indicators[5].In terms of supply response capability, two secondary indexes, relative supply capability and sufficient supply rate, are constructed.In terms of cooperation stability, considering the actual needs of enterprises, this paper constructs three secondary indicators including default rate, supply deviation degree and supply shortage rate[6].The evaluation index system is shown in Figure 2.

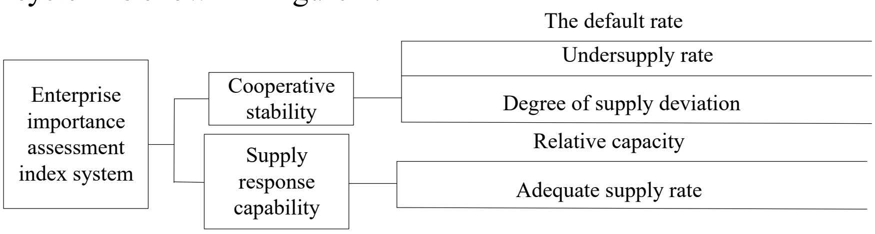

Figure 2 Evaluation index system

Supplier importance score is a dependent variable, representing the importance of supplier J to the production enterprise and directly affecting the willingness of the enterprise to continue cooperation with supplier J.C_j

Default rate is an independent variable, indicating the proportion of the orders that the supplier does not issue raw materials in all orders. Excluding the impact of the obvious difference in the number of orders from different suppliers on the number of defaults, it is used to measure the default situation and credibility of the supplier, and the calculation formula is as follows:x_1

$$x_1 = \frac{\sum_{week=1}^{240} 1_{\{\alpha_i \neq 0\}} \times 1_{\{\beta_i = 0\}}}{\sum_{week=1}^{240} 1_{\{\alpha_i \neq 0\}}} \times 100\% \tag{1}$$

$$1_{\{\alpha_i \neq 0\}}(x) = \begin{cases} 1 \ \ if \ \ x \in \{\alpha_i | \alpha_i \neq 0\} \\ 0 \ \ if \ \ x \in \{\alpha_i | \alpha_i = 0\} \end{cases} \tag{2}$$

$$1_{\{\beta_i = 0\}}(x) = \begin{cases} 1 \ \ if \ \ x \in \{\beta_i | \beta_i = 0\} \\ 0 \ \ if \ \ x \in \{\beta_i | \beta_i \neq 0\} \end{cases} \tag{3}$$

Undersupply rate x_2 is an independent variable, which represents the proportion of orders in which the quantity of supply is less than the quantity of order. It is used to measure whether the supplier's supply capacity is poor by excluding the influence of the obvious difference in the quantity of orders from different suppliers on The Times of undersupply[7]. The calculation formula is as follows:

$$x_2 = \frac{\sum_{week=1}^{240} 1_{\{\alpha_i > \beta_i\}}}{\sum_{week=1}^{240} 1_{\{\alpha_i \neq 0\}}} \times 100\% \tag{4}$$

$$1_{\{\alpha_i > \beta_i\}}(x) = \begin{cases} 1 \ \ if \ \ x \in \{\alpha_i > \beta_i\} \\ 0 \ \ if \ \ x \in \{\alpha_i \leq \beta_i\} \end{cases} \tag{5}$$

The degree of supply deviation is an independent variable[8], which is the variation coefficient of the difference between supply quantity and order quantity. It is used to measure the deviation between supply quantity and order quantity, excluding the influence of obvious difference between mean supply quantity of different suppliers. The calculation formula is as follows:x_3

$$x_3 = \frac{\sqrt{Var(|\alpha_i - \beta_i|)}}{E(|\alpha_i - \beta_i|)} \tag{6}$$

Where, E(X) represents the mean value and Var (X) represents the variance.

Relative supply capacity is an independent variable, which is obtained by dividing the total supply quantity by the total order quantity of the supplier in 240 weeks. It is used to measure the supply capacity of the supplier, excluding the influence of the obvious difference of the order quantity of different suppliers on the supply quantity. The calculation formula is as follows:x_4

$$x_4 = \frac{\sum_{week=1}^{240} \beta_i}{\sum_{week=1}^{240} \alpha_i} \tag{7}$$

Adequate supply rate is an independent variable, indicating the proportion of orders with supply quantity greater than or equal to order quantity in all orders, and measuring the order completion degree of suppliers, the calculation formula is as follows:x_5

$$x_5 = \frac{\sum_{week=1}^{240} 1_{\{\alpha_i \le \beta_i\}}}{\sum_{week=1}^{240} 1_{\{\alpha_i \ne 0\}}} \times 100\% \tag{8}$$

$$1_{\{\alpha_i \le \beta_i\}}(x) = \begin{cases} 1 \ \ if \ \ x \in \{\alpha_i \le \beta_i\} \\ 0 \ \ if \ \ x \in \{\alpha_i > \beta_i\} \end{cases} \tag{9}$$

