Raw Material Supplier Selection Model Based on Entropy Weight Method and TOPSIS Method

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Abstract—Manufacturing enterprises purchase a large number of raw materials with a high amount. Therefore, formulating a reasonable ordering and transportation scheme can minimize the purchase cost of raw materials and is conducive to the production development of enterprises. Based on the quantitative analysis of the supply characteristics of 402 suppliers, this paper makes a statistical description of 402 suppliers from the perspectives of supply quantity and order quantity, selects 8 quantitative supply characteristics indicators reflecting supply intensity, fluctuation, enterprise trust and supply change, and constructs a supply characteristics evaluation index system, The evaluation model reflecting the importance of enterprise production is established. The TOPSIS Model Based on entropy weight method is used to obtain the scores of 402 suppliers and determine the 50 most important suppliers.

Keywords-Supply characteristics; Entropy weight method; TOPSIS method; Supplier selection

1 INTRODUCTION

In the real manufacturing industry, manufacturing enterprises purchase large quantities and high amounts of raw materials [1]. Raw materials include ordering and transportation before warehousing. The raw materials purchased by a production enterprise in the construction and decoration plate industry are mainly wood fiber and other vegetable fiber, which can be divided into three types: A, B and C. The annual production cycle of the enterprise is 48 weeks. At the same time, in order to ensure the normal operation of production and operation activities, it is necessary to formulate a 24-week raw material procurement and transportation plan in advance. Before making the plan, select the matching raw material suppliers and the corresponding weekly ordering quantity of raw materials, as well as the forwarders required for raw materials after ordering and before warehousing based on the actual capacity of the enterprise. After ordering raw materials, the forwarder needs to transfer the weekly supply provided by the supplier to the enterprise warehouse according to the prior provisions.

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2 ANALYSIS OF PROBLEMS

This paper requires a quantitative analysis of the supply characteristics of 402 raw material suppliers, establishment of a mathematical model reflecting the importance of ensuring the production of enterprises and giving the 50 most important suppliers. Firstly, the order quantity and supply quantity of 402 raw material suppliers are statistically described from the perspectives of supply quantity and order quantity supply quantity combination. Then, the supply characteristics of suppliers are quantitatively analyzed from the perspective of enterprise and supplier, and the importance indicators for evaluating suppliers to ensure enterprise production are selected from the aspects of supply quantity, supply stability and supply deviation. On this basis, an evaluation model reflecting the production importance of guarantee enterprises is established. Then, the weight of the production importance index of guarantee enterprises in the model is solved by using the entropy weight method [2]. 402 supplier enterprises are scored and sorted in combination with TOPSIS method, and the top 50 suppliers are listed in the paper.

3 PROBLEM SOLVING

According to the order quantity and supply quantity data of 402 raw material suppliers of the enterprise in Annex 1 in five years, first make a statistical description, and preliminarily determine the perspective of quantitative analysis on the supply characteristics of 402 suppliers on the basis of statistical analysis, Build a supplier supply evaluation system, and establish a mathematical model to evaluate suppliers to reflect the importance of ensuring enterprise production based on the quantitative research of supply characteristics[3]. Finally, the entropy weight method is used to obtain the index weight of the model, and the top 50 supplier data are solved, that is, the 50 most important suppliers to the enterprise are obtained.

