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Research on optimal strategy of material ordering and transportation based on evaluation model and planning model

Cun Zhao[1], Teng Ma[1], Long Shi[2]

[1]*School of Mathematics and Computer Science, Yan'an University, Yan'an 716000, China*
[2]*School of Economics and Management, Yan'an University, Yan'an 716000, China*

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Abstract: With the development of enterprise productivity in China, material transportation and rational allocation of resources are of positive significance to promote the development of enterprises. This paper discusses that in the selection of raw material ordering and transportation scheme, after knowing the transportation cost, loss and other conditions, on the basis of meeting the weekly production capacity of the enterprise, the grey correlation analysis method in the evaluation model is used to analyze the problem, and 50 important suppliers are obtained. The second use of the planning model is to solve the cost optimization problem first, and then the loss problem in the transportation process, so as to obtain the optimal strategy of raw material ordering and transportation. On this basis, this paper can also improve the model to improve production capacity and a reasonable scheme to meet such problems. In order to quantitatively analyze the supply characteristics of suppliers, this paper first visualizes the data, then establishes the grey correlation analysis model, solves it with MATLAB, obtains the grey correlation value of 80 groups of data, analyzes the results, and obtains 50 most important suppliers. Among the 50 suppliers obtained in this paper, select the supplier with the least needs, and use 0-1 programming to select the most appropriate one. Secondly, use linear programming model to solve the ordering scheme and transshipment scheme, and then use LINGO to solve, and get at least 8 suppliers. There are 6 ordering schemes in the first week and 9 ordering schemes in the second week. The transshipment scheme is obtained in the model solution. Secondly, this paper need to consider the cost reduction, that is, there are more raw materials a and less raw materials C. using the planning model, this paper should first consider the cost problem, and then consider the loss problem, and finally get the ordering scheme: there are two kinds of ordering schemes in the first week, three kinds of ordering schemes in the first week and then every week, and the transshipment scheme is obtained in the solution of the model.

1. Introduction

Supply chain management is to establish a certain relationship between suppliers and enterprises through planning, acquisition, storage, distribution and service, so that enterprises can obtain the required products at the lowest cost and meet the appropriate time, quality, quantity and status [1].

The raw materials used by a manufacturer of building and decorative plates are mainly wooden fibers and other vegetable fiber materials, which are divided into three types: A, B and C. The enterprise carries out production 48 weeks a year. It needs to formulate a 24 week raw material order and transfer plan in advance, reasonably select the raw material supplier (Supplier) and the corresponding weekly raw material order plan (order quantity), and determine that the third-party logistics company (transporter) entrusts it to transfer the supply quantity (supply quantity) of raw materials to the enterprise warehouse.

The weekly production capacity of the enterprise is 28200 cubic meters. Each cubic meter of products 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. Due to the particularity of materials, the supplier cannot supply goods in strict accordance with the order quantity provided by the enterprise, and the actual supply quantity may be more or less than the order quantity. Therefore, the enterprise needs to ensure that the inventory of raw materials required for production in no less than two weeks as far as possible. Therefore, the enterprise purchases all the raw materials actually provided by the supplier

In the actual operation process, raw materials will be subject to certain loss (the percentage of loss in supply is called "loss rate"), and the quantity of raw materials actually transported by the forwarder to the enterprise warehouse is called "receiving quantity". The transportation capacity of each household is 6000 m3 week. Generally, raw materials supplied by one supplier every week shall be transported by one forwarder as far as possible.

The production efficiency of the enterprise is directly affected by the purchase cost of raw materials. In fact, the purchase unit price of class A and class B raw materials is 20% and 10% higher than that of class C materials respectively. The unit cost of transportation and storage of three types of raw materials is the same.

2. Grey correlation analysis of model

2.1 Grey correlation analysis principle

The basic principle of grey correlation analysis is to judge whether the relationship is close according to the similarity of sequence curve geometry. The closer the curve is, the greater the degree of correlation is, and vice versa.

