ISSN 2616-5902 Vol. 6, Issue 4: 240-246, DOI: 10.25236/AJBM.2024.060435

Research on Raw Material Ordering and Transportation Planning Based on Constraints

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Abstract: *The operation of an enterprise comes from the continuous supply of raw materials. In real life, the enterprise will cooperate with many suppliers of raw materials, and the suppliers will also choose the forwarders with low consumption and long-term cooperation among many forwarders for transshipment. For an enterprise, the production of products can be completed not only by certain materials, but also by a variety of materials, thus increasing the scope of the enterprise's selection. That is to say, the sufficiency of materials in a unit time should be considered, as well as the amount spent on purchasing raw materials, transshipment fees and storage fees. In this paper, the purchase and transportation of raw materials of enterprises are planned to maximize economic benefits, and the increase of enterprise capacity is predicted through data. The purchase and transportation of raw materials of enterprises are planned and arranged reasonably. Whether the delivery error is too large. Whether the cooperation is repeated. For the first indicator, calculate the variance of raw materials provided by all suppliers. The smaller the variance, the more stable the supply. For the selection of the second indicator, the acceptance range of error is set as 0.95-1.05, and the error proportion is obtained by calculating the ratio of supply quantity to order quantity. For the selection of the fourth indicator, by calculating the sum of weekly demand for ABC materials, it is used to remove the supply of each supplier to the only material. For the selection of the fifth indicator, calculate its total supply in five years to avoid some suppliers. Although they provide it every time, the number is very small. Then, the data are normalized, and the TOPSIS model is used to assign weights, so that the top 50 scores are finally obtained.*

Keywords: *TOPSIS model, Linear programming, 0-1 model*

1. Introduction

Since it is necessary to select 50 important suppliers, it is necessary to select indicators that meet the importance standard. 402 suppliers will screen and process the data provided through excel in terms of their cooperation status with enterprises and the types of materials sold within five years, and then draw five important standards, which are respectively provided for stability. Whether the delivery error is too large. Whether the cooperation is repeated. The enterprise's demand for materials provided by the supplier. Total orders in five years. For stability judgment, variance is used for comparison. The smaller the variance is, the better the stability is, that is, the supplier is in a continuous and stable supply state. For the judgment of the error of the delivered quantity, in order to ensure the normal production needs of the enterprise, the enterprise will purchase all the raw materials actually provided by the supplier in order to maintain the inventory of raw materials that meet the production needs of two weeks as much as possible[1]. Therefore, if the error fluctuation is too large, it will either affect the normal operation of the enterprise or affect the capital expenditure of the enterprise.

Due to the normal consumption of the forwarder, the forward TOPSIS model in the later stage is positioned as an interval type, which is acceptable in the 0.95-1.05 range. The shipment error is divided by the order quantity by the supply quantity. Since 0 cannot be used as the denominator, it is replaced by 1, which does not affect the error size. For the determination of the number of cooperation, excel records the sum of non-zero numbers, that is, the number of cooperation. For the enterprise's demand for materials from related suppliers, the proportion of demand for such materials is obtained by dividing the sum of A, B and C materials purchased every week by the relative unique materials. Finally, the sum of the five years is calculated to determine whether they are big sellers. Finally, the five indicators are standardized, so that they can be positively processed to obtain the weight, and the

ISSN 2616-5902 Vol. 6, Issue 4: 240-246, DOI: 10.25236/AJBM.2024.060435

top 50 suppliers with the greatest importance can be obtained.