3. Establishment of supplier evaluation model based on TOPSIS algorithm

3.1 Introduction to TOPSIS algorithm

TOPSIS method is a commonly used intra-group comprehensive evaluation method first proposed by C.L. Wang and K.Yoon in 1981.It can make full use of the information of original data, and the results can accurately reflect the gap between evaluation schemes[9].This method has no strict limitation on data distribution and sample size, and data calculation is simple and easy[10].TOPSIS method the basic process is as follows: first the original data matrix normalized processing, then cosine method is used to find out the limited solution of optimal solutions and the worst, and then calculate the evaluated object and the optimal solution and the distance between the worst plan, obtain the evaluated object and the optimal solution of relative proximity, as the basis of evaluation quality.

3.2 Supplier evaluation model based on TOPSIS algorithm

There are m evaluation objects (m suppliers) and n evaluation indexes. The importance evaluation indexes of each supplier constitute a matrix X, x_{ij} represents the jth index value of the ith supplier.

(1) Homogeneity of index attributes

TOPSIS method uses distance scale to measure sample gap, which requires homogeneity processing of evaluation index attributes.Usually adopt the method of transformation from cost - based index to benefit - based index.

Among the five indicators given in this paper, the default rate, undersupply rate and supply deviation degree are cost indicators, and the relative supply capacity and supply adequacy rate are benefit indicators, which need to be evaluated after the positive processing of default rate, undersupply rate and supply deviation degree.The formula for the forward transformation is as follows:

$$x' = \frac{1}{x}(x > 0) \tag{10}$$

(2) Construct the normalized initial matrix

The data is normalized by dividing the elements of each column by the norm of the current column vector.

$$z_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{n} x_{ij}^2}} \tag{11}$$

Thus, the normalized matrix after normalization is obtained, that is, the first row and column elements of the matrix.$Zz_{ij}ij$

(3) Determine the optimal scheme and the worst scheme

Find out the maximum value of each column in the standardization matrix, namely the importance assessment index of each supplier, denoted as component vector$Zz_i^+ (i = 1,2,\cdots,m)$

$$\begin{aligned} Z^+ &= (max\{z_{11}, z_{21}, \cdots, z_{n1}\}, max\{z_{12}, z_{22}, \cdots, z_{n2}\}, \cdots, max\{z_{1m}, z_{2m}, \cdots, z_{nm}\}) \\ &= (Z_1^+, Z_2^+, \cdots, Z_m^+) \end{aligned} \tag{12}$$

This vector represents the optimal solution, that is, the most ideal supplier.In the same way, the minimum value of each column, that is, each evaluation index, is determined as the component vector$z_i^- (i = 1,2,\cdots,m)$

$$\begin{aligned} Z^- &= (min\{z_{11}, z_{21}, \cdots, z_{n1}\}, min\{z_{12}, z_{22}, \cdots, z_{n2}\}, \cdots, min\{z_{1m}, z_{2m}, \cdots, z_{nm}\}) \\ &= (Z_1^-, Z_2^-, \cdots, Z_m^-) \end{aligned} \tag{13}$$

This vector represents the worst solution, that is, the least ideal supplier.

(4) Calculate the proximity of the importance assessment index of each supplier to the optimal plan and the worst plan

The approximation to the optimal scheme is defined as, and the calculation formula is as follows:D_i^+

$$D_i^+ = \sqrt{\sum_{j=1}^{m} w_j (Z_j^+ - z_{ij})^2} \tag{14}$$

The approximation to the worst scheme is defined , and the calculation formula is as follows:D_i^-

$$D_i^- = \sqrt{\sum_{j=1}^{m} w_j (Z_j^- - z_{ij})^2} \tag{15}$$

Where .$w_j j$ is the weight of the first attribute. The five indicators are artificially defined.In this paper, it is found through calculation that the differences between indicators are small, so the weights of the five indicators are approximately regarded as equal, namely.$w_j = 0.2$

(5) Calculate the proximity M_i between the importance assessment index of each supplier and the optimal scheme.

M_i scores that can be considered as the first supplier i :

$$M_i = \frac{D_i^-}{D_i^+ + D_i^-} \tag{16}$$

When the value is larger and closer to 1, the supplier is closer to the ideal supplier target, indicating a higher score of the supplier.$M_i ii$Finally, the sorting results are obtained according to the numerical size of the output results.

