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Research on Enterprise's Material Ordering and Transportation Model

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Abstract: The ordering and transportation plan of the company's raw materials is very important to the company's production. This article starts with ensuring the importance of the company's production and quantifying the supplier's supply characteristics. optimization. This paper uses the analytic hierarchy process to establish a hierarchical structure model based on supplier selection, and obtains the 50 most important suppliers by sorting and filtering the combination weight vector. Then, according to the supply volume to meet the limiting factors of production and reduce transshipment costs, with the minimum number of suppliers as the goal, this paper establishes a 0-1 planning model, and calculates the order plan and transshipment plan for the next 24 weeks through Matlab software.

1. Background

The fiber materials used by a building can be divided into three categories: A, B, and C. The company needs to formulate a 24-week raw material ordering and transshipment plan in advance. The raw material ordering plan includes determining the supplier, the order quantity, the transshipment provider and the entrusted transshipment provider to tranship the supply volume. The company needs to meet the production capacity requirement of 28,200 cubic meters per week. It is known that each cubic meter of product needs to consume 0.6 cubic meters of A material, 0.66 cubic meters of B material, or 0.72 cubic meters of C material. At the same time, the actual supply of the supplier may be more or less than the order quantity. In order to ensure production needs, the inventory is required to meet the production demand for at least two weeks, and the company must purchase all of the supplier's supply. During the actual transshipment, the transshipment capacity of each transshipment company is 6000 cubic meters per week, and usually the raw materials supplied by a supplier every week are transshipped by a transshipment company as far as possible. The purchase prices of Class A are 20% higher than those of Class C. The Class B are 10% higher than those of Class C respectively, and the unit costs of transportation and storage of the three types of materials are equal. This paper analyzes the supply characteristics of 402 suppliers and determines the 50 most important suppliers. Then, this article has developed a procurement and transshipment plan.

2. Build a weight model

We select indicators through analytic hierarchy process[1]: the average value of the supplier's weekly supply C_1, the standard deviation of the weekly supply C_2, the number of weeks the supplies meet the demand C_3, and the supplier's overall compliance rate C_4. The meaning of C_4 is:

$$C_4 = 1 - \frac{\left|\sum_{j=1}^{240} G_{ij} - \sum_{j=1}^{240} Q_{ij}\right|}{\sum_{j=1}^{240} Q_{ij}} \tag{1}$$

In the above formula, G_{ij} represents the supply quantity of the *i*-th supplier in week *j*, and *Qij* represents the order quantity of the company's order from the *i*-th supplier in week *j*. Through this indicator, we can have a quantitative judgment on the supplier's supply compliance degree in the past five years: the larger the value of *C4*, the higher the supplier's overall supply compliance degree.

According to the *Satty* judgment matrix scale table, combined with the actual meaning of the four indicators, our group gives the corresponding scales for the four indicators, where the scale of C_1 is 1, the scale of C_2 is 3, and the scale of C_3 is 5. The scale of C_4 is 9, and the importance of scales 1 to 9 increase sequentially. Based on this, we get the judgment matrix *A*.

$$A = \begin{bmatrix} 1 & 1/3 & 1/5 & 1/9 \\ 3 & 1 & 1/3 & 1/5 \\ 5 & 3 & 1 & 1/3 \\ 9 & 5 & 3 & 1 \end{bmatrix}$$

Calculated by Matlab software, at this time: λ_{max1} = 4.0763, feature vector = [0.0773, 0.1765, 0.3951, 0.8982]. CI_1 = 0.0254, look-up table RI_1 = 0.9, so CR_1 = 0.0286<0.1, meet the consistency check test. The normalized weight CW_i ($i \in [1,4]$) is shown in the following table.

Table 1: Relative weights of various indicators

C_i	C_1	C_2	C_3	C_4
CW_i	0.0499	0.1141	0.2554	0.5806

By comparing the data, this paper obtains the judgment matrix of the supplier's characteristics on C_i ($i \in [1,4]$), denoted as B_i ($i \in [1,4]$), and it is the consistency matrix. λ_{max2} = n = 402, where n represents the order of the matrix. And CI_2 = CR_2 = 0, CR_2 <0.1, the consistency check is passed. The eigenvectors obtained when λ = 402 of the four matrices are respectively normalized, and the relative weight BW_{ij} of each supplier under the four indicators is obtained ($i \in [1,4], j \in [1,402]$).

Through the relative weight of each indicator and the relative weight of each supplier under each indicator, we have obtained the combined weight vector of each supplier (total ranking weight vector), and the combined weight vector of some suppliers is shown in the table below.

Table 2: Part of the supplier's combined weight vector

Supplier	S001	S002	…	S402
Combined weight vector	0.023950	0.014200	…	0.000532

The consistency test is performed on the combination weight vector: $CR_3 = CR_1 + CI_3/RI_2$, the combination consistency index CI_3 = 0, so $CR_3 = CR_1$ = 0.0286 <0.1, and the consistency test passes. According to the ranking results of the combined weight vectors of all suppliers, this article selects the top 50 suppliers.

