Research on the Optimal Ordering and Shipping Scheme Based on TOPSIS and Objective Function Optimization Model

Jiaran An[1], Yuqing Si[1], Jingwen Zhu[2]

[1]School of Mathematics and Statistics, Guangxi Normal University, Guilin, 541000, China

[2] School of Computer Science and Engineering & School of Software, Guangxi Normal University, Guilin, 541000, China

*Corresponding author: vj162774@163.com

Abstract: The selection of different suppliers, different raw materials, and different transportation options all have an impact on costs, so it is important to measure and consider these factors to keep costs as low as possible. In this paper, we use the TOPSIS model to analyze the 240-week order quantity and the supplier's supply quantity to evaluate the supplier's fulfillment and to determine the most important supply for the optimal solution of material ordering and transportation. An objective function optimization model is applied to ensure that the inventory is kept at least two weeks to meet the production demand, so that the purchase price is the most economical, the depletion rate is the least, and the storage cost is the lowest, and finally the optimal ordering and transportation solution is programmed and analyzed.

Keywords: Ordering and transportation of raw materials for enterprises; Objective function optimization model; TOPSIS model

1. Introduction

1.1 Problem Background

A manufacturer of architectural and decorative panels uses three types of raw materials: A, B, and C. It needs to determine the raw material suppliers and the weekly raw material order quantity according to the capacity requirement, and determine the third party logistics company to transfer the weekly raw material supply quantity from the suppliers to the enterprise warehouse[1].

Due to the special nature of raw materials, suppliers cannot guarantee to supply strictly according to the order quantity, and the actual supply quantity may be more or less than the order quantity. In order to ensure normal production needs, the company has to keep as much raw material inventory as possible to meet the two-week production demand, so the company always acquires all the raw materials actually supplied by the supplier[2].

Moreover, during the actual transshipment process, there is a certain amount of loss of raw materials, and usually, the raw materials supplied by one supplier each week are transported by one forwarder as much as possible.

The procurement cost of raw materials directly affects the production efficiency of the enterprise, and the size of the purchase unit price of the three categories is A is greater than B is greater than C[3], while the unit cost of transportation and storage of the three categories of raw materials is the same.

1.2 Paper Overview

In order to fully determine the most important suppliers, it is necessary to analyze from the perspective of the enterprise so as to make a decision, we make a simulation from the process of product output: if the order quantity of the enterprise is much larger than the supply quantity of the supplier, the enterprise largely cannot maintain no less than the amount of raw material inventory to meet the two-week production demand, which can easily lead to supply chain disconnection. Therefore, we will use the entropy weight method [4] for model building, take the supplier completion ratio as the objective function, calculate the weight of each index according to the information entropy, and come up with the 50 most important suppliers after analysis.

In addition to this, after considering the constraints.

1, the company's weekly production capacity to meet the target

2, the inventory is maintained at not less than the amount of raw materials in stock to meet the two-week production demand (5.64wm3)

3, the development of the next twenty-four weeks of ordering program[5] (only twenty-four weeks of time)

4. Only eight forwarders (no more than 8*6000=4.8wm^3 of material to be transferred)

Set the objective function: total cost λ (transportation cost + storage cost minimum). In order to ensure that the inventory is maintained at a level not less than to meet the two-week production demand, so that the most economical purchase price, the minimum rate of depletion and the lowest storage costs, programming solution analysis to come up with the best ordering scheme and transshipment scheme[6].

2. Model assumptions and notation

2.1 Thesis hypothesis

1) No consideration is given to the increased consumption of raw materials caused by problems with the machine itself.

2) Do not consider the time delay caused by the weather.

3) Only the core factors of the problem are considered, without considering the impact of secondary factors.

4) Disputes between the company and the supplier are not considered.

5) The company and the supplier can go directly to the two places, without considering the midway transfer[7].

6) Do not consider the impact of other external factors on the cost.

2.1.1 Symbol Description

Symbol description is shown in Table 1.

