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Research on Enterprise Raw Material Ordering and Transportation Model based on 0-1 Planning

Tongzhenzhi Su*

Institute of Control Science and Engineering, North China Electric Power University, Baoding 071000, China

*meltdream@126.com

Abstract

The problem of ordering and transporting raw materials for enterprises is the key to solving how to ensure the safe production of enterprises. Through a typical case, this paper deeply mines and analyzes the past data of enterprise orders and receipts, supplier supply and other data, and under the premise of fully considering inventory reservation and order remaining, establishes a constrained 0-1 planning model. After using SPSS for seasonal decomposition and time series analysis, the supply loss rate curve of the transportation company is divided into fluctuation type, extreme value type and periodic type. According to the three models, ARIMA, simple seasonal model and Winters' additive model are used to forecast the time series, and the forecast curve of the supply loss rate of the transportation company is obtained, which is the basis for our planning scheme. The above model is solved by matlab programming, and the ordering and transportation plan of the raw materials of the enterprise in this case is given.

Keywords

0-1 Planning; Optimal Strategy; Time-series Analysis; Supply and Demand Balance; Characteristics.

1. Introduction

An enterprise is engaged in the production of construction and decorative panels, mainly using wood fiber and other plant fiber materials as raw materials (including three categories A, B, and C, but all meet the production requirements). Enterprises need to analyze production capacity requirements in advance to formulate ordering plans, so as to determine material suppliers and their order quantities, and to formulate transshipment plans and select transportation companies. The materials are transferred by the transportation company to the warehouse of the enterprise according to the supply quantity.

Enterprises need to formulate a 24-week raw material order and transfer plan in advance, that is, to determine the raw material suppliers to be ordered and the corresponding weekly order quantity of raw materials according to production capacity requirements. At the same time, identify a third-party logistics company (transportation company) that transfers the supplier's weekly supply of raw materials (called "supply") to the corporate warehouse. The weekly production capacity of the enterprise is 28,200 cubic meters, and each cubic meter of product needs to consume 0.6 cubic meters of Class A raw materials, or 0.66 cubic meters of Class B raw materials, or 0.72 cubic meters of Class C raw materials. Due to the particularity of raw materials, the supplier cannot guarantee the 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 the needs of normal production, the enterprise should try to maintain a raw material inventory that is not less than two weeks of production needs. Therefore, the company always buys all the raw materials actually provided by the supplier. In the actual transshipment process, there will be

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a certain loss of raw materials (the percentage of loss in the supply is called "loss rate"), and the number of raw materials actually delivered by the transportation company to the enterprise warehouse is called "received volume". The transport capacity of each transport company is 6000 cubic meters per week. Typically, raw materials supplied by one supplier each week are transported by a single carrier as much as possible.

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

There are 32 suppliers and 8 transport companies. We know:

1. In the past 240 weeks, the company's order category for each supplier and the order quantity of each category.

2. In the past 240 weeks, the actual supply situation of each supplier for the company's orders.

3. In the past 240 weeks, the transportation loss rate of these 8 transportation companies, that is, the loss rate = (supply volume - received volume) / supply volume * 100%.

For these suppliers, we will provide a plan for the company to formulate the most economical weekly raw material order plan for the next 24 weeks, and accordingly develop a transfer plan with the least loss.

2. Preparation Work

2.1. Model Assumptions

1. Assume that the raw materials required for the production of the enterprise are not easy to deteriorate and will not be lost due to a long time.

2. Assuming that the enterprise itself has a certain understanding and cognition of each supplier, the previous ordering plan was formulated based on this cognition.

3. Assuming that the supplier's supply capacity and characteristics remain basically unchanged, there will be no significant increase or decrease.

2.2. Symbol Description

Table 1. Symbol Description

symbol	illustrate	unit
A	Indicates whether each supplier supplies the enterprise in each week (0-1 matrix)	/
W	A vector of weekly supplies from various suppliers	m^3
N	A vector of unit prices of goods corresponding to each supplier	$/$m^3$
S	A vector of "capacity-to-cargo volume ratios" for various goods	
STORE	The production capacity corresponding to the remaining goods after the production of the enterprise in the jth week	m^3
μ	Storage cost per unit volume of goods	$/$m^3$
T	Shipping cost per unit volume of goods	$/$m^3$

2.3. Solution

We focus on the average supplier's supply over the past 240 weeks as the basis for our forecast. Limited by the requirements of the enterprise, it is necessary to keep the raw material inventory not less than two weeks' production demand as much as possible, so as to avoid the shortage of materials in future production; at the same time, it also takes into account the problems of transportation loss and shortage of actual shipments. Therefore, the expected sum of raw materials provided by the suppliers we need should be increased by a certain percentage on the basis of the expected production capacity as a necessary guarantee. [1]

ISSN: 2688-9323

3. Best Order Plan

To develop the most economical weekly raw material ordering plan for the business for the next 24 weeks, we need to plan to make decisions. First of all, the constraints should be considered, such as the cost of transshipment and storage, and the limitation of enterprise production capacity.

