Research on Optimization of Ordering and Transportation Strategy based on TOPSIS and Time Series Model

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ABSTRACT

The ordering and transportation of raw materials is a crucial process for enterprises to produce and receive receivables, so it is necessary to study this process pertinently. This paper studies the ordering and transportation of raw materials in production enterprises. The problem of ordering and transportation of raw materials needs to make use of relevant materials and information such as the order quantity of various enterprises, the inventory of all kinds of raw materials, the supply quantity of suppliers, the transshipment capacity and loss of transporters, and so on. After a comprehensive evaluation of enterprises, suppliers and transporters, a reasonable decision-making plan for ordering, supply and transshipment is put forward. First of all, this paper puts forward three mathematical indicators according to the supply characteristics of suppliers: supply capacity (average supply capacity), supply stability (coefficient of variation) and supply and demand satisfaction (safety factor). Secondly, based on these indicators, the supply characteristics of 402 suppliers are quantitatively analyzed. Then, in order to meet the production demand and maintain not less than the raw material inventory that meets the production demand for two weeks, we use these constraints and the consumption of three types of raw materials during production to establish a 0-1 programming model. It is concluded that at least 32 suppliers need to be selected to meet the production demand. In order to make the most economical order transfer plan, we set up an ARIMA time series model to forecast the order quantity of 32 suppliers in the next 24 weeks based on the order data of 240 weeks, and worked out the optimization scheme. It is found that in the next 24 weeks, the total ordering volume of the ordering and transshipment program will be reduced by 28.71% on average, and the ordering and transshipment costs will be reduced by 28.21% on average (see figure 5 and figure 6 of the text for details).

Keywords: *Order transportation strategy, TOPSIS evaluation model, 0-1 programming model, ARIMA time series prediction model*

1. INTRODUCTION

For the ordering, transportation and profit of a building decoration manufacturing enterprise, there are many factors that need to be considered in the operation of the enterprise. The relationship with various suppliers is complex, any enterprise in order to ensure the normal operation of the process chain, effectively improve the economic benefits of the operation. It is necessary to reasonably determine the inventory and ordering cost of the purchased raw materials. As companies rate [4] a constant demand for raw materials, in determining the optimal solution (model) of the supplier, will first need to attrition rate, ordering cost, transfer cost minimizing, secondly considering the relationship between the quantity of supply and demand and demand balance, make the inventory control in the reasonable scope, to determine the effect the ideal order plan and transport, Maximize corporate profits.

For enterprises, ordering and transportation are important factors of revenue and profitability. How to find the best scheme to maximize revenue benefit is very important, and it is also the most important for enterprises.

2. CALCULATION AND ANALYSIS OF QUANTITATIVE INDICATORS

2.1.Quantity supplied

For the supplier of an enterprise, the important basis to measure the importance of its supply is its supply quantity. Therefore, we solve the total supply quantity and average supply quantity of 402 suppliers within 240 weeks.

2.2.Balance of supply and demand

An important feature of an outstanding supplier is to maintain good supply and demand. Only when supply exceeds demand, can the manufacturer always be in a good production mode. For the supplier's supply quantity and the enterprise's order quantity given in Annex 1, we have customized the following standards:

$$\text{The true value of supply and demand for a given supplier in a given week} \begin{cases} 1 \text{ (for greater than or equal to required and not 0)} \\ 0 \text{ (supply is less than demand or both supply and demand are 0)} \end{cases} \quad (1)$$

$$\text{Safety factor Z} = \frac{\text{The total number of weeks in which the number of truth values is 1 in 240 weeks for this supplier}}{\text{Number of valid weeks w}} \times 100\% \quad (2)$$

Effective weeks W: In order to better prepare to determine the balance ability of supply and demand of a supplier, we regard the case where both the quantity of supply and the quantity of demand are 0 in a week as invalid week (that is, the manufacturer does not take any measures to supply the supplier in that week, and the supplier may not have the purchasing ability).

2.3.Degree of supply and demand risk

An index, variance S^2, was selected to evaluate the stability factors:

$$s^2 = \frac{(M-x_1)^2 + (M-x_2)^2 + (M-x_3)^2 + \cdots + (M-x_n)^2}{n} \quad (3)$$

As a result, the safety ranking and supply demand ranking of the top 50 suppliers can be obtained.

3. TOPSIS SUPPLIER EVALUATION MODEL

The higher the average weekly supply index is, the better it is (extremely large index), the higher the safety factor is, the better it is (extremely small index), and the supplier supply variance (originally an extremely small index, it is converted to extremely large index for better evaluation in the future, that is, the original matrix is forward). Then the original matrix is positive, and the standard of positive matrix is dealt with.