Table 1 Symbol description

Symbols	Description
$\mathbf{p}$	Number of suppliers
$\boldsymbol{\lambda}$	Total Cost
$\mathbf{X}$	Normalization matrix
$\mathbf{Z}$	Standardization Matrix
$\boldsymbol{\gamma_i}$	Capacity after material processing
$\mathbf{p}$	Number of suppliers
$\boldsymbol{\varphi_{ij}}$	Purchase Price
$\boldsymbol{E_A}$	Collection of suppliers whose raw materials are A
$\boldsymbol{E_B}$	Collection of suppliers whose raw materials are B
$\boldsymbol{E_C}$	Collection of suppliers whose raw materials are C
$\boldsymbol{\mu}$	Weekly output

3. Model construction and solving

3.1 Modeling and solving the screening of important suppliers

There are many factors that enterprises consider when making decisions, and a correct judgment of these factors will reduce unnecessary losses and costs for the enterprise[8]. This question focuses on the number of requested orders from suppliers, the final supply quantity achieved by suppliers and the completion of suppliers' supply, so as to select the 50 most important suppliers.

This is a typical objective optimization problem. According to Yuan, there are 402 suppliers to be evaluated, and the completion rate of suppliers is used as the evaluation index. Form these data into a forwarding matrix as follows.

$$X = \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1m} \\ x_{21} & x_{22} & & x_{2m} \\ \vdots & \vdots & \ddots & \vdots \\ x_{n1} & x_{n2} & \cdots & x_{nm} \end{bmatrix} \quad (1)$$

Now the matrix X consisting of suppliers and supplies is formed, after which the matrix X is normalized and denoted Z. Each element z_{ij} in Z is calculated as.

$$z_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{n} x_{ij}^2}} \quad (2)$$

Determine whether there are negative numbers in the normalized matrix Z. If there are negative numbers, the matrix X is normalized again to obtain the matrix $\tilde{Z}$.

$$\widetilde{z_{ij}} = \frac{x_{ij} - min\{x_{1j}, x_{2j}, \cdots, x_{nj}\}}{max\{x_{1j}, x_{2j}, \cdots, x_{nj}\} - min\{x_{ij}, x_{2j}, \cdots, x_{nj}\}} \quad (3)$$

Now we get the non-negative matrix.

$$\tilde{Z} = \begin{bmatrix} z_{11} & z_{12} & \cdots & z_{1m} \\ z_{21} & z_{22} & & z_{2m} \\ \vdots & \vdots & \ddots & \vdots \\ z_{n1} & z_{n2} & \cdots & z_{nm} \end{bmatrix} \quad (4)$$

After that, the probability matrix P is calculated, and each element in P is calculated as.

$$p_{ij} = \frac{z_{ij}}{\sum_{i=1}^{n} z_{ij}} \quad (5)$$

For the jth indicator supply, its information entropy is calculated as.

$$e_{j=\frac{1}{\ln n}\sum_{i=1}^{n} p_{ij} \ln p_{ij}} \ (j = 1,2 \ldots \ldots, m) \quad (6)$$

The information utility value is

$$d_j = 1 - e_j \quad (7)$$

Finally calculate the entropy weight.

$$w_j = \frac{d_j}{\sum_{j=1}^{m} d_j} \quad (8)$$

In order to select the 50 most important suppliers, we analyze the final results based on the above-mentioned model.

First, we calculate the summation based on the supplier's supply quantity, because the supplier's supply quantity changes every week, and sometimes supply and sometimes not supply[9], so we use the supply quantity as the main judgment criterion, and sort the 240-week total supply quantity of each supplier in descending order to get a new table.

Then, we sum up the order quantity of these suppliers to get the total order quantity of 240 weeks, calculate the completion ratio of suppliers, and use the completion ratio as the secondary judgment standard (completion ratio = total supply quantity of 240 weeks / total order quantity of 240 weeks).

The final result, Table 2, shows the results for 50 suppliers.