It is worth noting that while we need to keep as much raw material stock as possible to meet two weeks of production needs, the previous surplus should also be taken into account when considering the amount required for this week. The weekly cargo demand is always in dynamic balance. Therefore, for each week's decision-making, the remaining cargo is also one of the important factors affecting it. Therefore, we adopt a 0-1 plan to solve this problem.

$$F = \min \sum_{j=1}^{24} \sum_{i=1}^{32} A_{ij} W_i N_i \tag{1}$$

The constraint is that we do not need to make weekly order requests to every supplier because of the cost of storage and transshipment, that is [2]:

$$\begin{gathered} A_{ij} \in \{0,1\} \\ A_{ij} = 0, \text{In the jth week, the enterprise does not order from supplier i} \\ A_{ij} = 1, \text{In the jth week, the enterprise order from supplier i} \\ (\mathrm{i} = 1,2....32;\ \mathrm{j} = 1,2...24) \end{gathered} \tag{2}$$

The total amount of orders needs to ensure the production safety of the enterprise, that is, the supply of the supplier must ensure that the enterprise has excess capacity as much as possible. Therefore, we try our best to ensure that the company's purchase volume in the current week plus the company's inventory in the previous week can meet the company's production for three weeks, that is,

$$\begin{gathered} \sum_{i=1}^{32} A_{ij} W_i S_i + STORE_{j-1} \geq 3 \times 28200 \\ (j = 1,2,\cdots,24) \end{gathered} \tag{3}$$

The number of orders an enterprise places with suppliers is not the more the better, because the storage of goods requires storage costs. Therefore, although we purchase all the supplies from suppliers, we must limit the total amount of orders within a certain range. A 50% margin can be left for the order quantity, and the constraints are:

$$\sum_{i=1}^{32} A_{\mathrm{ij}} W_i S_i + STORE_{j-1} \leq 1.5 * 28200, (j = 1,2...24) \tag{4}$$

Since the production capacity of the enterprise is limited, it will leave inventory every week, STORE, where the jth element of STORE is the production capacity of the remaining goods after the production of the enterprise in the jth week. That is, there is the following relationship:

$$\begin{gathered} STORE(0) = 2 \times 28200 \\ \sum_{i=1}^{32} A_{ij} W_i S_i + STORE_{j-1} = STORE_j + 28200 \end{gathered} \tag{5}$$

ISSN: 2688-9323

In summary, the model is:

$$F = \min \sum_{j=1}^{24} \sum_{i=1}^{32} A_{ij} W_i N_i$$

$$s.t. = \begin{cases} \sum_{i=1}^{32} A_{ij} W_i S_i + STORE(j) \geq 3 \times 28200 & (j=1,2,\cdots,24) \\ \sum_{i=1}^{32} A_{ij} W_i S_i \leq 1.5 \times 2.82 & (j=1,2,\cdots,24) \\ \sum_{i=1}^{32} A_{ij} W_i S_i + STORE_{j-1} = STORE_j + 28200 \end{cases} \quad (6)$$

$$STORE(0) = 28200 \times 2$$

In the case of considering the noise, we bring the various matrices mentioned above into the model, and the optimal raw material ordering plan can be obtained by programming and solving.

4. The Least Wasted Transshipment Solution

The purpose of this scheme is to plan future solutions given a certain amount of data in the past. The idea of solving is to forecast the next 24 weeks, and then we use the method of Time-series analysis 0 to use the forecast data to solve.

The implementation steps are as follows:

The first step is to make a time series diagram of the transportation loss of each transportation company and analyze its laws.

The second step is to judge the changing components contained in the time series, decompose the time series (with periodicity, including seasonal changes or volatility), and establish a Time-series Analysis model.

The third step is to predict the indicator values for the next 24 weeks.

The fourth step is to select a transportation company based on the weekly loss data to complete the formulation of the plan.