2.2 Steps of grey correlation analysis

The weekly order quantity of all suppliers is compared with the weekly supply quantity of all suppliers in this paper

Reference sequence: $Y = Y(k) \mid k = 1,2 \ldots n;$

Comparison sequence: $X = X(k) \mid k = 1,2 \ldots m.$

The data is dimensionless. According to the data analysis, the average processing is selected in this paper:

$$x_i(k) = \frac{x_i(k)}{\overline{x_i}}, (k = 0,1,2 \ldots m; \quad i = 1,2...402). \tag{1}$$

Calculation of correlation coefficient:

$$\xi_i(k)=\frac{\min\limits_i\min\limits_k|y(k)-x_i(k)|+\rho\max\limits_i\max\limits_k|y(k)-x_i(k)|}{|y(k)-x_i(k)|+\rho\max\limits_i\max\limits_k|y(k)-x_i(k)|}. \tag{2}$$

$\rho\in(0,\ \infty)$, called resolution coefficient. The smaller the ρ, the greater the resolution. Generally, the value range of ρ is (0,1). The specific value can be determined according to the situation. When $\rho\le 0.5463$, the resolution is the best, usually $\rho=0.5$.

Correlation degree

$$r_i=\frac{1}{n}\sum_{k-1}^{n}\xi_i(k),k=1,2\ldots n. \tag{3}$$

Relevance ranking

Rank the correlation degree by size. The greater the r, the closer the supplier's supply is to the enterprise's order quantity.

After the quantitative analysis of the data, the grey correlation analysis model is established, which can reflect the importance of ensuring the production of the enterprise. By analyzing the correlation degree, 50 important suppliers can be obtained.

2.3 Supply consultation analysis

The analysis of this paper is to discuss the supply, establish an evaluation model, evaluate the importance of suppliers to ensure industrial production, and rank 50 important suppliers.

Firstly, the visual analysis of supply quantity and order quantity is as follows:

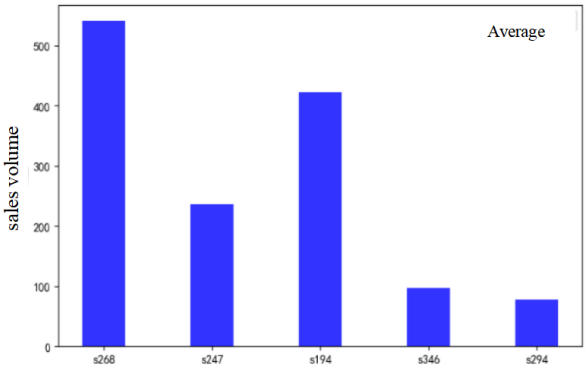

Figure 1 Average supply

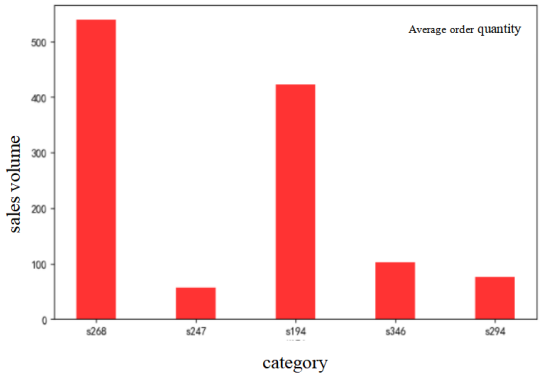

Figure 2 Average order quantity

Select the first four rows of data in the orderer table and the supplier table to visualize their orders in the first eight weeks, as shown in the following figure:

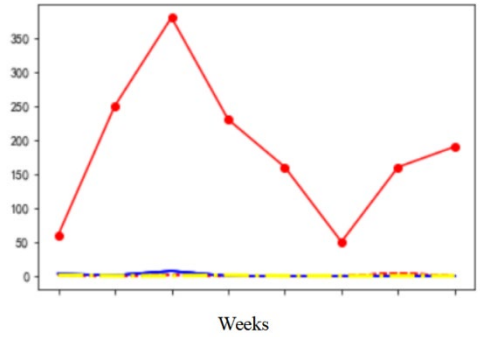

Figure 3 Data visualization of the first four orderers in the first eight weeks

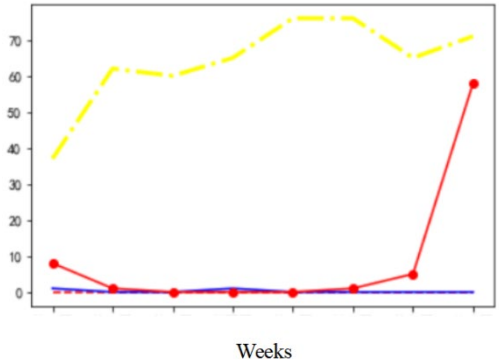

Figure 4 Data visualization of the first four suppliers in the first eight weeks

Secondly, the completion rate is used to screen them, and 80 groups of data are obtained. Then, according to the sum of the order quantity of all suppliers in the same week and the comparison with each supply quantity of each supplier, the correlation degree is calculated by grey correlation analysis, and the data of the top five suppliers is visualized, as shown in the following figure:

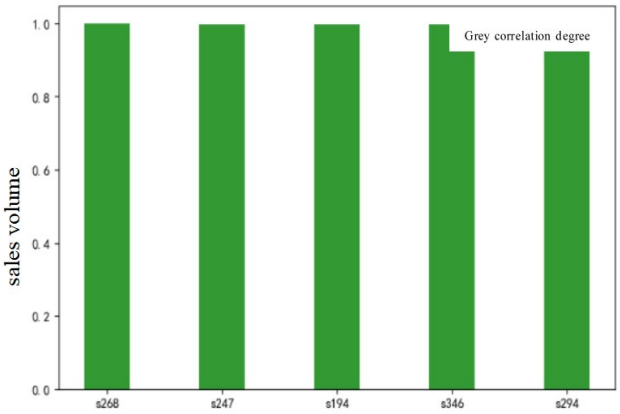

Figure 5 Visualization of the top five suppliers of relevance

After the grey correlation analysis of more than 50 production enterprises is established by MATLAB, the highest correlation degree of suppliers can be obtained:

Table 1 Ranking of 50 important suppliers

ranking	supplier	ranking	supplier	ranking	supplier	ranking	supplier	ranking	supplier
1	S268	11	S340	21	S218	31	S263	41	S273
2	S247	12	S229	22	S282	32	S110	42	S374
3·	S194	13	S361	23	S367	33	S360	43	S270
4	S346	14	S131	24	S356	34	S152	44	S321
5	S294	15	S123	25	S284	35	S003	45	S357
6	S031	16	S040	26	S007	36	S256	46	S159
7	S329	17	S352	27	S080	37	S005	47	S135
8	S275	18	S244	28	S143	38	S002	48	S128
9	S365	19	S108	29	S046	39	S065	49	S062
10	S306	20	S364	30	S189	40	S264	50	S397

3. Determination of minimum suppliers

3.1 Objective function

On the basis of 50 important suppliers, the minimum number of suppliers is the sum of suppliers that meet the decision variables.

$$\min F = \sum_{i=1}^{50} x_i \quad i = 1,2,\ldots,50. \tag{4}$$

3.2 Decision variables

Plan with 0-1:

$$x_i = \begin{cases} 1 \\ 0 \end{cases} (1 \text{ means to select, } 0 \text{ means not to select}) \tag{5}$$

Select the qualified suppliers among the 50 suppliers.

3.3 Constraint condition

The weekly production capacity of the enterprise is 28200 cubic meters. In order to meet the production needs of the enterprise, we need to determine that the total supply of the supplier is not less than the production efficiency, so we can get

$$\frac{A}{0.6} + \frac{B}{0.66} + \frac{C}{0.72} \geq 2.82 \times 10000. \tag{6}$$

In the process of determining the actual supply quantity of each supplier, this paper first calculates the maximum supply quantity within the known five years, excludes the weeks with supply quantity of 0, calculates the effective mean value of supply quantity with the effective weeks of supply quantity, and obtains the actual supply quantity of each supplier after analyzing the data:

$$\textit{Actual supply quantity of the supplier} = \frac{\textit{Maximum supply quantity of the supplier}}{3} + \textit{Supplier effective mean} \times \frac{2}{3} \tag{7}$$

Using LINGO to solve the model, it is found that at least 8 suppliers are required, which are S340,

S229, S361, S108, S282, S356, S143 and S374.

