Target-based planning of ordering solutions for manufacturing companies

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Abstract. Using the idea of mathematical modeling, we study the ordering problem of raw materials in manufacturing enterprises and develop the best ordering and transportation plan for enterprises through models such as goal planning, which provides a certain degree of reference value for the development decisions of the same type of enterprises. Firstly, the supplier supply characteristics of 402 enterprises are quantitatively evaluated, and in the process of quantitative analysis, the supplier supply characteristics indicators are derived through the analysis and pre-processing of data, followed by the establishment of evaluation index systems and guaranteed enterprise production models through different supply characteristics respectively, followed by the use of entropy weighting method to assign weights to the supply characteristics indicators, and finally the TOPSIS method is used to quantify the supply characteristics to determine the 50 most important suppliers. Then the objective planning model is established to determine the minimum number of suppliers and the most economical ordering scheme, and the optimization model is established to solve the problem, and the 0-1 integer planning mode and the approximate bundle condition are used to develop the transit scheme.

Keywords: Quantitative analysis; goal planning; entropy method; TOPSIS method.

1. Introduction

As one of the basic industries of China's national economy, the construction industry has been on a booming trend in recent years. In the new round of economic cycle, along with the growth of China's national economy, the construction industry has also always maintained a high growth rate. However, the rapid economic development has also brought about energy problems and environmental damage. Through the analysis of the current situation of energy conservation and emission reduction in China, with the development of industry, the demand for energy has increased rapidly, and China has gradually become the world's largest energy consumer. 20 years later, China's total energy consumption has grown at a higher rate, with a compound annual growth of about 7.8%, and surpassed the United States as the world's top energy consumer in 2010. In 2015, China's major energy consumption totaled 3,013.96 million tons in 2015, China's major energy consumption totaled 3,013.96 million tons of oil equivalent, accounting for 23% of the world's total energy consumption.

In order to respond to the national call for energy conservation and emission reduction and to maximize the use of available energy under reasonable conditions, every enterprise needs to seriously consider the rational and effective allocation of resources. In this paper, it is necessary to select the most reasonable 50 suppliers, to develop the most economical ordering scheme for raw materials, and to manufacture the transfer scheme with minimum losses, while ensuring that the production capacity conditions of the enterprise are met.

2. Problem Analysis

Through the relevant data and descriptions, the supply quantity of 402 suppliers and the order quantity of the enterprise in the last five years are now known, and the classification of materials associated with different suppliers is also available. This question requires the determination of the

50 most reasonable suppliers under the normal production conditions of the enterprise, which belongs to the evaluation decision class.

Due to the large amount of data and miscellaneous, we first thought of statistical information on the order quantity and supply quantity of different suppliers in 240 weeks, and judged the delivery situation of different suppliers in the process of supply and demand by the ratio of supply quantity to order quantity, and gave this situation as the delivery rate index; in addition, we also defined the ratio of supply quantity to order quantity as the supply rate index, which reflects the satisfaction of different suppliers to the enterprise's demand. Finally, the number of times the supply quantity is greater than the order quantity is found by the statistical supply and order quantity, and then compared with the order quantity, which expresses the stability of supply and demand relationship, and is defined as the stability of supply and demand rate index.

Firstly, the entropy weighting method is applied to the above indicators, then the TOPSIS method is used to quantify the different supply characteristics of different suppliers, and finally the 50 most important suppliers are decided on the basis of the mathematical model.

It is known that the weekly production capacity of the enterprise is 28,200 cubic meters, and each cubic meter of product requires 0.6 cubic meters of raw material of category A, or 0.66 cubic meters of raw material of category B, or 0.72 cubic meters of raw material of category C. The unit price of raw material of category A and B is 20% and 10% higher than that of raw material of category C respectively, and the transportation capacity of each forwarder is 6,000 cubic meters per week.