Table 2 50 most important suppliers

A	354887	359885	98.61%	204	36
C	328080	333452	98.39%	196	44
B	240950	271445	88.77%	18	222
C	194498	266510	72.98%	11	229
B	136998	186278	73.54%	21	219
B	151862	177748	85.44%	23	217
B	136652	172980	79.00%	27	213
B	171426	172000	99.67%	11	229
A	169340	168531	100.48%	59	181
A	158553	158150	100.25%	0	240
A	156518	156350	100.11%	0	240
B	137512	139381	98.66%	2	238
C	130307	132612	98.26%	32	208
C	129786	129370	100.32%	0	240
C	126096	125680	100.33%	0	240
A	75843	105436	71.93%	25	215
A	78196	101983	76.68%	14	226
C	101365	101380	99.99%	0	240
A	82787	94570	87.54%	7	233
A	89031	89300	99.70%	0	240
C	50686	67677	74.89%	14	226
C	56698	56000	101.25%	0	240
C	49224	48613	101.26%	4	236
C	46597	45515	102.38%	1	239
C	41631	40960	101.64%	0	240
B	41207	40554	101.61%	0	240
B	30109	38172	78.88%	23	217
C	15694	34603	45.35%	13	227
B	31905	32360	98.59%	0	240
B	24041	32155	74.77%	13	227
C	17949	30135	59.56%	11	229
B	28763	29030	99.08%	0	240
B	26335	27640	95.28%	0	240
B	23240	24710	94.05%	0	240

According to the results of the above table, the demand of suppliers for raw materials A, B and C are counted and their pie charts are as Figure 1.

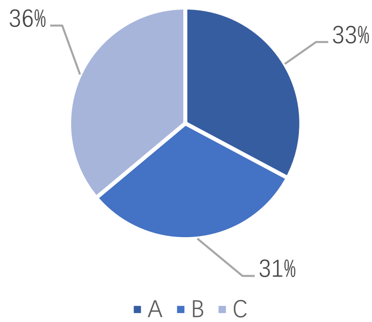

Figure 1 Material requirements for total supply from 50 suppliers

3.2 The best ordering and forwarding solution is requested

3.2.1 Modeling

If 2.82wm^3 are all raw material A output, then raw material A 1.692wm^3 is required; if 2.82wm^3 are all raw material B output, then raw material B 1.8612wm^3 is required; if 2.82wm^3 are all raw material C output, then raw material C 2.0304wm^3 is required. then at least 2.0304wm^3 of raw material is consumed each week, and because the inventory is kept Not less than the amount of raw material in stock to meet the two-week production demand (5.64wm^3)[10].

If it is the maximum supply for one week and the maximum loss, i.e. 4.8*0.95=4.56wm^3, it cannot meet the demand.

If it is two weeks, i.e. 9.6*0.95=9.12wm^3, 9.12-2.0304=7.0896wm^3>5.64wm^3.

So we can meet at least two weeks of production to meet two weeks of production demand for raw material inventory. For different operators the loss rate is different and the average loss rate is also different in size, so the size of their average loss rate is analyzed.

From Figure 2, it can be obtained that the magnitude of its loss rate is too large, for this reason, in order to reduce reduce the calculation, we in this question will be different operators loss rate of the average loss rate of the largest that is the smallest loss rate subtracted, the remaining to obtain the average value β as the consumption rate of this question.

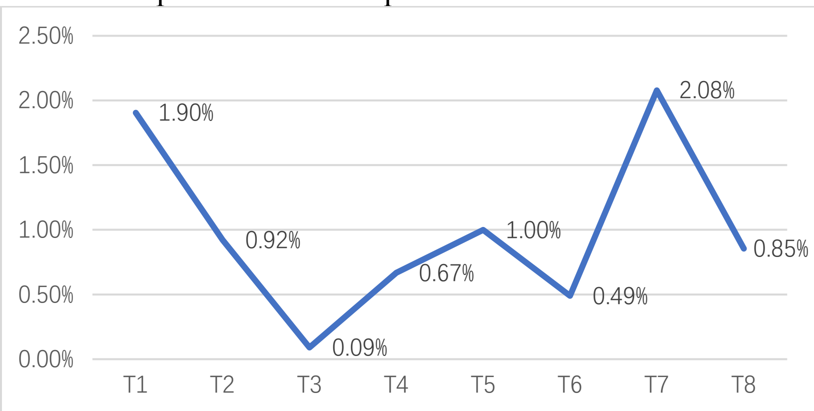

Figure 2 Average attrition rate in the last five years

Then, at this time, let γ_i be the capacity of the material after processing α_i be the amount received by the enterprise.