2. Establishment and solution of model

2.1. Establishment of supplier evaluation criteria

In this question, the ordering quantity and supply quantity of 402 raw material suppliers in the last 24 weeks (that is, five years) are given. In order to comprehensively evaluate the most important 50 of the 402 suppliers, five important evaluation criteria are determined for each supplier:

Whether the nth supplier provides μ stably in five years

$$\mu_{1n}=\frac{1}{240}\sum_{i=1}^{240}\left(\text{Whether the nth supplier supplies in the first week - the average supply times in 5 years}\right)^{2} \tag{1}$$

Difference between the nth supplier's actual supply quantity and the enterprise's order quantity μ

In the order quantity table, for the convenience of ratio calculation, "0" without order quantity is changed to "1" here.

$$\mu_{2n}=Var\left(\frac{\text{Actual supply}}{\text{Enterprise order quantity}}\right) \tag{2}$$

Number of cooperation between the nth supplier and the enterprise in five years μ3

$$\mu_{3n}=\sum_{i=1}^{240}\text{Whether the nth supplier will supply in the ith week} \tag{3}$$

Enterprise's demand for materials provided by the supplier u4

According to statistics, there are 146 A material suppliers, 134 B material suppliers and 122 C material suppliers among 402 suppliers. According to the types of materials provided by suppliers, three lists of material suppliers A, B and C are arranged[2]. In the list of material A suppliers, the ratio between the supplier's supply in the ith week and the total supply of material A in this week can be understood as the supplier's supply of material A in this week. Do the same treatment every week, and add up the supplier's 240 week supply level. The value obtained is the supplier's supply level for the enterprise's total demand for materials A in the past five weeks, which can also be understood as the enterprise's demand for materials provided by the supplier. The data of material B and material C suppliers shall be handled in the same way.

$$\mu_{4n}=\sum_{i=1}^{240}\frac{\text{Supply of the nth supplier in the ith week}}{\sum\text{Supply volume of suppliers who also provide similar materials in week i}} \tag{4}$$

The total number of orders of the enterprise to the nth supplier in five years is U. Sum the 240 week supply of the supplier.

$$\mu_{5n}=\sum_{i=1}^{240}\text{Supply of the nth supplier in the ith week} \tag{5}$$

2.2. Supplier Evaluation Criteria Matrix Preprocessing

Get the initial matrix

Arrange the above five indicators in columns to form 402×5.

$$Z_1=\begin{bmatrix}\mu_{11} & \mu_{12} & \mu_{13} & \mu_{14} & \mu_{15}\\ \mu_{21} & \mu_{22} & \mu_{23} & \mu_{24} & \mu_{25}\\ \vdots & \vdots & \vdots & \vdots & \vdots\\ \mu_{n1} & \mu_{n2} & \mu_{n3} & \mu_{n4} & \mu_{n5}\end{bmatrix},\ n=402 \tag{6}$$

Normalization of initial matrix

ISSN 2616-5902 Vol. 6, Issue 4: 240-246, DOI: 10.25236/AJBM.2024.060435

The indicators in the third column are extremely large, the indicators in the fourth column are extremely large, and the indicators in the fifth column are extremely large. Convert all indicators into very large ones, and make indicators positive:

The indicators in the first column are very small, which can be converted into very large indicators using the following formula

$$\max - \mu_{ni} \tag{7}$$

Among them, $n = 1, 2, 3, \cdots, 402 \ \ \mu = 1, 2, \cdots, 5$

For the second indicator, if the fluctuation range is within 5%, the indicator is an interval type indicator, and the optimal interval range is [0.95,1.05]. Use the following formula to convert into very large indicators

$$K = \max\left\{1.05 - \min\left\{\mu_{ni}\right\}, \max\left\{\mu_{ni}\right\} - 0.95\right\} \tag{8}$$

$$\tilde{x}_{ni} = \begin{cases} 1 - \dfrac{1.05 - \mu_{ni}}{K}, \mu_{ni} < 0.95 \\ 1 \qquad\qquad\quad , 0.95 \le \mu_{ni} \le 1.05 \\ 1 - \dfrac{\mu_{ni} - 0.95}{K}, \mu_{ni} > 1.05 \end{cases} \tag{9}$$