3. Supplier selection

Firstly, two problems need to be solved, the first of which is an evaluation type problem, based on the quantitative analysis of the working characteristics of 402 suppliers and finally giving the characteristic degree of each supplier. For this problem, this paper first finds out the characteristics of each supplier from the order quantity and supply quantity of the 402 suppliers given in Annex I for the last five years. In this paper, the delivery rate, supply rate, supply and demand stability rate and other aspects of the supply characteristics are evaluated comprehensively, and the evaluation index system of supplier supply characteristics degree is to be established. Subsequently, the entropy weighting method is adopted to assign weights to the indicators just analyzed, and finally the TOPSIS method is used to quantify the supply characteristics of each supplier. The second problem is a decision-making problem, which requires the establishment of a mathematical model to determine the 50 most important suppliers on the basis of the importance of production. In this paper, the first problem is to determine whether the suppliers are close to the supply standard based on the supply characteristics of the suppliers analyzed in the first problem.

3.1. Selection of supplier characteristic data variables and construction of characteristic evaluation system

3.1.1 Data Integration

This paper will be analyzed and processed based on the collected data. Annex I contains information on the supply quantity of 402 suppliers and the order quantity of enterprises in the past five years, including the names of suppliers, the categories of raw materials supplied by suppliers, and the weekly order quantity of enterprises from each supplier. The categories of raw materials supplied by suppliers are divided into A, B and C categories.

3.1.2 Select data

The focus of this paper is on how to extract the data that can be used as the characteristics of supply from the supplier's supply and the enterprise's order quantity, and then quantify the supply characteristics based on the data as above. According to the question, the enterprise production mainly selects the delivery rate, supply rate, the relationship between the amount of supply and order quantity, the number of supply and order quantity as the characteristics of the proposed evaluation system and

model, the following will be mainly from the delivery rate, supply rate and supply and demand stability rate and other three aspects to start the variable selection.

3.1.3 Delivery Rate

In this paper, the delivery rate is judged according to the ratio of the supply quantity to the order quantity.

The delivery quantity is the sum of the deliveries of each supplier in the case of fixed material classification, and its specific formula is

$$M = \sum_{i=1}^{240} m_1 \tag{1}$$

Where M is the supply quantity and m_i is the supplier's supply quantity in week i.

The order quantity is the sum of each company's orders for a particular material and is specified by the formula

$$N = \sum_{i=1}^{240} n_i \tag{2}$$

Where N is the order quantity and n_i is the order quantity of the company in week i.

The delivery rate is the ratio of the supply quantity to the order quantity, and its specific formula is

$$G = \frac{M}{N} \tag{3}$$

Where, G is the delivery rate

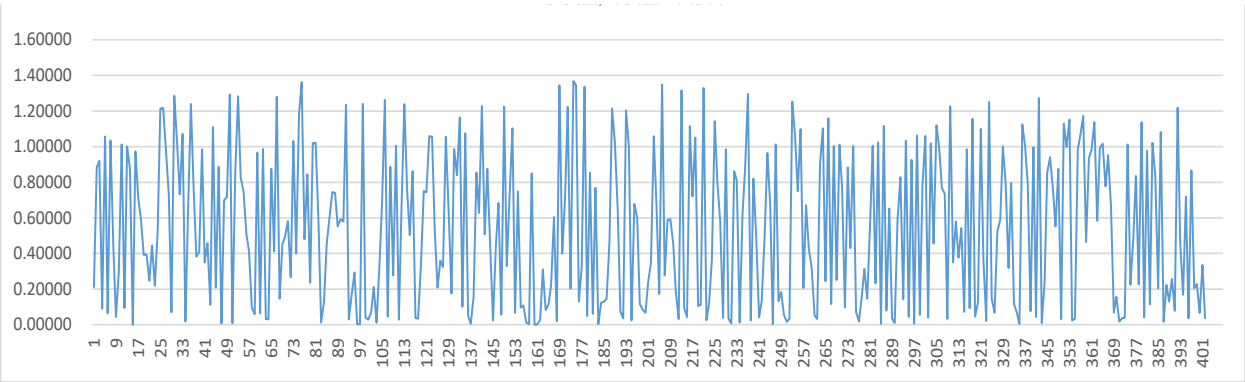

Fig 1. Delivery rate by supplier.

3.1.4 Supply rate

The supply rate is judged by the ratio of the number of deliveries to the number of orders.

The number of deliveries is the sum of the number of orders for a particular material for each company.