3. Develop an ordering and transshipment plan

On the basis of identifying the 50 most important orderers, this article continues to develop an ordering plan and a transshipment plan.

3.1 Data processing

We take the weekly supply of each supplier in the *x*th week of the next 24 weeks as the maximum weekly supply of the supplier in that week in the past 5 years (for example, the second week's supply is the past The maximum value of the supply in the second week of each year in 5 years), the *i*-th supplier's supply G_{ij} in the *j*-th week in the future (i∈[1,24], j∈[1, 50]). Then, since the unit production capacity of each raw material is different, in order to be a unified unit and facilitate the establishment of subsequent models, we have converted the supply of each merchant on the basis of the previous step: for the supplier of A material , The capacity $Pij = Gij /0.6$; for the supplier of B materials, the capacity $Pij = Gij /0.66$; for the supplier of C materials, the capacity $Pij = Gij /0.72$. According to this correspondence, the supply volume is converted into production capacity, and we obtains the production capacity Pij (i∈[1,24], j∈[1,50]).

3.2 Ordering plan based on 0-1 planning model

In this question, considering that there will be a remaining value for the current week's supply, the remaining value will be used as the initial value of the next week's inventory. Therefore, for the order plan for the next 24 weeks, our team has decided to create 24 corresponding 0-1 Planning model. For each model, there is a target demand for the minimum number of suppliers, so our objective function is the minimum number of merchants. By setting the 0-1 variable X_{ij} (i∈[1,24],j∈[1,50]) to indicate whether the *j*-th merchant in the *i*-th week participates in the supply (the order *j* of the merchant is consistent with Table 6), we got the objective function of each 0-1 planning model[2] (according to the different values of the number of weeks *i*, the following formula can be divided into 24 single-week 0-1 planning models' respective objective functions).

$$minZ_i = \sum_{j=1}^{50} X_{ij} \ (i = 1,2,3, \dots ,24) \tag{2}$$

Afterwards, according to the meaning of the question, our team believes that we must first meet the weekly production needs of the raw material quantity per week, and reserve at least 2 weeks of production raw material inventory, so we got the first constraint on production capacity. After that, considering that too much inventory will lead to an increase in the storage cost of the warehouse, in order to meet the most economical ordering plan in the question, we believe that the production raw material inventory cannot exceed the needs of the company's production for 3 weeks, which is equivalent to the current week's raw material quantity The converted capacity should not be more than 3 times the weekly capacity requirement, so we got the second constraint on capacity. Combined with the constraints of the 0-1 variable itself, we obtain the constraints of each 0-1 programming model (according to the different values of the week number *i*, the following formula can be divided into 24 single-week 0-1 programming models. Condition) is

$$\begin{cases} \sum_{j=1}^{50} P_{ij} \cdot X_{ij} \geq 2 \cdot 28200 (i = 1) \\ \sum_{j=1}^{50} P_{ij} \cdot X_{ij} \geq 2 \cdot 28200 - \sum_{j=1}^{50} P_{ij} \cdot X_{i-1j} \ \ (i = 1,2,3, \dots ,24) \\ \sum_{j=1}^{50} P_{ij} \cdot X_{ij} \leq 3 \cdot 28200 - \sum_{j=1}^{50} P_{ij} \cdot X_{i-1j} \ \ (i = 1,2,3, \dots ,24) \\ X_{ij} = 0 \text{ 或 } 1 \ (i = 1,2,3, \dots ,24, j = 1,2,3, \dots ,50) \end{cases} \tag{3}$$

Through Matlab software, our team solved the 0-1 variable X_{ij}, and through X_{ij}, our team got the supplier serial number and the corresponding supply quantity that correspond to the needs of each week.

3.3 Formulation of transshipment plan

For the transfer plan with the least loss, this article ranks 8 transferers according to the loss rate in the next 24 weeks. Since the total loss value L of the forwarder depends on the total cargo volume H and the loss rate R_i ($i \in [1,8]$) of the eight forwarders, and satisfies the following formula:

$$L = \sum_{i=1}^{n} H \cdot R_i \tag{4}$$

So when our total cargo volume H is constant, the smaller the loss rate R_i and the required number of forwarders n, the smaller the loss value. Therefore, at this time, our transshipment plan formulation strategy can be divided into two steps:

(1) First, we determine the minimum number of transshipment providers required through the total supply of suppliers each week. In actual operation, we only need after a transshipment provider has completed the transshipment of a supplier's supply, the remaining part can continue to be used as the next supplier's transshipment, that is, the minimum number of transshippers meets:

$$\min n = \left\lceil \frac{H}{6000} \right\rceil \tag{5}$$

Among them, ⌈ ⌉ means rounding up.

(2) Then, through the previously calculated ordering plan, refer to the minimum number of forwarders, and select the forwarders with low loss rate from top to bottom, and meet the number of transportation.

4. Conclusion

First of all, this paper analyzes the characteristics of suppliers through the analytic hierarchy process and selects the 50 most important buyers to simplify the problem, then uses the 0-1 planning model to formulate the ordering plan, and finally formulates the transshipment plan with the goal of minimum loss.

References

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