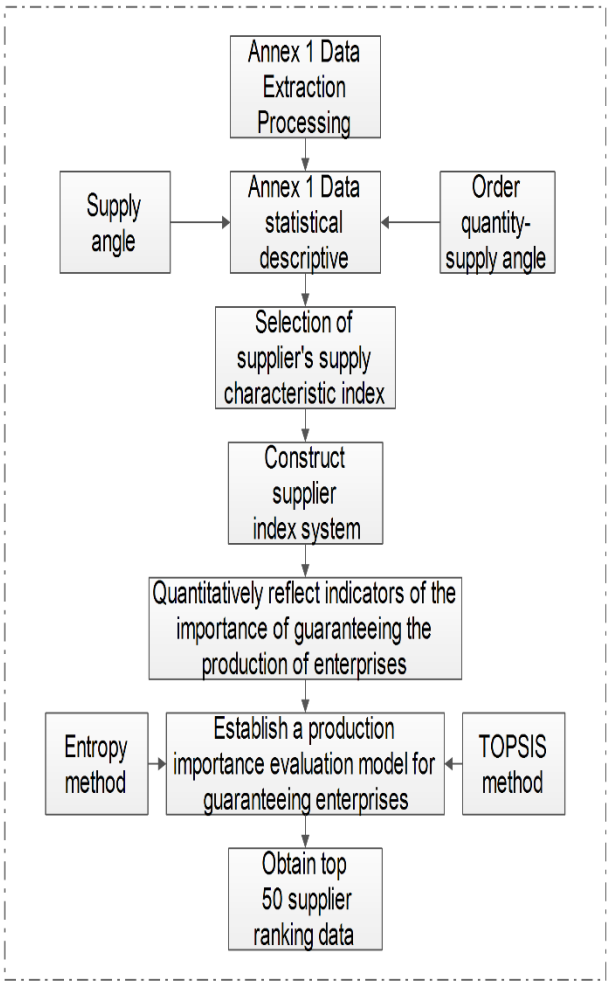

Figure1. Analysis flow chart

3.1 Statistical description of order quantity and supply quantity data

The data in Annex 1 includes the enterprise's order quantity and the supplier's supply quantity. In view of different suppliers (supplier ID in the table), the categories of raw materials provided to the enterprise are fixed, that is, one of the three categories of raw materials a, B and C. W001~W240 represent the supply quantity sent by suppliers every week for five years. Considering the need for quantitative analysis of the supply characteristics of 402 suppliers, statistical analysis is mainly carried out from two parts: supply quantity, enterprise order quantity and supplier supply quantity.

3.1.1 Statistical analysis of supply quantity

According to the scale statistics in the supply cycle, the number of suppliers affected by different supply quantities is obtained, which is presented in the form of Fig.2.

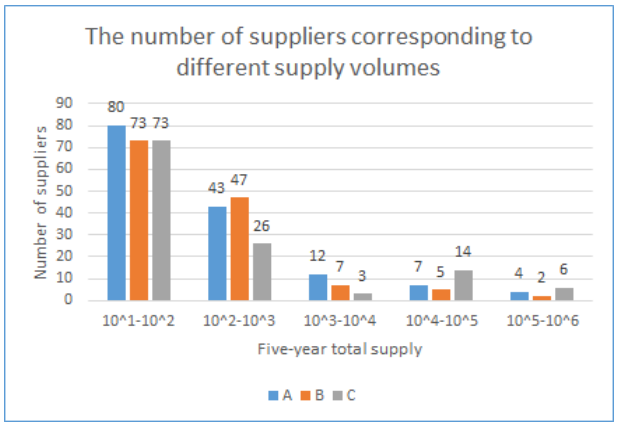

Figure2. Statistical chart of quantity division of material interval provided by the supplier

Based on the analysis of the order quantity of the enterprise, it can be preliminarily judged that the enterprise is a small and medium-sized production enterprise, and the suppliers of upstream raw materials are relatively concentrated in the types of smaller suppliers. In the past five years, the enterprise prefers to choose suppliers that can provide class a raw materials and fewer suppliers that can provide class C raw materials.

3.1.2 Combined with the statistical analysis of supply and order quantity

Take the 240 weeks in Annex 1 as the data statistics cycle, draw the change curve of the enterprise's weekly order quantity in five years, use scattered points to represent the actual supply quantity provided by the corresponding weekly supplier, and obtain the change curve of the weekly order quantity and the total supply quantity.

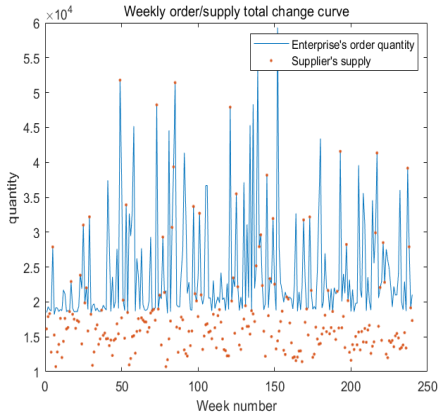

Figure3. Weekly order / total supply change curve

The blue change curve in the figure represents the change of the order quantity issued by the enterprise in 240 weeks, and the red scatter represents the supply quantity of the corresponding supplier every week. It can be seen from the figure that the quantity of raw materials provided by most suppliers is less than the order quantity issued by the enterprise. The red scatter on the enterprise order quantity change curve corresponds to the raw materials provided by the supplier to meet the order quantity, and the red scatter below the change curve is the raw materials actually provided by the supplier.

Through statistical analysis, the quantitative characteristics and time distribution characteristics of 402 suppliers in terms of supply and order supply are obtained. Based on this, this paper selects the corresponding categories of indicators from the perspectives of supply intensity, fluctuation, enterprise trust and supply change to quantitatively analyze the supply characteristics of suppliers.

3.2 Symbolic description of the model

The symbols used in the quantitative analysis model are explained in the following table [4].

