Optimal ordering and transportation scheme of raw materials in production enterprises based on objective programming model

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Abstract. In order to better realize the development of construction production enterprises and create greater profit space for them, based on the relevant data of raw material suppliers and forwarders of a production enterprise within five years, this paper first uses ARIMA algorithm to solve the enterprise's ordering scheme, and then uses 0-1 integer programming to find the constraints between suppliers and forwarders, Finally, LINGO software is used to build the target programming model to solve the 24-week transfer scheme.

Keywords: Arima algorithm; Mixed integer programming model; Objective programming model; Order transportation plan.

1. Introduction

For manufacturing enterprises, it is essential to ensure the scientificity of internal daily management. From the supply level of production factors, the choice of suppliers will directly affect the quality level of raw materials, the cost of products and services and the profit space of the enterprise itself. As for the transfer of production factors, enterprises should pay attention to all process links from raw material supply to transfer and storage to the warehouse. The level of transportation loss rate will directly affect the judgment of enterprises on the inventory of raw materials, and the storage of raw materials will also increase the invisible production cost of products, closely related to the realization of enterprise profits.

However, due to the different quantities and purchase costs of different raw materials to meet the enterprise's production capacity, the types and supply characteristics of raw materials provided by different suppliers are also different, and the impact of different forwarders on the different transportation loss degree of raw materials, the formulation of enterprise ordering and transportation scheme of production factors is by no means easy. Therefore, in order to maintain enterprise competitiveness and maximize enterprise profits, it is necessary for us to use relevant mathematical algorithms to build a good mathematical model, reasonably evaluate the implementation effect of the current enterprise raw material ordering and transportation scheme, and put forward constructive suggestions for further improvement and optimization of the scheme.

2. Establishment and solution of model

2.1. Data preprocessing

Firstly, we use Excel to calculate the difference, summary, variance and other functions to obtain the supply and demand relationship of raw materials, the stability of suppliers' supply, the cost of purchasing raw materials and the suppliers' supply capacity of suppliers. Then use the Excel table and pivot table function to re-screen the data such as suppliers and ordering quantity of raw materials A, B and C for subsequent model training.

2.2. Solution of ordering scheme

We first draw the trend chart of raw material order quantity, as shown in Figure 1 below:

It can be seen from Figure 1 that the order quantity data type of raw materials belongs to non-stationary series data in time series data. Therefore, this paper uses Arima algorithm to predict the order quantity of raw materials a, B and C in the next 24 weeks. The specific process of ARIMA algorithm is shown in Figure 2:

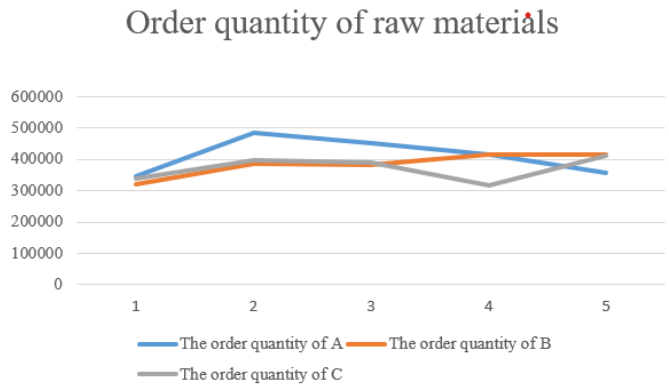


Figure 1 Trend chart of order quantity of raw materials

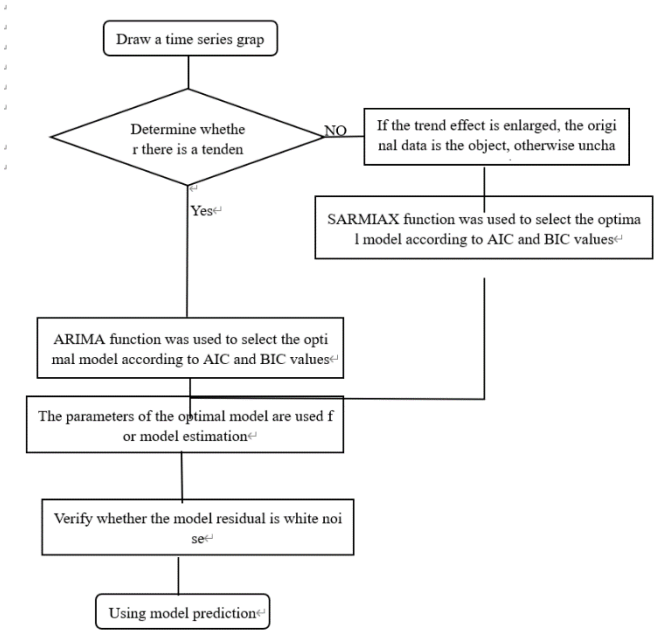


Figure 2 Arima algorithm flow chart

2.2.1 Prediction of order quantity of raw materials A

The optimal model is selected according to AIC and BIC values. It can be seen from the time series diagram that the ordering quantity of raw material has a trend, so Arima function is used to calculate AIC and BIC values. The difference operator and delay operator shall be introduced, and the relationship between them is as follows:

$$\nabla = 1 - B,\ \ \nabla^2 = (1-B)^2,\ \ \nabla^d = (1-B)^d \tag{1}$$

Where d is the order of the difference. This paper assumes that it $\{Z_t\}$ is a time non-stationary series and $\{x_t\}$ is a series of ARIMA (P, q). When $x_t = \nabla^d z_t, t > d$, there are:

$$\varphi(B)(1-B)^d z_t = \theta(B)a_t \tag{2}$$

According to the prediction model with the optimal values of AIC and BIC, the calculation results using spssau software are shown in Table 1:

Table 1 correlation coefficient of optimal prediction model

Item	Symbol	Coefficient	Standard error	Z value	P value	95%CI
Constant term	c	370169.791	7805.620	47.423	0.000	354871.058~385468.525
AR function	α_1	-0.681	0.318	-2.139	0.032	-1.305~-0.057

2.2.2 Solving the optimal model

It can be seen from the table that the p value is less than 0.05, indicating that it is significant. AIC and BIC values are 103.142101.301, which is lower than the standard value, so the construction of the model is reasonable. For the order quantity of a and a, combined with the information criteria of AIC and BIC, spssau software automatically models, compares and selects multiple potential suitable models, and finally solves the optimal model through analysis. The specific model form is:

$$y = 435653.982 - 0.676y(t-1) \tag{3}$$

2.2.3 Parameter estimation and test model

Spssau software is used to calculate the parameters of the model. Since Arima algorithm requires the model residual to be white noise, Q6, that is, the first 6-order autocorrelation coefficient, is used to test whether it meets the white noise. According to the calculation, the corresponding p value is greater than 0.1, indicating that it meets the white noise test. That is, the residual of the model is white noise, and the model meets the requirements.

2.2.4 Model prediction

Finally, spssau software predicts the order quantity of enterprise raw materials. The results are shown in Table 2. Finally, the order quantity in the next 24 weeks is obtained.

Table 2. Forecast order volume for 24 weeks

forecast	1)back	2)back	3)back	4)back	5)back	6)back	7)back	8)back	9)back	10)back	11)back	12)back
value	4490.2	4266.1	4417.6	4315.2	4384.5	4337.4	4369.3	4347.9	4362.3	4352.6	4359.2	4354.7

forecast	13)back	14)back	15)back	16)back	17)back	18)back	19)back	20)back	21)back	22)back	23)back	24)back
value	4358.7	4354.9	4358.5	4355.1	4358.3	4355.2	4358.2	4355.4	4358.0	4355.5	4357.9	4355.7

Similarly, the order quantity of raw materials B and C in the next 24 weeks can be obtained. In order to meet the demand for raw materials produced by the enterprise, the supply shall not be less than the order quantity of the enterprise. Use the vlookup of Excel table to match the data, and then use the pivot table function to summarize the supply. It is concluded that when the number of suppliers is 107, the supply quantity is slightly greater than the enterprise's demand for a, B and C. In addition, when the number of suppliers is 106, the supply quantity is less than the enterprise's demand. Therefore, enterprises should select at least 107 important suppliers to supply raw materials to meet the production demand. Because the time series is in units of year, quarter and day, and under the condition of good model significance, the mean value can be calculated to represent the demand of the enterprise in the next 24 weeks.