3.3 Solving the model

Based on this model, the importance scores of suppliers were solved and sorted, and the importance rankings of all suppliers were obtained. The supply quantities of the top 50 suppliers in the importance rankings were visualized. After drawing the chart, it was observed that the supply quantities of suppliers showed certain periodicity.The following are the four most representative curves. The abscissa represents the number of weeks and the ordinate represents the quantity of supply. The visual diagram of the quantity of supply is shown in Figure 3.

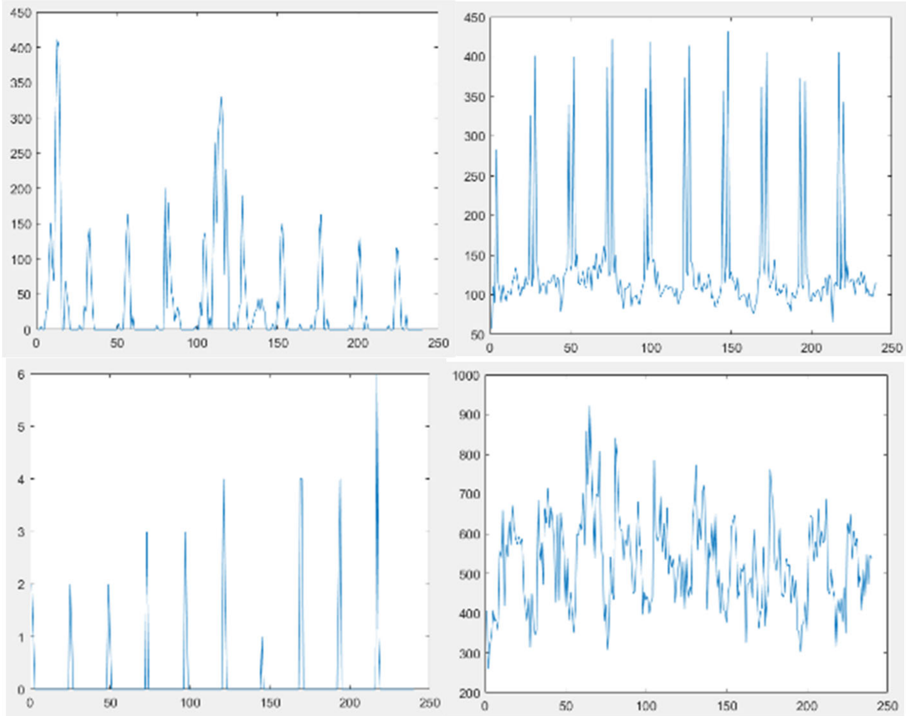

Figure 3 Visualization of supply quantity

After comparative analysis, the variation trend of suppliers' supply quantity in each cycle is similar. Most suppliers have peaks at similar time points in the past 240 weeks, and there are about 10 peaks in the past 240 weeks.In this paper, 24 weeks is regarded as a planning period, and the data of the past 240 weeks are converted into 10 periods, which are used to estimate the supply quantity in the next 24 weeks.

In data estimation, the incremental weighted average, the simple arithmetic average and the maximum are selected as the representative levels of weekly supply in the past 10 cycles and used as the estimation values for the next 24 weeks.The method name and method description are shown in Table 1.

Table 1 Method name and method description table

Method names	Methods described
incremental weighted average	For the 10 cycles, different weights are given, the weight with the furthest time is the smallest, and the weight with the most recent time is the largest.
Simple arithmetic mean	Assign equal weights to the 10 cycles, i.e.$y = \frac{1}{10}$
Maximum estimation method	By comparing the supply quantity of the first week within 10 cycles, the maximum supply quantity is selected as the corresponding supply quantity of the next 24 weeks.ii

After repeated calculation, it is found that when simple arithmetic mean and maximum estimation method are used to estimate the supply quantity in the next 24 weeks, the weekly consumption of each type of raw materials cannot meet the production needs of the enterprise, while the supply quantity of each type of materials estimated by progressive weighted average can meet the production needs of the enterprise. Therefore, the progressive weighted average is finally selected as the estimated weekly consumption of each type of raw materials in the next 24 weeks.According to the situation that the closer it is to the current time point, the more it can reflect the supplier's supply quantity in the next 24 weeks, the weight is set to increase gradually with time, i.e

$$y_i = \frac{i}{\sum_{j=1}^{10} j}, i = 1,2,\cdots,10 \tag{17}$$

The weight of each cycle increases linearly with time.For example, the weight of the farthest cycle is, and the weight of the nearest cycle is.$\frac{1}{55}\frac{10}{55}$The prediction formula of each supplier's supply quantity in the first week is as follows:

$$\beta_{f1} = \frac{1}{55} \times \beta_1 + \frac{2}{55} \times \beta_{25} + \cdots + \frac{10}{55} \times \beta_{216} \tag{18}$$