Get the forward matrix

$$X = \begin{bmatrix} x_{11} & x_{12} & x_{13} & x_{14} & x_{15} \\ x_{21} & x_{22} & x_{23} & x_{24} & x_{25} \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ x_{n1} & x_{n2} & x_{n3} & x_{n4} & x_{n5} \end{bmatrix}, \ n = 402 \tag{10}$$

Standardization of positive matrix

According to the formula

$$z_{ni} = \frac{x_{ni}}{\sqrt{\sum_{n=1}^{402} x_{ni}^{\ 2}}} \tag{11}$$

The standardized matrix of 402 evaluation objects and 5 evaluation indicators is obtained:

$$Z = \begin{bmatrix} z_{11} & z_{12} & z_{13} & z_{14} & z_{15} \\ z_{21} & z_{22} & z_{23} & z_{24} & z_{25} \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ z_{n1} & z_{n2} & z_{n3} & z_{n4} & z_{n5} \end{bmatrix}, \ n = 402 \tag{12}$$

2.3. Objective weighting by entropy weight method

Calculate the probability matrix P, in which each element Pni is calculated as follows:

$$p_{ni} = \frac{z_{ni}}{\sum_{i=1}^{n} z_{ni}} \tag{13}$$

Calculate the information entropy of each indicator:

ISSN 2616-5902 Vol. 6, Issue 4: 240-246, DOI: 10.25236/AJBM.2024.060435

$$e_i = -\frac{1}{\ln n}\sum_{i=1}^{n} p_{ni} \ln\left(p_{ni}\right)\left(i = 1,2,\cdots,5\right) \tag{14}$$

Using Matlab programming, the following results are obtained:

$$e_1 = 0.0358 \;\; e_2 = 0.0176 \;\; e_3 = 0.1032 \;\; e_4 = 0.4130 \;\; e_5 = 0.4305 \tag{15}$$

2.4. Weighted distance method for calculating supplier scores

For standardized matrices:

$$Z = \begin{bmatrix} z_{11} & z_{12} & z_{13} & z_{14} & z_{15} \\ z_{21} & z_{22} & z_{23} & z_{24} & z_{25} \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ z_{n1} & z_{n2} & z_{n3} & z_{n4} & z_{n5} \end{bmatrix},\ n = 402 \tag{16}$$

Define Maximum

$$\begin{aligned} Z^+ &= \left(Z_1^+, Z_2^+, Z_3^+, Z_4^+, Z_5^+\right) \\ &= \left(\max\left\{z_{11}, z_{21}, \cdots, z_{n1}\right\}, \max\left\{z_{12}, z_{22}, \cdots, z_{n2}\right\}, \cdots, \max\left\{z_{15}, z_{25}, \cdots, z_{n5}\right\}\right) \end{aligned} \tag{17}$$

Define Minimum

$$\begin{aligned} Z^+ &= \left(Z_1^+, Z_2^+, Z_3^+, Z_4^+, Z_5^+\right) \\ &= \left(\min\left\{z_{11}, z_{21}, \cdots, z_{n1}\right\}, \min\left\{z_{12}, z_{22}, \cdots, z_{n2}\right\}, \cdots, \min\left\{z_{15}, z_{25}, \cdots, z_{n5}\right\}\right) \end{aligned} \tag{18}$$

$$e_1 = 0.0358 \;\; e_2 = 0.0176 \;\; e_3 = 0.1032 \;\; e_4 = 0.4130 \;\; e_5 = 0.4305 \tag{19}$$

Define the distance between the nth evaluation object and the maximum value

$$Dist_n^+ = \sqrt{\sum_{i=1}^{5} e_i \left(Z_i^+ - z_{ni}\right)^2} \tag{20}$$

Define the distance between the nth evaluation object and the minimum value

$$Dist_n^- = \sqrt{\sum_{i=1}^{5} e_i \left(Z_i^- - z_{ni}\right)^2} \tag{21}$$

Calculate the score of the nth evaluation object (not normalized)

$$S_n = \frac{Dist_n^-}{Dist_n^+ + Dist_n^-} \tag{22}$$

Obviously, $0 \leqslant S_n \leqslant 1$ The scores will then be normalized, $\tilde{S}_n = S_n / \sum_{n=1}^{402} S_n$, According to Matlab's scoring results, 402 suppliers were ranked, and the top 50 suppliers with the best comprehensive evaluation were obtained, Table 1.