2.3. Solution of transfer scheme

The mixed-integer programming model uses 0-1 integer programming to constrain the relationship between suppliers and forwarders, and then uses the objective programming model to solve the 24-week transshipment scheme.

The goal is to make the number of raw materials supplied by suppliers equal to the production demand of the enterprise. The sum of the difference between production supply and demand is the smallest. The specific form is

$$\sum_{i}^{n}(X_{it}-D_{it}) \tag{4}$$

Since the unit price of class A and B raw materials is 20% and 10% higher than that of class C raw materials, and the transportation and storage costs of the three types of raw materials are the same, if the unit price of raw material C is set as 1, the unit prices of raw materials a and B are 1.2 and 1.1, respectively. Similarly, if the transportation and storage fees of raw materials C are 1, the transportation and storage fees of raw materials a and B are 1, 1, 1 and 1 respectively. As the weekly production capacity of the enterprise is 28200 cubic meters, the class A, B and C raw materials required for each cubic meter of products are 0.6, 0.66 and 0.72 cubic meters, respectively. Secondly, the transport capacity of the forwarder is 6000 m3 / week. 0 − 1 constraint is adopted for the relationship between suppliers and forwarders, that is, 0 means transportation and 1 means no transportation. According to the given data, calculate the average loss rate of each forwarder and the obtained value. Based on this, the constraints can be written out.

$$\begin{aligned} &I_{i,t-1}+X_{i,t}-I_{i,t}=D_{i,t}+\sum_{j\in S(i)}R_{i,j}X_{j,t} \\ &0\le X_{i,t}\le MY_{i,t} \quad Y_{i,t}\in\{0,1\} \end{aligned} \tag{5}$$

$$I_{i,t}>0, M=28200 \tag{6}$$

Lingo software is used to solve, and some results are shown in Table 3

Table 3 partial results

X(A,1)	6315.789	0.000000
X(A,2)	6947.368	0.000000
X(A,3)	7578.947	0.000000
X(A,4)	6315.789	0.000000
X(A,5)	6947.368	0.000000
X(A,6)	7578.947	0.000000
X(A,7)	5745.322	15.30000
X(A,8)	6229.229	14.45000
X(A,9)	4476.939	13.60000
X(A,10)	4657.769	12.75000
X(A,11)	5846.102	11.90000
X(A,12)	7805.845	11.05000
X(A,13)	6547.053	10.20000
X(A,14)	6709.802	9.350000
X(A,15)	6014.795	8.500000
X(A,16)	7070.362	7.650000
X(A,17)	8593.113	6.800000
X(A,18)	6644.804	5.950000
X(A,19)	8334.778	5.100000
X(A,20)	7198.340	4.250000
X(A,21)	8563.408	3.400000
X(A,22)	7648.049	2.550000
X(A,23)	5146.716	1.700000
X(A,24)	6436.298	0.850000

3. Advantages and disadvantages of the model

This paper mainly adopts the planning model to analyze the production planning scheme. The linear programming process is simple and easy to solve. Using the simulation process, the theoretical values are brought into the model for simulation many times, and the data results have a more scientific basis.

However, the convergence speed of ordinary mathematical programming models is slow, and it may converge to the local optimal solution and cannot converge to the global optimal solution.

4. Conclusion

In this paper, we first use Arima algorithm to solve the enterprise's ordering scheme, and then establish a mixed integer programming model to solve the enterprise's transshipment scheme. In solving the ordering scheme, we first use Arima function to calculate AIC and BIC values, solve the optimal model form through spssau software, and then calculate the model's parameters. The test parameters show that the model meets the white noise test. Finally, we use spssau software to predict the order quantity of different raw materials, and find that at least 107 suppliers can meet the requirements. In solving the transshipment scheme, we first find the objective function, then use 0-1 integer programming to find the constraints between suppliers and forwarders, and finally, use lingo software to build an objective programming model to solve the 24-week transshipment scheme.

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