Table1. Symbol description table

Symbol	interpretative statement
S_i	Average weekly supply of supplier i
S_{ik}	Week k supply of the i supplier
T	Total number of data cycles given
D_i	Supply stability of the i^{th} supplier
A_i	Supply deviation of the i^{th} supplier
O_{ik}	The enterprise's order quantity for week k of the i^{th} supplier
T_{C_i}	The total number of cycles in which the i^{th} supplier has orders
T_{r_i}	Total cycle quantity of the i^{th} supplier without order quantity
I_i	Supply interruption rate of the i^{th} supplier
T_L	5-year data cycle
T_{jn}	Total cycle in year j
GS_i	Annual supply growth rate of supplier i^{th}
S_{ai}	Supply satisfaction of the i^{th} supplier
P_i	Supply completion rate of the i^{th} supplier
GP_i	Change rate of annual supply completion of the i^{th} supplier

3.3 Quantifying supply characteristics -- establishing a model to ensure the importance of production

On the basis of statistical description, eight indicators are selected from four aspects: supply intensity, fluctuation, enterprise trust and supply change to form the supplier supply characteristic evaluation index system.

3.3.1 Supply intensity

In order to measure the supply intensity of suppliers, the average weekly supply is defined as the research index:

$$S_i = \frac{\sum_{k=1}^{T} S_{ik}}{T} \tag{1}$$

Where T is the total cycle of the studied data, i.e. 240 weeks in total in five years, S_{ik} representing the supply of the raw material supplier i in week k, and S_i represents the average weekly supply of the raw material supplier i. Considering the needs of normal production, the enterprise will always choose to maintain the raw material inventory no less than the production demand of two weeks, and always purchase all the raw materials provided by the supplier. Therefore, the larger the average weekly supply of the supplier, the more it can meet the production demand of the enterprise.

3.3.2 Fluctuation degree

3.3.2.1 Supply stability

$$D_i = \sqrt{\frac{\sum_{k=1}^{T} (S_{ik} - S_i)^2}{T-1}} \tag{2}$$

Where D_i represents the stability of raw material supply. The smaller the value, the more stable the i^{th} raw material supplier is, and S_i represents the weekly average supply of i^{th} raw material supplier.

3.3.2.2 Supply deviation

A_i is the degree of supply deviation, S_{ik} is the supply quantity of the i^{th} raw material supplier in week k, and O_{ik} is the order quantity of the enterprise in week k.

3.3.2.3 Supply interruption rate

$$A_i = \frac{\sum_{k=1}^{T_{ci}} \frac{|S_{ik} - O_{ik}|}{O_{ik}}}{T_{ci}} \tag{3}$$

At the same time, defining supply interruption rate:

$$I_i = \frac{T_{ri}}{T} \tag{4}$$

3.3.3 Changes in supply

3.3.3.1 Supply satisfaction

$$S_{ai} = \frac{\sum_{k=1}^{T} S_{ik}}{\sum_{k=1}^{T} O_{ik}} \tag{5}$$

$\sum_{k=1}^{T} S_{ik}$ represents the total supply quantity of suppliers in the total cycle T, and $\sum_{k=1}^{T} O_{ik}$ represents the total quantity of raw materials ordered by the enterprise in the total cycle.

3.3.3.2 Supply completion rate

Use T_{p_i} to represent the total cycle amounts of raw materials provided by the order issued by the supplier to the enterprise in the total cycle T, and the supply completion rate P_i represents the ratio of completion weeks T_{p_i} to the total cycle number.

$$P_i = \frac{T_{pi}}{T} \tag{6}$$

3.3.4 Enterprise trust

The degree of enterprise trust represents the enterprise's trust and dependence on suppliers, which is reflected in the close cooperation between raw material upstream enterprises and production enterprises.

3.3.4.1 Annual supply change rate

$$GS_i = \frac{\sum_{j=1}^{T_L - 1} (S_{(j+1)i} - S_{ji})}{T_L - 1} \tag{7}$$

The annual supply change rate is GS_i, which represents the annual supply growth of the i^{th} supplier, and T_L represents the sum of years of data.

3.3.4.2 Annual change rate of supply completion

$$GP_i = \frac{\sum_{j=1}^{T_L-1}(P_{(j+1)i} - P_{ji})}{T_L - 1} \tag{8}$$

T_L is the total number of years, $P_{(j+1)i}$ is the supply completion rate of the i^{th} supplier in the $j+1$ year, and P_{ji} is the supply completion rate of the i^{th} supplier in the j year.