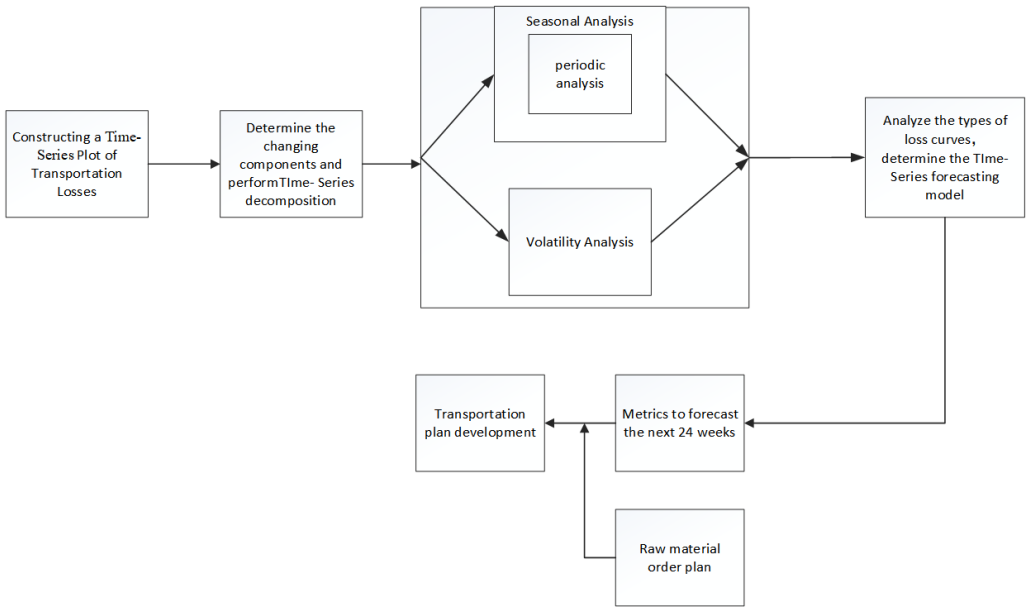

Fig 1. The flow chat of developing a transfer plan

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Based on the different transportation methods and route conditions of different transportation companies, the time series of their transportation loss are also different. First, we use seasonal analysis to analyze the characteristics of the loss rate of the eight transportation companies. Seasonal decomposition.

First of all, it can be seen that the positive and negative distribution of seasonal factors of some transportation companies at various time points in the cycle is relatively uniform and regular, and it can be guessed that the loss rate curve has periodicity. For some transportation companies, the positive seasonal factors are relatively large and concentrated in a few time points, and the negative seasonal factors are more and the absolute value is small. It can be guessed that there are extreme values in the curve.

We further analyze and give a typical time series of attrition rate as follows [4]:

1) Periodic type, the transshipment loss of the transportation company represented by this kind of model has a greater correlation with the season, which may be related to the seasonal influence of the transportation means used by the transportation company. Generally speaking, it is relatively stable. We use a simple seasonal model and Winters' additive model for forecasting.

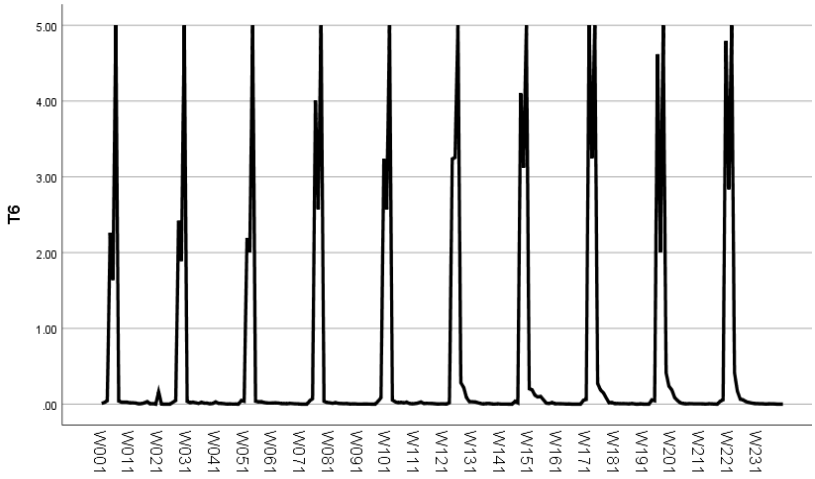

Fig 2. Transport loss of periodic type (W means week)

2) Extreme value type, an extreme value will be generated at a certain time point, and it will be very stable at other times. Considering that this may be some unexpected situation, we will ignore the extreme value and use ARIMA (0,1,1) for prediction.