The number of orders is the sum of the number of deliveries made by the supplier in the case of a fixed material category.

The supply rate is the ratio of the number of orders to the number of deliveries, and the specific formula is

$$T = \frac{\omega}{\varphi} \tag{4}$$

Where T is the supply rate, ω is the number of deliveries, and φ is the number of orders.

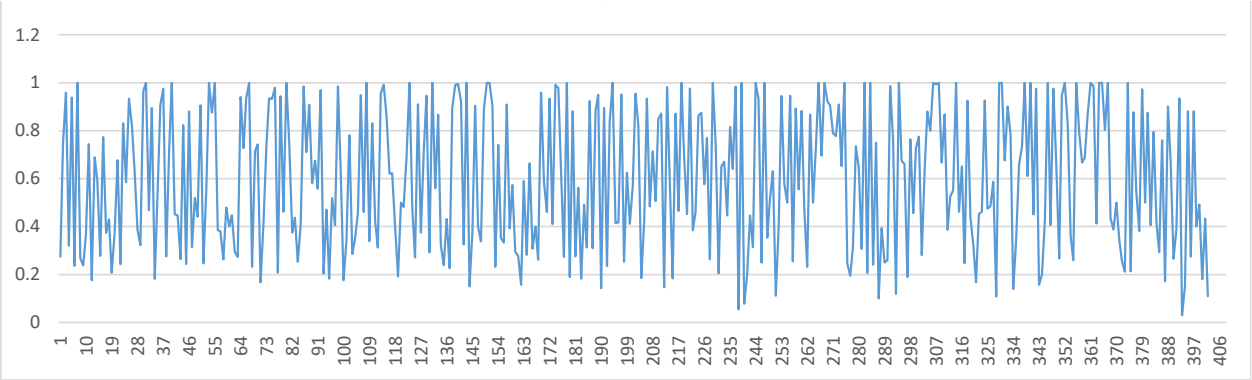

Fig 2. Supply rate by supplier.

3.1.5 Supply and demand stability rate

The stability rate of supply and demand is the ratio of the stability of the enterprise's order and the supplier's supply. Here, we first find out the number of times when the supply is greater than the order, and then compare the number of orders found in (2), which is the stability rate of supply and demand, and the closer this value is to 1, the more stable the supply and demand.

$$S = \frac{P_{B>A}}{\varphi} \tag{5}$$

Where, S is the stability rate of supply and demand, and $P_{B>A}$ is the number of times the supply quantity is greater than the order quantity.

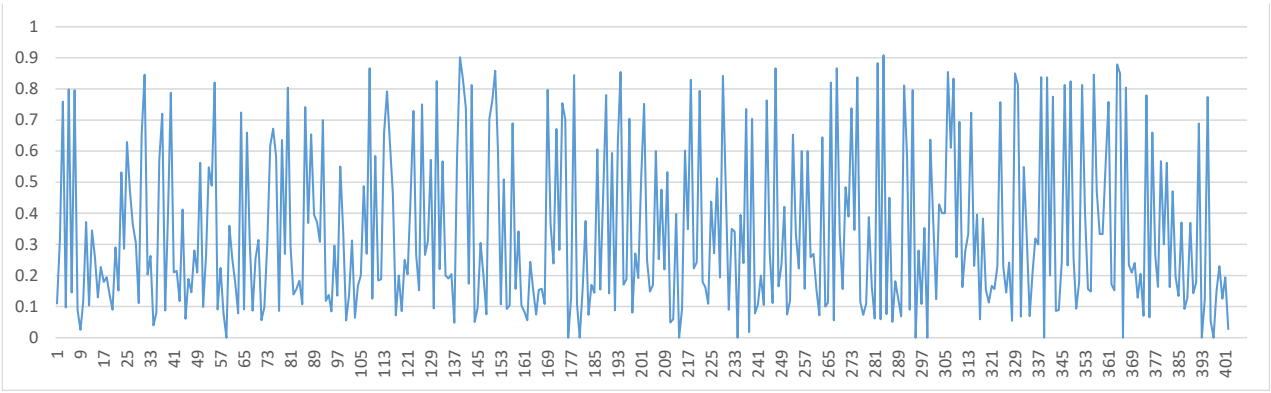

Fig 3. Stable rate of supply and demand by manufacturers.