For the normalized matrix obtained:

$$Z = \begin{bmatrix} Z_{11} & Z_{12} & Z_{13} \\ Z_{21} & Z_{22} & Z_{23} \\ \cdots & \cdots & \cdots \\ Z_{(402)1} & Z_{(402)2} & Z_{(402)3} \end{bmatrix} \quad (4)$$

Define the distance between the ith (i=1,2,3) evaluation object and the maximum value:

$$\mathrm{D}_\mathrm{i}^+ = \sqrt{\int_{j=1}^{3} \left(Z_j^+ - z_{ij}\right)^2} \quad (5)$$

Then, we can calculate the unnormalized score of the ith (i=1,2,3) evaluation object:

$$\mathrm{S}_\mathrm{i} = \frac{D_i^-}{D_i^+ + D_i^-} \quad (6)$$

The relevant ranking results can be obtained by the superior and inferior distance method of python.

4. ANALYSIS AND ESTABLISHMENT OF 0-1 PROGRAMMING MODEL

Mean weekly supply (expectation), standard deviation of weekly supply and safety factor; Calculate the safe supply quantity that each supplier can provide Pi[5];

$$P_i = (E_i - F_i) * S_i \quad (7)$$

In addition to meeting the total amount of weekly materials required by enterprises as far as possible and reserving warehouse reserves for 2 weeks, this model requires as few suppliers as possible. Therefore, set 1 to select the supplier, 0 to not select the supplier.

Establish the objective function of the number of suppliers:

$$F = \min = \sum_{\mathrm{i}=1}^{50} \mathrm{x_i} \quad (8)$$

The weekly total supply shall meet the total supply of the next three weeks (including this week) :

$$\sum_{\mathrm{i}=1}^{\mathrm{n}} (l_i * x_i) \geq 3 \times 28000 \quad (9)$$

$$l_i = (E_i - F_i) * S_i \quad (10)$$

5. ESTABLISH ARIMA MODEL-TIME SERIES ANALYSIS FOR PREDICTION

Time series data is according to the chronological order, changes over time, for the 32 suppliers data, raw materials order for 24 weeks, the most economic plan, now a week for more than 32 suppliers to ARIMA model analysis, forecast the total supply respectively to get the next 24 weeks weekly estimated order quantity. Translate forecast result analysis into ordering plan.

5.1.ARIMA model process and composition

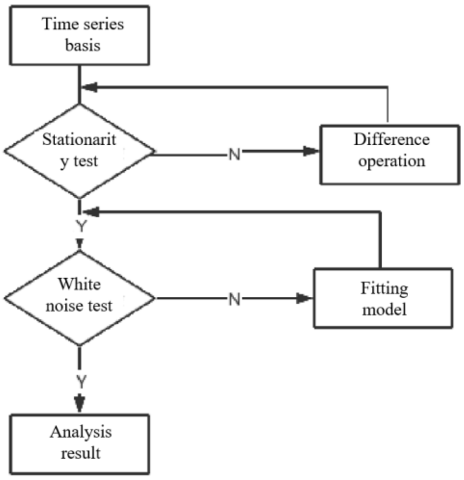

Figure 1 Process steps

5.2.Prediction of data results

With weekly intervals, ARIMA model in Stats models library of Python language is used for prediction (see appendix for code), and the initial sequence diagram is as follows:

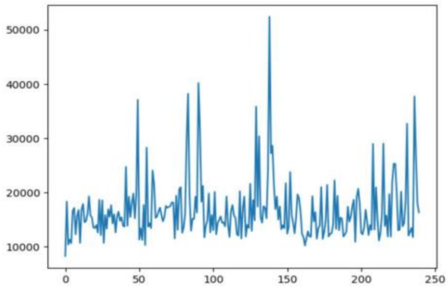

Figure 2 Total order time sequence chart of 240 weeks

5.3.Stationary model testing

Stationarity requirement: Stationarity requires that the curve of material quantity supplied by the supplier can maintain a certain stationarity in the future period. Therefore, autocorrelation function and partial autocorrelation function are used to test stationarity to reflect the correlation of values between different weeks. Python is used to generate the autocorrelation function ACF (determine q value) and partial autocorrelation function PACF (determine P value), and the obtained Q and P are used to observe whether they conform to normal distribution:

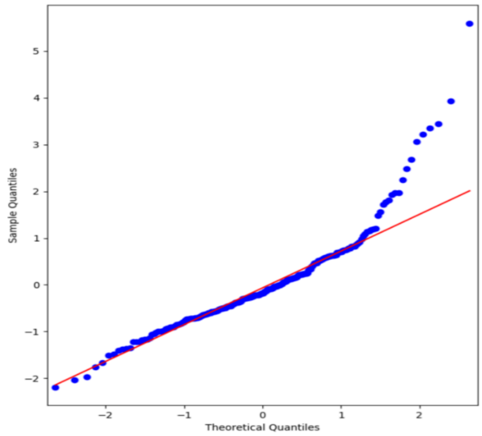

Figure 3 Normal distribution test

Finally, the ARIMA (P, D, Q) model is established with the confirmed P, Q and D, and the final prediction graph is as follows for the total weekly supply in the next 24 weeks:

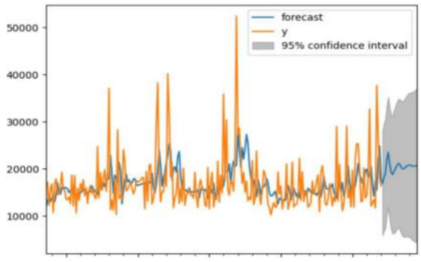

Figure 4 Forecast the order quantity of 32 suppliers in the next 24 weeks

5.4.Comparison of ordering scheme effect

Through the final results predicted by the ARIMA model, the total supply quantity supplied by 32 suppliers and 16 suppliers per week in the next 24 weeks can be preliminarily determined, and then the most economical ordering plan in the next 24 weeks can be determined according to the proportion of the actual total supply of each supplier in the first 24 weeks. Compare the most economical ordering plan with the previously given ordering plan in terms of order quantity and cost, as shown in the following figure:

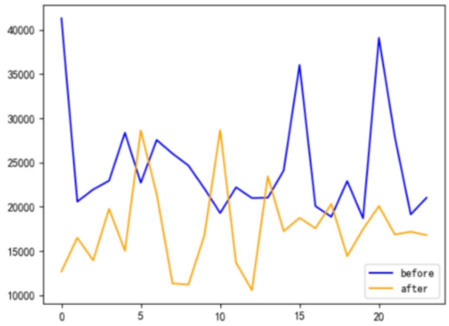

Figure 5 Order plan order quantity optimization result display

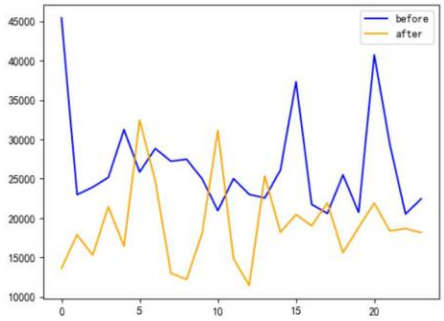

Figure 6 Show the cost optimization results of ordering scheme

As can be seen from the above two pictures, compared with the previous plan, the order of raw materials is reduced by 28.71%, the cost is reduced by 28.21%, and the order quantity is more stable. Therefore, it is a more economical ordering scheme.

6. TRANSSHIPMENT SCHEME FORMULATION

According to the loss rate of the transporter in the process of transportation,

$$\text{Attrition rate} = \frac{\text{Supply quantity -Acceptance quantity}}{\text{output}} \times 100\% \quad (3)$$

Assuming that:

$$x_{ij} = \begin{cases} 0, \text{ the } i_{th} \text{ transporter does not transfer the raw materials from the } j_{th} \text{ supplier} \\ 1, \text{ the } i_{th} \text{ transporter shall transfer the raw materials from the } j_{th} \text{ supplier} \end{cases} \quad (4)$$

A greedy algorithm is one that, when solving a problem, always does what seems best at the moment. That is to say, instead of considering the global optimal solution, the algorithm gets the local optimal solution in a certain sense. Partial transshipment plans for the next week are presented below:

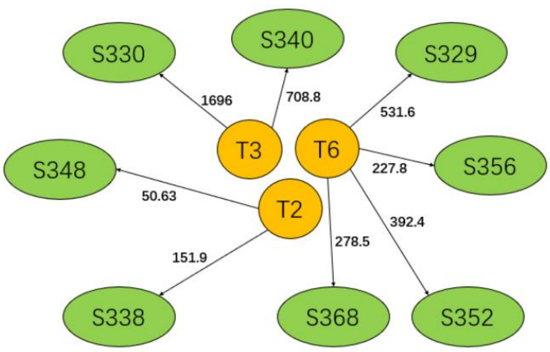

Figure 7 Partial results of transfer scheme are displayed

7. CONCLUSION

Generally speaking, there are many factors to be considered in the operation of the production enterprise, and the relationship between the enterprise and the suppliers is complicated. It is very important and most important for the enterprise to find the best way to maximize the income benefit. This paper studies the ordering and transportation of raw materials in production enterprises. This paper not only reduces the cost of production, but also reduces the loss in the process of raw material transportation. First of all, this paper puts forward three mathematical indicators according to the supply characteristics of suppliers: supply capacity (average supply capacity), supply stability (coefficient of variation) and supply and demand satisfaction (safety factor). Establish TOPSIS evaluation model to get the score of each supplier. Then, in order to meet the production demand and maintain not less than the raw material inventory to meet the production demand for two weeks, a 0-1 programming model is established and the results are obtained. After that, the ARIMA time series model is established to predict the order quantity of 32 suppliers in the next 24 weeks. Finally, by comparing the transshipment capacity and loss rate of transporters, the greedy algorithm is used to work out the optimization scheme. As a result, the total ordering volume of the ordering and transshipment scheme will be reduced by an average of 28.71% in the next 24 weeks, and the ordering and transshipment costs will be reduced by an average of 28.21%.

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