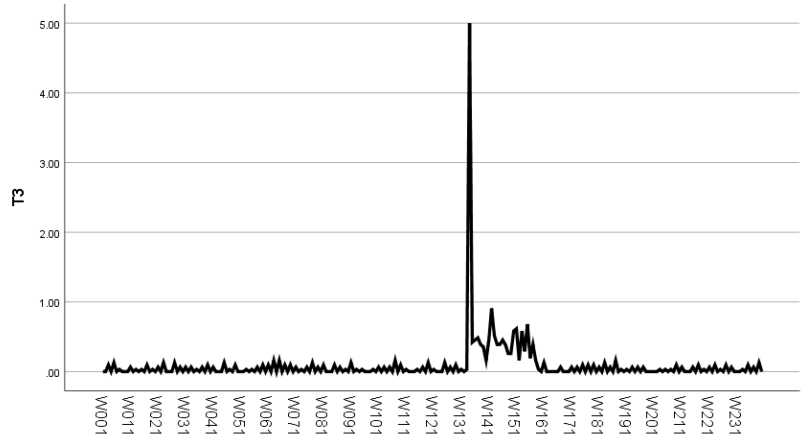

Fig 3. Transport loss of extreme value type (W means week)

ISSN: 2688-9323

3) The type of fluctuation, which shows a relatively large fluctuation at each time point, but the overall average value is stable at a certain level. This is also a relatively common situation, so the basis for future forecasts is more based on recent conditions. We use ARIMA (0,1,1) and a simple seasonal model for forecasting. Among the results obtained by these two schemes, we select the fluctuation situation and the result that the overall mean of the predicted data is close to the recent data as the final result.

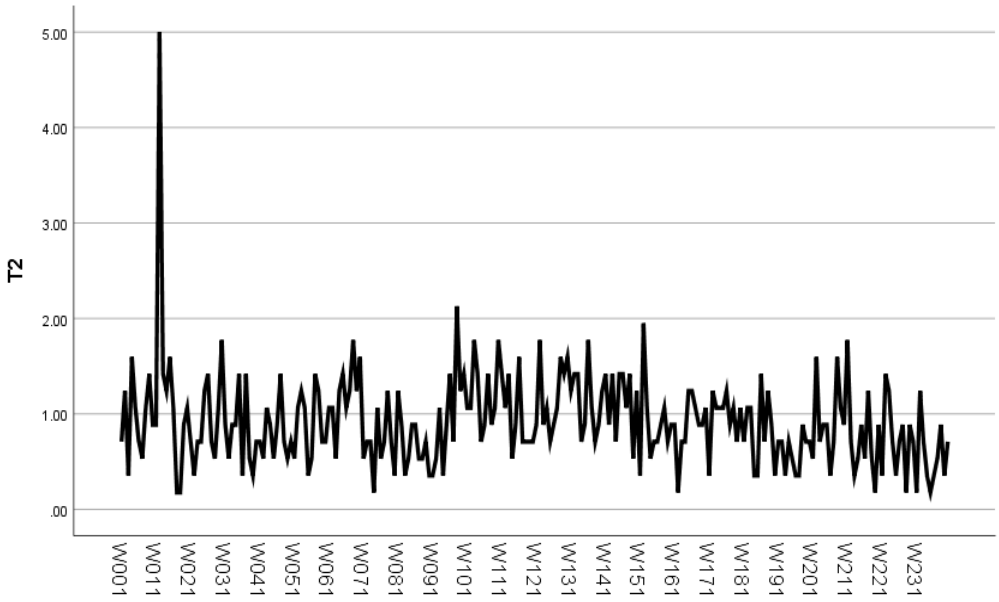

Fig 4. Transport loss of fluctuation type (W means week)

Combining the above types, we can classify each transportation company, so as to predict the predicted value of the transportation loss rate of all transportation companies in the next 24 weeks. Then, we forecast the known supply of each supplier for the next 24 weeks, and get result 1. Sum the supply of all suppliers for each of the forecasted 24 weeks to get the total supply required for each of the next 24 weeks. This is the amount that needs to be transported every week, which is the second result.

According to the meaning of the question, the maximum transportation capacity of each transportation company is 6000 cubic meters per week. Based on this value and combining result 2, we can calculate the minimum number of shipping companies required per week. Under the condition that the same transport company is selected for transshipment as much as possible, a certain number (set as n) of transport companies need to be selected every week. Then, from the corresponding weeks in result 1, select the n transportation companies with the smallest loss as the transshipment plan for this week to complete the solution.

5. Conclusion

The planning mainly adopts the 0-1 planning model, which is closely related to the actual situation, and can solve the global optimal solution and achieve the optimization goal. The results are reliable, the model is stable, and the adaptability to data is strong.

The time series used in the model can better obtain the transportation losses of the eight transportation companies in the next 24 weeks, which provides a new idea for solving the problem. Simplicity makes it possible to generalize the model.

The use of the 0-1 planning model in this paper is very flexible. The 0-1 variable is an important method for us to solve the integer programming of bounded variables, and it is also more

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convenient in computer implementation. In the problem of this paper, it speeds up the solution of our problem with many constraints.

At present, this model can also be applied to solve the production schedule problem, the traveling salesman problem, the mutually exclusive planning problem, etc., and it also plays an important role in solving real-life problems.

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