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The ordering and transportation of raw materials for production companies based on the superior-disadvantageous solution distance method and multi-objective planning model

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Abstract

This paper mainly studies the ordering and transportation of raw materials in manufacturing enterprises, based on the superiority and inferiority solution distance method, quantifies the supplier's supply characteristics, and then establishes a multi-objective planning model based on the minimum production cost and the minimum loss rate of transshipment, and finally gives the optimal ordering and transshipment scheme and analyzes the implementation effect. Based on the relevant data of suppliers, dig out the supplier's supply characteristics indicators and screening, find the seven indicators describing the supplier's supply capacity and supply risk, quantify these indicators using the superiority and inferiority solution distance method, and find the most important 50 suppliers. We use 0-1 integer planning to select the 50 important suppliers and get at least 5 suppliers to meet the production demand of the company. The feasibility and effectiveness of the scenarios were then analyzed.

Keywords

TOPSIS, 0-1 planning, multi-objective planning.

1. Introduction

In manufacturing companies, the selection of suppliers is particularly important for the development of the company. The instability of the market economy, the volatility of the demand market, various risks arising from natural and human factors, and the concern of decision-makers about the effectiveness of the supply chain lead to a great deal of uncertainty between suppliers and producers. Therefore, the analysis of raw material ordering and transportation between producers and suppliers is of great importance for the sustainability of the company.

2. Model Establishment and Solution

2.1. Superior and inferior solution distance model

Principles for the selection of indicators

The selection of suppliers for manufacturing enterprises is related to indicators such as supplier supply capacity and supply risk. To select the most important 50 suppliers more effectively, the selection of quantitative analysis indicators should follow the principles of consistency, effectiveness, and unbiasedness, and take into account the impact of all aspects on the selection of suppliers for enterprises.

Based on the quantitative index analysis system, and comprehensive known data, this paper mainly from the supplier supply capacity and supply risk of the two aspects of refinement index selection, supplier capacity, this paper selected 402 suppliers in the past five years, total orders, total supply and supply satisfaction rate of a total of three refinement indexes, in the supply

risk, selected the supply average, order average, supply variance, order These seven detailed indicators measure the supplier's supply capacity and supply risk from different perspectives. Specific indicators are as follows.

Supply variance ${\sigma_k}^2$: $\sigma^2 = \dfrac{\sum_{i=1}^{n}\left(x_k - \overline{X}_k\right)^2}{n-1}$, $(n = 402)$;

Average quantity supplied $\overline{X}_k$: $\overline{x}_k = \dfrac{\sum_{i=1}^{n} x_k}{n}$, $(n = 402)$;

Number of orders L_k : Calculate the number of non-zero cells for each supplier for 240 weeks according to the order quantity data of the company in Annex 1, if the cell data is non-zero, it is recorded once;

Total supply quantity Q_k : According to the supplier supply quantity data in Annex 1, the supply quantity of each supplier in 240 weeks is summed up;

Supply fulfillment rate λ: Firstly, supply the supply quantity/order quantity >1, which means the supply order ratio >1. And then the supply order ratio/order number of such suppliers is normalized to eliminate the effect of different units, i.e. Supply fulfillment rate λ= supply order ratio/order number.

The most important vendor selection is based on the distance method model of superior and inferior solutions

The TOPSIS method [1] is a more common comprehensive evaluation method that better expresses the gaps between programs in the system, making full use of the information contained in the raw data.

(1) Original matrix normalization

(2) Normalization of the normalization matrix

(3) Calculate and normalize the score

2.2. The optimal value of the number of suppliers based on 0-1 integer programming

The 0-1 variables are often used as logical variables to show whether the system is in some particular state, or whether a particular option is chosen when making a decision. x_i =1 denotes the supplier is selected and 0 denotes not selected.

Based on the selection of the most important suppliers, these 50 suppliers are used x_i to construct the objective function of the minimum number of suppliers required to meet the production needs of the firm, as follows.

$$\min z = x_1 + x_2 + \cdots + x_{50} \tag{1}$$

The constraints of this objective function, are as follows.

