

Material Ordering and Transferring Plan Development Based on 0-1 Planning Model

Shiyu Tian¹, Yangyang Guo², Shengyan Liao²

¹College of General Education, Hunan University of Information Technology, Changsha, Hunan, 410100, China

²School of Electronic Science And Engineering, Hunan University of Information Technology, Changsha, Hunan, 410100, China

Abstract: How to develop material ordering and transferring plans in advance to ensure smooth production of the enterprise is a major problem faced by the actual production process. In this paper, we make reasonable assumptions by combining the ordering supply and transshipment data of previous years and establish a supply-transshipment model based on 0-1 planning. Firstly, we selected the Supply and demand ratio, large order ratio, Supply error rate, and Supply rate as the evaluation indexes, and then established the evaluation model to select the top 50 from 402 suppliers. To make the ordering and transferring plans in the next 24 weeks, we firstly analyzed the objectives and constraints. A multi-objective planning model is established and it is transformed into a single-objective 0-1 planning model.

Keywords: multi-objective planning, 0-1 planning, evaluation indexes

1. Introduction

We select order failure rate, supply rate, supply-demand ratio, and large order ratio as evaluation indexes. Then we establish the importance evaluation model, followed by statistical analysis of the order-supply data of 402 suppliers. Finally, we quantify the importance of each supplier according to the statistical analysis results and select the top 50 suppliers of importance.

Then, we make the ordering and transferring plans in the next 24 weeks. We determine the objectives and constraints, make reasonable assumptions, and establish a multi-objective multivariate planning model.

2. Model establishment and solution

2.1. Select evaluation indexes to determine the important suppliers

Let the total number of orders of the enterprise be D and the number of successful orders is G . The supply quantity of the supplier is P (m^3), and the order quantity of the firm is Q (m^3). Here we introduce the Supply and demand ratio, Large order ratio, Supply error rate, and Supply rate to describe this problem.

2.1.1. Supply and demand ratio (η)

It is the ratio of the supplier's supply to the company's order quantity, and the relationship is $\eta=P/Q$.

2.1.2. Large order ratio (λ)

For suppliers, the more large orders they supply, the more stable the supply channels are, and the more likely they are to provide more raw material resources when their production capacity increases later. Therefore, the higher the proportion of large orders, the more important it is to ensure the production of enterprises. The calculation formula is $\lambda=\text{num}(\eta>1)/D$.

2.1.3. Supply error rate (γ)

The supply error rate (γ) represents the error ratio between the supplier's supply and the quantity ordered from the company, and the difference between the supply quantity P and the order quantity Q is calculated, and then divided by the order quantity is measured. The supply error rate is small, the more stable the supplier's supply, the more important it is to protect the production of enterprises. $\gamma =$

$|P - Q|/Q$.

2.1.4. Supply rate (μ)

The greater the supply rate, the more reliable the supplier is and the more important it is to guarantee the production of the company. The formula is $\mu = G/D$.

Determine whether the number of supply performance has been reached and if it has been reached, record the number of times that the supply performance (large order ratio) is greater than 1. Record the number of supply failures. According to the above importance evaluation model, we can finally find out the evaluation coefficients of 402 suppliers' production assurance enterprises and take the top 50 most important suppliers in descending order.

2.2. Ordering and transferring plans by the optimization model

2.2.1. Ordering plan

First, assume that the company orders from one supplier whenever possible. If the company orders from the supplier, it orders the maximum amount of supply.

The order of material A from i_1 suppliers in week j is expressed as $x_{i_1,j}p_{i_1}$, where $x_{i_1,j} = \{0,1\}$. $x_{i_1,j} = 0$ indicates that the j th week does not order material A from i_1 suppliers, else $x_{i_1,j} = 1$. p_{i_1} denotes the availability of the i_1 th supplier. Similarly, we can get the meaning of $x_{i_2,j}p_{i_2}$ and $x_{i_3,j}p_{i_3}$.

2.2.2. Material costs

The unit prices of materials A and B are 20% and 10% higher than C, respectively. Let the unit price of material C be c . Then the unit price of material A is $1.2c$ and B is $1.1c$. It follows that the cost of raw materials is determined by the quantity ordered by the firm from each supplier.

$$C = 1.2c \sum_{i_1=1}^{n_1} x_{i_1,j}p_{i_1} + 1.1c \sum_{i_2=1}^{n_2} x_{i_2,j}p_{i_2} + c \sum_{i_3=1}^{n_3} x_{i_3,j}p_{i_3} \tag{1}$$

2.2.3. Transfer plan

In week j , the i_1 th supplier is forwarded by the k_i th forwarder with a forwarding loss of $s_{i_1k_i,j}q_{k_i}x_{i_1,j}p_{i_1}$, where $s_{i_1k_i,j}$ indicates whether the k_i th deliver transforms for the i_1 th supplier in the week j , and q_{k_i} denotes the loss rate. Similarly, we can get the meaning of $s_{i_2k_i,j}q_{k_i}x_{i_2,j}p_{i_2}$ and $s_{i_3k_i,j}q_{k_i}x_{i_3,j}p_{i_3}$.