3.4 The most economical raw material ordering scheme

Still using the planning model, the analysis shows that among the eight suppliers, three supply raw material a, two supply raw material B and three supply raw material C. The unit cost of transportation and storage of three types of raw materials is the same, and assuming that a supplier supplies 6000 cubic meters at a time according to the transfer volume.

3.4.1 Objective function

$$\min F = 1.2x + 1.1y + z. \tag{8}$$

3.4.2 Constraint condition

Raw materials from the first two weeks need to be stored in the first week, so raw materials a, B and C required for ordering in the first week can be subject to the following constraints:

$$\frac{x}{0.6} + \frac{y}{0.66} + \frac{z}{0.72} \geq 56400. \tag{9}$$

The upper limit of decision variables X, Y and Z is calculated according to the problem analysis

$$\begin{aligned} 0 \leq x \leq 7392; \\ 0 \leq y \leq 9036; \\ 0 \leq z \leq 28299. \end{aligned} \tag{10}$$

Lingo can be used to solve directly, and the total amount required for the three raw materials is 7392, 3153 and 28299 respectively. Therefore, two suppliers are required to supply raw material a, one supplier supplies raw material B, and the other raw material C is supplied by three suppliers supplying C. Therefore, the following six ordering schemes can be obtained.

The ordering plan for the first week is:

S143,S229,S108,S356,S361,S374	**S143,S282,S108,S356,S361,S374**	**S229,S282,S108,S356,S361,S374**
S143,S229,S340,S356,S361,S374	**S143,S282,S340,S356,S361,S374**	**S229, S282, S108, S356, S361, S374**

When calculating the ordering scheme after one week, this paper only needs to meet the supply of raw materials for one week, and the constraint conditions become:

$$\frac{x}{0.6} + \frac{y}{0.66} + \frac{z}{0.72} \geq 28200. \tag{11}$$

The total amount of three raw materials calculated by lingo is 7390, 0 and 11436 respectively, so the suppliers of a, B and C are 3, 0 and 3 respectively, so the following 9 ordering schemes can be obtained

The order plan after the first week is

S143,S229,S356,S361	**S143,S282, S356,S361**	**S229,S282, S356,S361**
S143,S229,S356,S374	**S143,S282, S356,S374**	**S229,S282, S356,S374**
S143,S229,S361,S374	**S143,S229, S361,S374**	**S229,S282, S361,S374**

3.4.3 Minimum consumption transfer scheme

When considering the problem of minimum consumption, it is necessary to summarize the data in this paper to obtain the data in the following table:

Table 2 Summary of data in question

	A goods	B goods	C goods
Weekly production capacity (m^3)	2.82*10000		
Material consumed per cubic meter	0.6	0.66	0.72
Transportation capacity	6000		
material cost	1.2C	1.1C	C
Transportation cost	1	1	1
Storage costs	1	1	1

Based on the previous planning model, the order quantity of the first week and the order quantity after the first week are obtained. Assuming that the cost of raw material C is 1, the costs of a and B are 1.2 and 1.1 respectively. We can calculate the satisfaction of 8 suppliers first. The calculation formula is as follows:

$$Satisfaction\ rate=\frac{Effective\ mean+Order\ rate}{2} \tag{12}$$

Among them, $Effective\ mean=\frac{Sum\ of\ loss\ rate}{Number\ of\ valid\ orders}$, $Order\ rate=\frac{Number\ of\ valid\ orders}{Total\ orders}$