Denote by *a*, *b*, and *c*, respectively, the quantities of raw materials of categories A, B, and C consumed by the enterprise to produce the product. And it is known that the capacity of the enterprise is 2.82*10^4 m^3/week, and for each product produced at 1 m^3, it needs to consume 0.6 m^3 of raw material of category A or 0.66 m^3 of raw material of category B or 0.72 m^3 of raw material of category C, that is:

$$\frac{1}{0.06}a + \frac{1}{0.66}b + \frac{1}{0.72}c \geqslant 28200 \tag{2}$$

Based on the data of 50 important suppliers derived from the first question, the suppliers providing raw materials A, B, and C are selected and weighted with the supply reference value and then summed to obtain constraints.

$$\begin{aligned} a = {} & 2x_3 + 2x_{11} + 6x_{14} + 0x_{17} + 2035x_{18} + 10x_{22} + 2x_{23} + 2x_{25} + 4x_{27} \\ & + 3x_{28} + 2x_{30} + 1x_{34} + 2x_{38} + 9x_{40} + 1045x_{42} + 43x_{43} + 3x_{49} \end{aligned} \tag{3}$$

$$\begin{aligned} b = {} & 5x_1 + 2x_2 + 32x_6 + 24x_{10} + 3x_{12} + 2x_{13} + 3x_{19} + 6x_{20} + 2x_{26} \\ & + 6x_{31} + 5x_{33} + 2x_{37} + 5x_{41} + 52x_{44} + 11x_{45} + 2x_{46} + 2x_{48} \end{aligned} \tag{4}$$

$$\begin{aligned} c = {} & 6x_4 + 1970x_7 + 8035x_8 + 18x_9 + 4x_{15} + 480x_{16} + 2x_{21} + 3x_{24} \\ & + 2x_{29} + 2x_{32} + 4x_{35} + 7629x_{39} + 0x_{47} + 4x_{50} \end{aligned} \tag{5}$$

After the solution, the enterprise needs to choose at least five suppliers to supply raw materials to meet the demand of production.

2.3. Determine ordering and transit options under multi-objective planning

Determine ordering options

Multi-objective planning is used to study the optimization of more than one objective function in a given region, for an enterprise, the selection of different suppliers, the goal is to ensure that the enterprise meets the weekly capacity of the case, the maximum production efficiency, while production costs and supply risk as small as possible. In practice, from C to A, the raw material purchase unit price increases by 10%, and the unit cost of transportation and storage of different kinds of raw materials is the same, so let the purchase unit price of C raw materials be unit 1, the purchase unit price of A raw materials be 1.2, and the purchase unit price of B raw materials be 1.1.

With *a*, *b*, and *c* denote the quantities of raw materials of A, B, and C consumed by the enterprise to produce the product, respectively, the objective function aiming to minimize the procurement cost, is as follows.

$$\min z = 1.2a + 1.1b + c \tag{6}$$

The constraints are the same as (2), (3), (4), and (5) above. the results are derived. When *a*=2125, *b*=77, and *c*=1767, the enterprise will achieve the most economical raw material ordering scheme.

Determine the transit program

Based on the above ordering scheme, for the identified suppliers and the supplier's supply quantity for further transshipment, it is necessary to select the forwarder, and through the analysis and processing of the data in Annex II about the transportation loss rate of eight forwarders in the past five years, the average loss rate of these eight forwarders is obtained, and the average value is sorted from lowest to highest to find out the forwarder with the smallest to largest loss rate.

Table 1 Analysis of raw material production costs

Category	A	B	C
Unit price	1.2	1.1	1
Required for production	0.6	0.66	0.72
Production costs	0.72	0.726	0.72

From the perspective of economic efficiency, the production cost of raw materials in category B is higher, and the production price of raw materials in categories A and C is the same and lower than that of category B. However, from the perspective of capacity conversion, the

transportation cost and storage cost of raw materials in categories C are higher than those of raw materials in categories A and B because more supply is required for replacement into capacity, and the suppliers of raw materials of category C are the least.

The constraints are as follows.

(1) To reduce the dimensionality of the search for excellence, a priority condition is added here. Since the replacement of raw materials in category C is the lowest capacity replacement rate, it is preferred to use the larger loss of transshipment providers, so that the overall capacity loss is smaller, followed by raw materials of category B.