The total transportation loss in week j is:

$$S = \sum_{i_1=1}^{n_1} \sum_{k_i=1}^8 s_{i_1k_i,j}q_{k_i}x_{i_1,j}p_{i_1} + \sum_{i_2=1}^{n_2} \sum_{k_i=1}^8 s_{i_2k_i,j}q_{k_i}x_{i_2,j}p_{i_2} + \sum_{i_3=1}^{n_3} \sum_{k_i=1}^8 s_{i_3k_i,j}q_{k_i}x_{i_3,j}p_{i_3} \tag{2}$$

The transfer volume of the k_i th deliver in week j satisfies:

$$\sum_{i_1=1}^{n_1} s_{i_1k_i,j}x_{i_1,j}p_{i_1} + \sum_{i_2=1}^{n_2} s_{i_2k_i,j}x_{i_2,j}p_{i_2} + \sum_{i_3=1}^{n_3} s_{i_3k_i,j}x_{i_3,j}p_{i_3} \tag{3}$$

The actual volume accepted by the enterprise in week j is:

$$\begin{cases} W_{1j} = \sum_{i_1=1}^{n_1} \sum_{k_i=1}^8 s_{i_1k_i,j}(1 - q_{k_i})x_{i_1,j}p_{i_1} \\ W_{2j} = \sum_{i_2=1}^{n_2} \sum_{k_i=1}^8 s_{i_2k_i,j}(1 - q_{k_i})x_{i_2,j}p_{i_2} \\ W_{3j} = \sum_{i_3=1}^{n_3} \sum_{k_i=1}^8 s_{i_3k_i,j}(1 - q_{k_i})x_{i_3,j}p_{i_3} \end{cases} \tag{4}$$

2.2.4. Relationship between Production and Storage

The relationship between the number of materials produced and stored in week j is the amount of storage in week $j-1$ + the amount received in week j - the amount produced in week j = the amount stored in week j , and the cost of transshipment, i.e.

$$\begin{cases} Z_{1j-1} + W_{1j} - t_{1j} = Z_{1j} \\ Z_{2j-1} + W_{2j} - t_{2j} = Z_{2j} \\ Z_{3j-1} + W_{3j} - t_{3j} = Z_{3j} \end{cases} \quad (5)$$

2.2.5. Transit storage costs

Let both the transfer and storage costs per unit of material be l . Then the transfer and storage costs in week j are:

$$l \left(\sum_{i_1=1}^{n_1} x_{i_1j} p_{i_1} + \sum_{i_2=1}^{n_2} x_{i_2j} p_{i_2} + \sum_{i_3=1}^{n_3} x_{i_3j} p_{i_3} + Z_{1j} + Z_{2j} + Z_{3j} \right) \quad (6)$$

2.2.6. Objective function

(1) Objective 1: Select the supplier with the least.

$$\min \sum_{i_1=1}^{n_1} x_{i_1j} + \sum_{i_2=1}^{n_2} x_{i_2j} + \sum_{i_3=1}^{n_3} x_{i_3j} \quad (7)$$

(2) Objective 2: The most cost-efficient material ordering program.

$$\min C = \min \left(1.2c \sum_{i_1=1}^{n_1} x_{i_1j} p_{i_1} + 1.1c \sum_{i_2=1}^{n_2} x_{i_2j} p_{i_2} + c \sum_{i_3=1}^{n_3} x_{i_3j} p_{i_3} \right) \quad (8)$$

$$\min l \left(\sum_{i_1=1}^{n_1} x_{i_1j} p_{i_1} + \sum_{i_2=1}^{n_2} x_{i_2j} p_{i_2} + \sum_{i_3=1}^{n_3} x_{i_3j} p_{i_3} + Z_{1j} + Z_{2j} + Z_{3j} \right) \quad (9)$$

(3) Objective 3: The least lossy transit plan.