The prediction formula of supply quantity in the second week is as follows:

$$\beta_{f2} = \frac{1}{55} \times \beta_2 + \frac{2}{55} \times \beta_{26} + \cdots + \frac{10}{55} \times \beta_{217} \tag{19}$$

In this way, the prediction formula of supply quantity in the 24th week is as follows:

$$\beta_{f24} = \frac{1}{55} \times \beta_{24} + \frac{2}{55} \times \beta_{48} + \cdots + \frac{10}{55} \times \beta_{240} \tag{20}$$

β_iRepresents the supply quantity in the first week of the past 240 weeks, and represents the supply quantity in the first week of the next 24 weeks.$i\beta_{fi}i$According to the above formula, the supply quantity of each supplier can be predicted in the next 24 weeks.

4. Determination of the number of suppliers

It is assumed that the enterprise needs three raw materials A, B and C, and each supplier can only supply one raw material. n_A, n_B, n_C are the number of suppliers supplying raw material A in the assumed ordering scheme, and 28200 is the minimum production capacity demand of the company every week. The weekly production capacity of the enterprise is 28,200 cubic meters, and each cubic meter of product needs to consume 0.6 cubic meters of class A raw materials, or 0.66 cubic meters of Class B raw materials, or 0.72 cubic meters of Class C raw materials.

The objective is to minimize the number of suppliers, i.e

$$\min N = n_A + n_B + n_C \tag{21}$$

Where is the number of suppliers that the enterprise should choose in order to meet the production needs of the enterprise.$Nn_L LL = A, B, C$

According to the backgroud, the raw materials purchased in the first week should not be less than two weeks' production demand, but the materials purchased in the week after the first week need not less than one week's production capacity. Constraints can be given:

$$S_{1,A} + S_{1,B} + S_{1,C} \geq 28200 \times 2 \tag{22}$$

$$S_{t,A} + S_{t,B} + S_{t,C} \geq 28200, t = 2, \cdots, 24 \tag{23}$$

Is defined as equivalent production capacity of the total supply of class a materials in the week, and equivalent production capacity represents 28200m in the week$S_{t,L}tLt^3$The total production demand of is m$S_{t,L}{}^3$Class materials are needed.$LL = A, B, C$According to this problem and the hypothesis of this model, the consumption of class A, B and C materials is M respectively$0.6S_{t,A}{}^3$, m$0.66S_{t,B}{}^3$, m$0.72S_{t,C}{}^3$.There are:

$$\sum_{i=1}^{n_A} \beta_{t,i,A} = 0.6 \times S_{t,A}, \sum_{i=1}^{n_B} \beta_{t,i,B} = 0.66 \times S_{t,B}, \sum_{i=1}^{n_C} \beta_{t,i,C} = 0.72 \times S_{t,C}, t = 1, \cdots, 24$$

namely

$$S_{t,A} = \frac{\sum_{i=1}^{n_A} \beta_{t,i,A}}{0.6} \tag{24}$$

$$S_{t,B} = \frac{\sum_{i=1}^{n_B} \beta_{t,i,B}}{0.66} \tag{25}$$

$$S_{t,C} = \frac{\sum_{i=1}^{n_A} \beta_{t,i,C}}{0.72} \tag{26}$$

$\beta_{t,i,L}$Represents the supply of the first supplier in week 1 (i.e. the importance ranking obtained in supplier selection).$itt = 1, \cdots, 24i = 1, \cdots, Ni$. The order scheme of 27 suppliers can meet the demand of the enterprise by using the quantity of supply predicted by increasing the weight.

5. Conclusion

In this article, through the supply of supplier information, establish the mathematical model reflects the importance of enterprise production, according to the actual operation data of a company, make the future a week at the lowest cost of loss minimum order plan and transport, and determined the 27 suppliers ordering carried out considering ordering and transportation decisions step by step in this paper under the guarantee enterprise weekly capacity requirements, Calculate the number of suppliers the enterprise needs. The supplier evaluation and ordering scheme decision model proposed in this paper can provide better solutions for related enterprises, and can be applied to other similar enterprises, which has practical application value for enterprise supplier selection research.

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