In summary, the characteristic evaluation system is constructed by analyzing the characteristic variables such as delivery rate, supply rate, the relationship between the amount of supply and the amount of order, the number of supply and the number of order.

3.2. Quantification of supply characteristics

The prerequisite for quantifying the supply characteristics is to determine the weights of each indicator. Through the analysis, we determined that each indicator has a different size of weight. In order to highlight the objectivity of the quantitative results, this paper decided to use the assignment of weights based on the entropy method, and after calculating the weights, the supply characteristics were quantified by TOPSIS.

3.2.1 Entropy weighting method to calculate weights

According to the definition of information entropy, for a certain indicator, the entropy value can be used to determine the dispersion degree of a certain indicator, and the smaller its information entropy value, the greater the dispersion degree of the indicator, the greater the influence (i.e., weight) of the indicator on the comprehensive evaluation, and if the values of a certain indicator are all equal, the indicator does not work in the comprehensive evaluation. Therefore, the tool of information

entropy can be used to calculate the weights of each indicator to provide a basis for the comprehensive evaluation of multiple indicators.

First of all, this paper needs to normalize and normalize the supplier index data to ensure the non-negativity of the data

$$z_{ij} = \frac{x_{ij} - x_{\min}}{x_{\max} - x_{\min}} \tag{6}$$

Where z_{ij} is the normalized variable, and $x_{\min}$ and $x_{\max}$ are the maximum and minimum values of each indicator, respectively.

Calculate the weight accounted for by the j-th firm under the i-th supply characteristic indicator and consider it as the probability p_{ij} in calculating the information entropy

$$P_{ij} = \frac{Z_{ij}}{\sum_{i=1}^{n} Z_{ij}} \tag{7}$$

The information entropy e_j of the j-th indicator is calculated, and the corresponding information utility value d_j is calculated. The reason for the conversion here is that a higher information entropy means less information about the indicator, and the introduction of the information utility value d_j can positively measure the amount of information.

$$e_j = -\frac{1}{\ln n} \sum_{i=1}^{n} p_{ij} \ln(p_{ij}) \tag{8}$$

$$d_j = 1 - e_j \tag{9}$$

$$w_j = \frac{d_j}{\sum_{j=1}^{m} d_j} \tag{10}$$

The weights of the three indicators were obtained as

Table 1. Weight of each indicator.

Indicators	Delivery Rate	Supply rate	Stability rate of supply and demand
Weighting	0.00249	0.00248	0.00249

The final quantitative supply characteristics of 402 suppliers were obtained, and the results are shown in the Appendix.

Table 2. Supplier supply characteristics results table.

Supplier ID	Supply characteristics	Supplier ID	Supply characteristics
S003	0.99	S247	0.92
S005	0.98	S266	0.92
S007	0.98	S268	0.91
S031	0.98	S273	0.91
S040	0.97	S275	0.91
S055	0.97	S282	0.91
S075	0.97	S284	0.90
S080	0.97	S294	0.90
S092	0.96	S306	0.90
S108	0.96	S308	0.87
S114	0.96	S324	0.87
S123	0.96	S329	0.86
S131	0.96	S330	0.85
S139	0.96	S338	0.85
S141	0.95	S340	0.85
S143	0.95	S342	0.85
S151	0.94	S346	0.84
S178	0.94	S352	0.84
S189	0.93	S356	0.84
S194	0.93	S361	0.84
S218	0.93	S364	0.84
S221	0.93	S365	0.84
S229	0.93	S367	0.84
S239	0.93	S374	0.84
S244	0.93	S392	0.84

3.3. Cost Analysis

The unit prices of raw materials of categories A and B are 0.2 and 0.1 higher than those of category C. Assuming that the unit price of category C is 1, the unit prices of category A and B are 1.2 and 1.1, respectively. Since the question clearly gives the same unit costs for transportation and storage of the three categories of raw materials, the effects of transportation and storage costs are ignored here. Combining the unit prices and the raw material consumption data of the product given in the question, we can obtain the cost analysis table as follows

Table 3. Cost analysis table.