$$\begin{cases} \gamma_i = \dfrac{\alpha_i(1-\beta)}{0.6} & \alpha_i \in E_A \\ \gamma_i = \dfrac{\alpha_i(1-\beta)}{0.66} & \alpha_i \in E_B \\ \gamma_i = \dfrac{\alpha_i(1-\beta)}{0.72} & \alpha_i \in E_C \end{cases} \tag{9}$$

Number of suppliers of the objective function p.

$$5.64 \le \sum_{i=1}^{p} \gamma_i \le 7.0896 \tag{10}$$

Since the economics of A, B, and C all differ, we determine the magnitude of the economics of A, B, and C based on the amount of product consumed per cubic meter, the amount of production obtained per cubic meter of raw material, and the unit price.

Table 3 The magnitude of the economic benefits of A, B and C

	A	B	C
Product consumption per unit area	0.6	0.66	0.72
Raw material production per unit area	1.67	1.52	1.39
Unit price	1.2	1.1	1
Economic benefits	1.389	1.3774	1.3889

From Table 3 can be obtained from A, B, C material supplier economic efficiency in order from largest to smallest A, B, C then for 50 important suppliers, A class suppliers for priority selection, and in decreasing order, until meet the supply of the week.

Then the output of different suppliers of A, B and C after processing are

The enterprise should choose at least how many suppliers to supply raw materials.

$$\begin{cases} \gamma_{ij} = \dfrac{\alpha_{ij}(1-\beta)}{0.6}, \quad \varphi_{ij} = 1.2\alpha_{ij} & \alpha_{ij} \in E_A \\ \gamma_{ij} = \dfrac{\alpha_{ij}(1-\beta)}{0.66}, \quad \varphi_{ij} = 1.1\alpha_{ij} & \alpha_{ij} \in E_B \\ \gamma_{ij} = \dfrac{\alpha_{ij}(1-\beta)}{0.72}, \quad \varphi_{ij} = \alpha_{ij} & \alpha_{ij} \in E_C \end{cases} \tag{11}$$

The restrictions for suppliers are.

$$\begin{cases} \sum_{i=1}^{50} \gamma_{ij} \ge 2.82 & j \subset (1,24] \\ \sum_{i=1}^{50} \sum_{j=1}^{k} \alpha_{ij} - 2{,}82k \ge 5.64 \end{cases} \tag{12}$$

The objective function cost λ.

$$\lambda = \sum_{i=1}^{50} \varphi_{ij} + 0.078 \sum_{i=1}^{50} \gamma_{ij} \tag{13}$$

The maximum supply quantity of the selected supplier for the last five years is calculated and the average loss value is used to calculate the loss value of the shipper's shipments and the quantity received by the company, and then the final production volume is calculated based on the consumption of different materials. Based on the model established above, the final results are obtained through analysis.

4. Conclusion

The advantages of the model are that it can deeply reflect the distinguishing ability of the indicators and thus determine the weights; it is an objective assignment method with strong high credibility and accuracy relative to the competent assignment; the algorithm is simple and easy to implement; however, the dependence on the sample is large and the weights change somewhat with the continuous changes of the modeled sample.

According to the topic construction and decorative panel manufacturers use raw materials mainly wood fiber and other plant vegetal fiber materials, such materials for the weather requirements are a little harsh, due to the weather is variable and unpredictable, but can be based on the weekly weather specific depending on the transport requirements with the north and south are not the same.

If in the south, the rainy season is very easy to damage, whether handling or therefore for the model of the time should have specific requirements, the model at this time only according to the supplier's supply, in addition to the southern volcanic days, the cost of transport should be increased, try to give the wood to a closed space.

At this time, the amount of cost is greatly increased, and the transportation of materials should be reduced. In the north, the probability of traffic jams due to rain and snow is 73.66%.

There is a high probability that the transport of materials will not be completed on time. For this reason, we must purchase materials on a large scale in the time before the onset of rain and snow to ensure adequate stock levels.

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