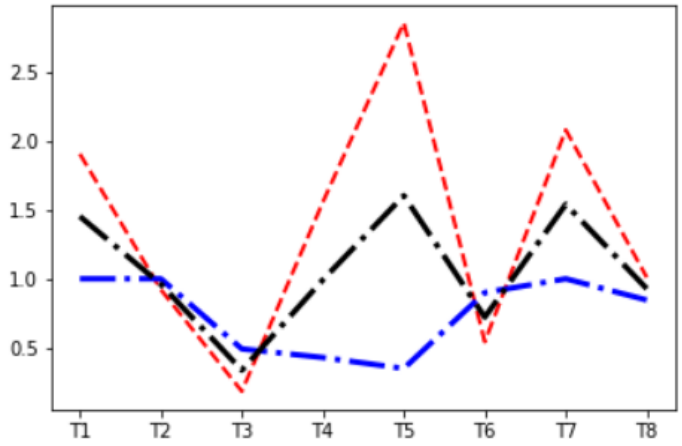

Figure 7 Distribution of satisfaction, order rate and mean value

Secondly, the satisfaction rate of 8 suppliers is ranked from low to high, and the suppliers with high ordering cost choose the forwarder with low satisfaction rate for transportation, so as to minimize the loss rate.

In the first week, the suppliers corresponding to each forwarder are selected as follows:

T3	One supplier of raw material B (6000) × 1.2)
T6, T8, T2, T4	One supplier of raw material C (6000)
T1	A supplier of raw material C (4298)
T7	One supplier of raw material B (3165) × 1.1)
T5	A supplier of raw material a (1392) × 1.2)

According to the calculated data, the minimum loss is 38330.070754, After the first week, select the suppliers corresponding to each forwarder as follows:

T3	One supplier of raw material a (6000) × 1.2)
T6	One supplier of raw material C (6000)
T8	A supplier of raw material C (5436)
T2	A supplier of raw material a (1390) × 1.2)

According to the calculated data, the minimum loss is 13412.74908.

4. Raw material optimization

By analyzing the cost, it can be seen that raw material a can be selected as much as possible and the order of raw material C can be reduced, which is to increase the upper limit of decision variable x in the constraints and reduce the upper limit of decision variable Z, which can be regarded as

$$0 \le x \le 15000;$$

$$0 \le z \le 18000.$$

Using LINGO to solve the model, the quantity of three raw materials required in the first week and the quantity of three raw materials ordered after the first week are obtained. Using the same analysis method as in Chapter 2, the ordering scheme and transportation scheme are obtained.

4.1 Two options for the first week:

S143, S229, S282, S108, S356, S361, S374
S143, S229, S282, S340, S356, S361, S374

4.2 Three options after the first week:

S143, S229, S282, S356
S143, S229, S282, S361
S143, S229, S282, S374

4.3 Transshipment scheme

After the first week, select the suppliers corresponding to each forwarder as follows:

T3	A supplier of raw material a
T6	A supplier of raw material a
T8	A supplier of raw material C
T2	A supplier of raw material C
T4	A supplier of raw material C
T1	A supplier of raw material B
T7	A supplier of raw material a

According to the calculated data, the minimum loss is 37207.590432, After the first week, select the suppliers corresponding to each forwarder as follows:

T3	A supplier of raw material a
T6	A supplier of raw material a
T8	A supplier of raw material a
T2	A supplier of raw material C

According to the calculated data, the minimum loss is 13186.08576

5. Conclusion

In this paper, the gray correlation analysis method is adopted, which has no excessive requirements for the number of samples, flexible data processing, and does not need the typical distribution law. The results are consistent with the results of qualitative analysis. It is an ideal and

reliable model.

In this paper, the 0-1 programming model is adopted to meet the different requirements in different situations and achieve the maximum satisfaction of the goal to a certain extent.

Lingo software is used to solve and analyze the table data, which makes the solution process more convenient and fast.

This paper uses the grey correlation analysis model, which can be used in plant nutrition diagnosis, selection of mining methods, slope stability analysis, debris flow risk evaluation, elevator safety evaluation, teaching system evaluation and other models. By selecting the reference sequence, the correlation degree of multiple sub sequences can be calculated, and the closest data can be obtained from the correlation degree, so as to finally complete the evaluation of the model.

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