(2) For quantities that have been ordered, arrangements should be made to provide a forwarder with a lower attrition rate to the supplier with the higher quantity for forwarding, and so on.

(3) Typically, one supplier's weekly supply of raw materials is shipped by one forwarder as much as possible.

(4) Each forwarder has a transportation capacity of 6,000 cubic meters per week.

As the ordering scheme has been obtained, based on the order quantity of the ordered supplier to provide transit, it is known that the number of raw materials of category A need to be transferred is 2125 m^3, the number of raw materials of category B need to be transferred is 77 m^3, the number of raw materials of category C needs to be transferred is 17670 m^3. After the previously derived priority conditions, all the raw materials of categories A and B can be ordered first by the least loss of T3 forwarders Then, according to the constraint, we will arrange the forwarders with a lower loss rate for category C raw materials, and finally, we will only need the first four forwarders with the lowest loss rate to be responsible for the forwarding.

Analysis of the effect of program implementation

In the creation of indicators, due to the different understanding of the differences, in addition to the selection of indicators, there is also a great deal of subjectivity, for the indicators of the screening refinement of the different ways to make the difference and the use of different models of different software solutions to the problem so that different programs have a certain degree of uncertainty, such as in the selection of the supply reference value, this paper explains the following: The maximum value of each supplier's supply quantity is given a weight of 1/3 plus a weight of 2/3 of the average value of the supply quantity. The obtained data gives a relatively optimal result for the decision of the ordering scheme.

The ordering scheme is a choice made by the company based on the availability of 50 important suppliers that have been selected to order to meet the company's weekly production capacity. Since the company wants to keep as much raw material in stock as possible to meet its two-week production needs, it is assumed that the company will have the previous stock in the first week of production and will only need to order raw materials for the second week in the first week, the third week in the second week, and so on, and will need to order raw materials for the twenty-fifth week in advance in the twenty-fourth week.

The forwarding scheme is based on the planning of the supply quantity ordered by the enterprise under the ordering scheme again, and new constraints and new influencing factors are added under the target planning of the ordering scheme: the forwarding loss rate and the forwarding allocation of the supply quantity are carried out. Among them, since the measurement index of the influencing factor of the transit loss rate directly affects the results of the transit scheme, we process the data of the transportation loss rate in Annex II to derive the average value of the loss of each transit provider and rank the advantages and disadvantages. In addition, the capacity conversion of the three raw materials of category A, category B, and category C was ranked to arrive at the result of A>B>C, which was used to provide the corresponding transshipment solution for the suppliers ordering the solution.

3. Conclusion

The superiority-disadvantage solution distance method compared with other evaluation class algorithms, the superiority-disadvantage distance can fully utilize the comprehensive information of the original data, and is more suitable for processing a large amount of data, with simple data processing and less arithmetic, while compared with models such as hierarchical analysis, the superiority-disadvantage solution distance method is more objective and less subjective.

When assigning weights by the superiority-disadvantage distance method, it is difficult to select quantitative indicators, and the number of evaluation indicators is not certain, which makes it difficult to portray the influence strength of indicators, while he needs the number of evaluation objects, which must be higher than two to be allowed.

To avoid the influence of subjective color, we consider adding the entropy value to objectively assign the weight, through which we can judge the dispersion of the index.

The 0-1 integer planning model is more conducive to generalization and practicality because it is relatively closely related to practice compared to the other models.

The disadvantages of the 0-1 integer planning model are that it is too difficult to calculate, the program is complicated to run, and it is more troublesome to program and write. At the same time, the planning model takes into account many factors, and errors and omissions may lead to unsatisfactory results or errors.

The 0-1 integer planning is more difficult to solve at first, so we can use the hidden enumeration algorithm to improve the efficiency of the computation, or of course, we can switch to the heuristic algorithm to find the approximate solution of the target planning, thus improving the efficiency of the computation.

The superiority and inferiority solution distance method can be used for supplier selection. This method is relatively objective, and to a certain extent, it gets rid of the subjective color and provides some ideas for enterprises to select suppliers and prevent the collapse of the supply chain, while the 0-1 planning model can provide convenience for enterprises to achieve good economic benefits by constructing different target decision layers, to arrive at the goal of preventing insufficient inventory and excessive depletion.

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