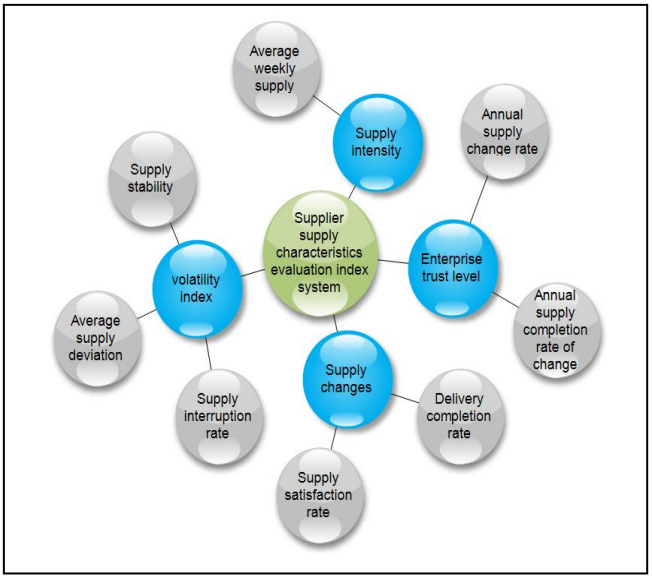

Figure4. Evaluation index system of supplier supply characteristics

3.4 Solution of model

In order to obtain the importance ranking of 402 enterprises, TOPSIS method is used to normalize and standardize the indexes, and entropy weight method is used to obtain the weight coefficient before each index in the evaluation model of production guarantee importance [5]. On this basis, TOPSIS is used to quantify the important indexes, and the scores of 402 suppliers in the normalized interval under the evaluation index system in this paper are obtained, According to the score, the top 50 suppliers constitute the most important suppliers to the enterprise.

3.4.1 Forward processing

$$\tilde{x}_i = x_{\max} - x_i \tag{9}$$

The forward matrix corresponding to the index system is obtained after the forward processing of the very small index.

$$X = \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1m} \\ x_{21} & x_{22} & \cdots & x_{2m} \\ \vdots & \vdots & \ddots & \vdots \\ x_{n1} & x_{n2} & \cdots & x_{nm} \end{bmatrix} \tag{10}$$

3.4.2Normalization processing

Among the eight indicators selected in this paper, there are positive indicators, such as average weekly supply, supply completion rate, and negative indicators. For example, supply stability, average supply deviation. When evaluating the importance of suppliers to the enterprise, the positive indicator hopes that the larger the selected indicator value, the better. Therefore, the indicator is normalized.

$$x'_{ij} = \frac{x_j - x_{\min}}{x_{\max} - x_{\min}} \tag{11}$$

3.4.3Calculate index weight

$$P_{ij} = \frac{x_{ij}}{\sum_{i=1}^{m} x_{ij}}$$

$$0 \le P_{ij} \le 1 \tag{12}$$

For solving the weight coefficients of 8 indexes in the model, the objective weight proportion of 8 indexes is given by entropy weight method.

$$e_j = -\frac{1}{\ln m} \sum_{i}^{m} P_{ij} \ln P_{ij}$$

$$d_j = 1 - e_j \tag{13}$$

The difference degree of the j index is defined on the basis of entropy value, and the corresponding weight of each index is obtained by weighting the difference degree of each index flag value [6].

$$w_j = \frac{d_j}{\sum_{j=1}^{n} d_j} \tag{14}$$

3.4.4 TOPSIS quantitative key indicators

For 402 suppliers to be evaluated, each supplier has 8 indicators to evaluate the importance, so the standardization matrix is a 402 * 8 matrix.

$$D_i^+ = \sqrt{\sum_{j=1}^{m} \omega_i (Z_j^+ - z_{ij})}$$

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

Where ω_i is the weight of the i index, the score of the i evaluation object (Supplier) is:

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

S_i is normalized, and the larger the value of $S_i \in [0,1]$ is, the closer it is to the maximum value. The scores and ranking of some suppliers in TOPSIS Model Based on entropy weight method are as follows, and 50 suppliers most important to the enterprise are selected.

Table 2. 50 most important suppliers selected

50 most important suppliers selected	**Supplier ID**			
S361	S131	S365	S294	S076
S229	S139	S031	S080	S098
S140	S330	S247	S218	S338
S108	S308	S284	S055	S150
S151	S306	S364	S307	S067
S340	S268	S040	S007	S114
S282	S194	S348	S244	S003

S329	S352	S367	S266	S037
S275	S143	S346	S392	S379
S356	S374	S395	S123	S175

4 CONCLUSION

Aiming at the problem of enterprise raw material supplier selection, based on the historical data of 402 suppliers, this paper selects 8 quantitative supply characteristics indicators in four aspects: supply intensity, fluctuation, enterprise trust and supply change, establishes an evaluation model reflecting the importance of enterprise production, and obtains the scores of 402 suppliers by using TOPSIS model based on entropy weight method, The method is reasonable and effective.

The most important evaluation index system constructed in this paper comprehensively and objectively reflects the supply characteristics of 402 suppliers, and the 50 most important suppliers selected based on this index system have high reliability, which is of guiding significance for the supplier selection of practical enterprises.

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