Table 1: 50 Most Important Suppliers

ranking	Supplier ID	ranking	Supplier ID	ranking	Supplier ID
1	S229	19	S194	38	S338
2	S361	20	S143	39	S080
3	S140	21	S352	40	S294
4	S108	22	S126	41	S244

ISSN 2616-5902 Vol. 6, Issue 4: 240-246, DOI: 10.25236/AJBM.2024.060435

5	S151	23	S395	42	S218
6	S201	24	S307	43	S074
7	S340	25	S247	44	S114
8	S308	26	S037	45	S123
9	S330	27	S031	46	S007
10	S282	28	S284	47	S266
11	S275	29	S365	48	S150
12	S329	30	S040	49	S314
13	S131	31	S160	50	S291
14	S268	32	S055		
15	S356	33	S374		
16	S139	34	S364		
17	S306	35	S367		
18	S348	36	S346		
19	S194	37	S086		

3. Research on supplier supply of raw materials and enterprise demand

Enterprises choose as few suppliers as possible to supply raw materials to meet their daily production needs. Consider the supply of production raw materials for two weeks in the first week, and the rest in turn meet the supply of the remaining production cycle[3]. Here, the supply capacity of suppliers is certain. Therefore, 0-1 planning model is selected to select the minimum number of suppliers under the premise of meeting the weekly production capacity of the enterprise.

3.1. Establish 0-1 planning model

Suppose $x_i\ (i=1,2,\cdots,50)$ is the symbolic abbreviation of 50 suppliers ranked according to the model, and seek the minimum number of suppliers.

$$x_i=\begin{cases}1, & \text{This supplier does not provide raw materials}\\ 0, & \text{This supplier supplies raw materials}\end{cases}\quad i=1,2,\cdots,50 \tag{23}$$

That is, meet $x_i(x_i-1)=0$.

3.2. Capacity analysis of suppliers

Because the supplier needs to meet the maximum production capacity demand of the enterprise every week, there are constraints. The supplier's supply volume is more than 28200m^3

$$\sum_{i=1}^{50}\frac{J_i}{Li}x_i\geq 28200 \tag{24}$$

J_i refers to the quantity of raw materials supplied by the supplier, L_i refers to the material conversion rate of A, B and C corresponding to the raw materials supplied by the second supplier, and the division of the two numbers is the converted weekly product output of the enterprise.

3.3. Distribution capacity analysis of forwarders

As the raw materials supplied by suppliers need to be transported on the basis of forwarders, the distribution capacity of forwarders needs to be considered on another level. Since there is no difference in the types of raw materials delivered by forwarders, each forwarder's weekly delivery volume is 6000 cubic meters, and there are 8 forwarders available, so there are constraints $\sum_{i=1}^{50}J_ix_i\leq 48000$.

That is to say, the supplier 0-1 planning model is

ISSN 2616-5902 Vol. 6, Issue 4: 240-246, DOI: 10.25236/AJBM.2024.060435

$$s.t.\begin{cases}\sum_{i=1}^{50}\frac{J_i}{L_i}xi \geq 28200 \\ x_i(x_i-1)=0 \\ \sum_{i=1}^{50} J_i x_i \leq 48000\end{cases}$$
$$\min Z = \sum_{i=1}^{50} x_i \tag{25}$$