$$\min \left(\sum_{i_1=1}^{n_1} \sum_{k_i=1}^8 s_{i_1k_ij} q_{k_i} x_{i_1j} p_{i_1} + \sum_{i_2=1}^{n_2} \sum_{k_i=1}^8 s_{i_2k_ij} q_{k_i} x_{i_2j} p_{i_2} + \sum_{i_3=1}^{n_3} \sum_{k_i=1}^8 s_{i_3k_ij} q_{k_i} x_{i_3j} p_{i_3} \right) \quad (10)$$

2.2.7. Constraint

(1) Assume that the firm completes all production at capacity for each week.

$$t_{1j}/0.6 + t_{2j}/0.66 + t_{3j}/0.72 = L \quad (11)$$

(2) The weekly raw material inventory is not less than the number of materials needed to meet the demand of two production sheets.

$$Z_{1j}/0.6 + Z_{2j}/0.66 + Z_{3j}/0.72 \geq 2L \quad (12)$$

(3) The transport capacity of each forwarder is M (m^3 /week).

$$\sum_{i_1=1}^{n_1} s_{i_1k_ij} x_{i_1j} p_{i_1} + \sum_{i_2=1}^{n_2} s_{i_2k_ij} x_{i_2j} p_{i_2} + \sum_{i_3=1}^{n_3} s_{i_3k_ij} x_{i_3j} p_{i_3} \leq M (k_i = 1, 2, \dots, 8) \quad (13)$$

2.3. Model Transformation

2.3.1. Material cost minimization

The material cost ratio of each square meter of product produced is 0.72:0.726:0.72. Therefore, the ordering scheme is set up to satisfy:

$$\sum_{i_1=1}^{n_1} x_{i_1j} p_{i_1} > \sum_{i_3=1}^{n_3} x_{i_3j} p_{i_3} > \sum_{i_2=1}^{n_2} x_{i_2j} p_{i_2} \quad (14)$$

2.3.2. Transfer loss

Since the transfer loss of each forwarder is different, it is required to meet the transfer loss of the forwarder transferring as much material as possible when setting up the transfer program to meet the low transfer loss.

$$\begin{aligned}
 & \sum_{i_1=1}^{n_1} s_{i_1 k_1 j} x_{i_1 j} p_{i_1} + \sum_{i_2=1}^{n_2} s_{i_2 k_1 j} x_{i_2 j} p_{i_2} + \sum_{i_3=1}^{n_3} s_{i_3 k_1 j} x_{i_3 j} p_{i_3} \\
 & > \sum_{i_1=1}^{n_1} s_{i_1 k_2 j} x_{i_1 j} p_{i_1} + \sum_{i_2=1}^{n_2} s_{i_2 k_2 j} x_{i_2 j} p_{i_2} + \sum_{i_3=1}^{n_3} s_{i_3 k_2 j} x_{i_3 j} p_{i_3} > \dots \\
 & > \sum_{i_1=1}^{n_1} s_{i_1 k_8 j} x_{i_1 j} p_{i_1} + \sum_{i_2=1}^{n_2} s_{i_2 k_8 j} x_{i_2 j} p_{i_2} + \sum_{i_3=1}^{n_3} s_{i_3 k_9 j} x_{i_3 j} p_{i_3} \tag{15}
 \end{aligned}$$

2.3.3. Storage cost

The production of each square meter of product requires the consumption of 0.6 cubic meters of raw materials of category A, or 0.66 cubic meters of raw materials of category B, or 0.72 cubic meters of raw materials of category C. At the same time to meet the enterprise to maintain as far as possible not less than the number of raw materials in stock to meet the needs of two weeks of production, that is, the requirement to store as little as possible of raw materials of category C, that is:

$$Z_{1j}/0.6 > Z_{2j}/0.66 > Z_{3j}/0.72 \tag{16}$$

2.3.4. Model transformation results

In summary, the multi-objective 0-1 planning model is transformed into a single-objective 0-1 planning model.

$$\begin{aligned}
 & \min \sum_{i_1=1}^{n_1} x_{i_1 j} + \sum_{i_2=1}^{n_2} x_{i_2 j} + \sum_{i_3=1}^{n_3} x_{i_3 j} \tag{17} \\
 & \text{s.t. (5) (11) (12) (13) (14) (15) (16)}
 \end{aligned}$$

3. Evaluation and promotion of the model

There are no very deep mathematical concepts in the model. In practical applications, the planning problem is also widely used and easily accepted by everyone.

In the planning models we construct, there are many variables, so it is complicated to deal with them and it is difficult to give a direct solution. Although it can be solved indirectly using a computer, there are too many model variables and the number of model variables needs to be reduced according to the actual problem, which will make the accuracy of the model vary from user to user.

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