	A	B	C
Unit price	1.2	1.1	1
Production consumption	0.6	0.66	0.72
Cost analysis	0.72	0.726	0.72

From the table, we can conclude that the production cost of B is greater than the production cost of A, and the production cost of A is equal to the production cost of C. And because the consumption of raw materials per cubic meter of product A is the least, so we roughly conclude that we can appropriately increase the demand for A. And because there are problems such as transportation losses in the process of transshipment by forwarders, so the specific situation needs to be analyzed in detail.

3.4. Supplier Selection

3.4.1 Decision variables

By the question in the supplier stage, the number of suppliers selected under the premise of meeting production needs our decision variables.

3.4.2 Objective function

From the question we get the capacity of the enterprise is 28,200 cubic meters per week, that is, the production is fixed, we need to ensure the minimum number of suppliers under this condition, so consider it as the objective function.

$$\min \sum_{i=1}^{50} X_i \tag{11}$$

$$X_i = \begin{cases} 1 & Supply \\ 0 & Notavailable \end{cases} \tag{12}$$

3.4.3 Constraints

The enterprise should keep as much raw materials as possible to meet the production demand for at least two weeks, and here we specify two weeks as the two weeks including this week and the starting week already in stock. From the cost analysis, we know that without considering the transportation loss and other factors, the raw materials of category A are optimal, so we assume that all raw materials of category A are used.

$$\sum_{i=1}^{50} X_i I_i \geqslant 2.82 \times 10^4 \times 0.6 \tag{13}$$

Where I_i is the supply quantity?

The raw materials supplied by one supplier are transported by one forwarder each week, and one forwarder can forward multiple suppliers' goods, so in the selection of decision variables, we decided to use a 0-1 matrix with suppliers as the horizontal axis and forwarders as the vertical axis, and the selection of suppliers in the matrix, i.e., the values of each column add up to less than or equal to 1, and it should be ensured that each forwarder's The transportation capacity of each forwarder is 6000 m3 /week.

$$\sum_{i=1}^{50} Q_i x_i u_{ij} \leqslant 6000 \tag{14}$$

Where x_i is the supply quantity of the i-th supplier, Q_i is the 0-1 matrix, and the 0-1 variable is introduced

$$u_{ij} = \begin{cases} 1 & The\ i-th\ companygoestothej-thsuppliertotransferrawmaterials \\ 0 & not \end{cases} \tag{15}$$

In summary, the optimization model for the supplier selection problem to meet the production demand problem is obtained by modeling the decision variables, objective function and constraints, combined with Matlab modeling analysis as

$$\min \sum_{i=1}^{50} X_i \tag{16}$$

$$s.t.\begin{cases}\sum_{i=1}^{50} X_i I_i \geq 2.82\times10^4\times0.6, i=1,2,\cdots,50\\ \sum_{i=1}^{50} Q_i x_i u_{ij} \leq 6000, j=1,2,\cdots 8\end{cases} \tag{17}$$

The final result was the selection of at least 27 suppliers to supply raw materials.

Table 4. Selected Supplier ID.

Serial number	Supplier ID	Serial number	Supplier ID
1	S031	15	S284
2	S040	16	S306
3	S055	17	S308
4	S080	18	S329
5	S108	19	S330
6	S131	20	S340
7	S143	21	S346
8	S151	22	S352
9	S194	23	S356
10	S229	24	S361
11	S247	25	S364
12	S268	26	S365
13	S275	27	S367
14	S282		

4. Conclusion

For the redundant data, in this paper, we firstly count the order quantity information and supply quantity information of different suppliers in 240 weeks, and judge the delivery situation of different suppliers in the supply process by the ratio of supply quantity information and order quantity, and give this situation as the delivery rate index; in addition, we also define the ratio of supply quantity to order quantity as the supply rate index, which reflects the demand of different suppliers to the enterprise Finally, we can find out the number of times the supply quantity is greater than the order quantity through the statistical supply and order quantity, and then compare it with the order quantity, which expresses the stability of the supply and demand relationship and is defined as the stability rate indicator of the supply and demand relationship. Using the entropy weighting method to assign weights to the above indicators, we finally get 27 suppliers.

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