3.4. Model solving

The impact of seasonal changes on suppliers' supply capacity will not be considered here. In an ideal situation, 50 high-quality suppliers are selected from the first question. The average value of raw materials supplied by suppliers in the first 240 weeks is used as the supply capacity of future suppliers to determine the number of suppliers needed[4]. The production volume of the enterprise is 28200 cubic meters per week, and the unit product needs to consume 0.6 cubic meters of Class A raw materials, 0.66 cubic meters of Class B raw materials, or 0.72 cubic meters of Class C raw materials. Therefore, the supplier's supply volume needs to be greater than the weekly production volume to ensure that the enterprise's weekly production capacity is fully released, Fig 1. In addition, for the forwarders, the distribution capacity of the eight forwarders is 6000 m3/time. The difference is that there are certain differences in the transit loss rate of different forwarders. It is necessary to ensure that the forwarders with low transit loss rate are selected on the premise of economy and that the supplier's raw material quantity can be transferred.

After establishing the above model through Matlab, we need to calculate the average supply capacity of 50 suppliers to yi, which also reflects the supply capacity of suppliers as real as possible. Here is based on the average value of suppliers when they supply raw materials[5]. In the Matlab program operation interface, at least ten suppliers are required, and the following interface can be obtained after the suppliers are ranked and processed in order.

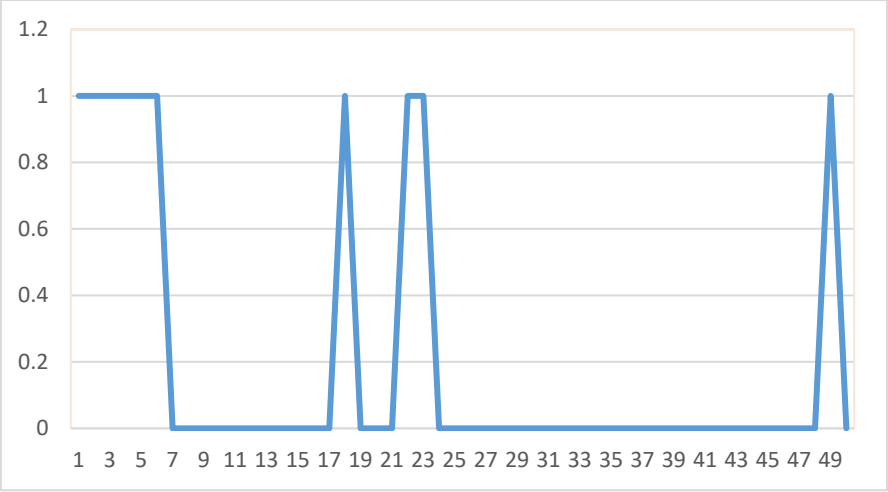

Figure 1: Optimal Selection of Suppliers

The 10 suppliers selected here are S229, S361, S140, S108, S151, S201, S348, S126, S395 and S314.

So far, it can be concluded that the enterprise can only meet its production needs by selecting at least 10 suppliers to supply raw materials. In the best case, these 10 suppliers are the above 10. On the premise of meeting the production capacity of the enterprise, at least the above suppliers are required to supply raw materials, otherwise more suppliers are required to supply raw materials.

ISSN 2616-5902 Vol. 6, Issue 4: 240-246, DOI: 10.25236/AJBM.2024.060435

4. Conclusion

TOPSIS is a commonly used comprehensive evaluation method, which can make full use of the information of the original data, and its results can accurately reflect the gap between the evaluation schemes.

In this paper, when the economy is optimized, that is, the cost is the lowest and the cost is the least, the order for the next 24 weeks is planned. Since the quantity of goods supplied by each supplier is not explained, the average value is calculated by the sum of the same week in each year, which is regarded as the standard value. The 0-1 model is used to calculate which suppliers can ship, and the type of materials shipped is under the premise of economic optimization. Find a method to reduce transportation loss. Similarly, in order to tell the loss degree in the next 24 weeks, the same method is used to calculate the average value, carry out linear programming, and combine the constraints to obtain a reasonable scheme.

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