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Study of Raw Material Ordering and Transportation Scheme for Manufacturing Companies based on 0-1 Planning Model

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Abstract

Since the 21st century, China's consumption structure has undergone fundamental changes and the development of private enterprises has gained momentum by leaps and bounds. The urbanization process will be further promoted comprehensively, the urban population will grow significantly, and the housing conditions of China's urban and rural residents will be improved even more. The new consumption hotspots become housing, automobiles, etc. In this paper, we analyze the weekly supply of 402 suppliers and the transportation loss rate of 8 forwarders of a manufacturing company for 5 years, and establish a mathematical model to continuously optimize the raw material ordering and transportation scheme for the company. The most economical raw material ordering solution and the transportation solution with the least loss for the next 24 weeks, the solution that minimizes the cost of transshipment and storage and the solution with the highest capacity are developed.

Keywords

0-1 Planning; Material Ordering and Transport; Assignment; Fitting.

1. Introduction

Since the 21st century, China's consumption structure has undergone fundamental changes and the development of private enterprises has gained momentum by leaps and bounds. The urbanization process will be further promoted comprehensively, the urban population will grow significantly, and the housing conditions of China's urban and rural residents will be improved even more. The new consumption hotspots become housing, automobiles, etc [1].

Nowadays, the construction industry has an important position and role in the national economy, improving people's learning, living and working environment, people live and work in peace, thus promoting the development of the national economy and overall social progress. Building and decorative sheet production enterprises are to meet the housing needs of residents, to improve the housing conditions of residents an important force. To ensure production, reduce costs, is to promote construction and decorative sheet enterprises to better and faster development of the road. Therefore, it is important to make a rational arrangement to develop an optimal plan based on the supply characteristics of suppliers and the loss rate of forwarders [2].

Now a building and decorative panel manufacturer has determined the weekly production capacity of 28,200 cubic meters, each cubic meter of product needs to consume 0.6 cubic meters of raw material of category A, or 0.66 square meters of raw material of category B, or 0.72 cubic meters of raw material of category C. The purchase unit price of raw material of category A and B is 20% and 10% higher than that of raw material of category C, respectively, and the transportation capacity of each forwarder is 6000 cubic meters. Develop a mathematical model to solve the problem based on the above background.

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2. Assumptions and Notations

2.1. Assumptions

We use the following assumptions.

1 The main factor in judging the importance of the manufacturer is whether the supply of the manufacturer can meet the production and sales of the enterprise.

2 The secondary factors to judge the importance of the manufacturer are: the manufacturer's supply quantity, maximum supply quantity, delivery period, etc.

3 When the enterprise is in urgent need of raw materials, the manufacturer can temporarily provide a large number of raw materials for the enterprise to use.

4 The supplier's usual supply quantity is the average of 240 weeks in Annex I.

5 enterprise weekly demand for raw materials and time, that is, the first 240 weeks of data on the weighting of time to get the next 24 weeks of weekly demand for raw materials.

6 Generally, a supplier is supplied with raw materials from one forwarder each week, but if the raw materials exceed the capacity of the forwarder, they can be delivered by other forwarders.

2.2. Basic Concept Supplement

0-1 planning is a special class of integer planning in which the decision variables only take the value 0 or 1. 0-1 variables can quantitatively describe the logical relationships, sequential relationships and mutually exclusive constraints among discrete variables reflected by phenomena such as haves and have-nots, take and discard, on and off. Its application is very wide and it is - an important problem in operations research [3].

Curve fitting is the process of constructing a curve or function based on a set of existing data points. In a wide variety of scientific problems. There are many ways to obtain data that are not continuous, which makes it impossible to know the specific value of the points that do not appear in the data set, and there is no way to know where the data points are located in the overall data, so it is hoped that a curve or a curve that can roughly express the relationship of discrete points can be obtained from these data. Through the curve fitting method to fit the function of the curve, you cannot appear in the function of the point into the corresponding value of the point can also reflect the trend of the data set or the relationship between data and data.

3. Model Construction and Solving

3.1. A Mathematical Model Reflecting the Importance of Securing the Production of the Enterprise

The "availability of supply to meet the order quantity", "the quantity available at one time" and "the ratio between the difference between supply and order quantity and the order quantity" all have an impact on the production of the company [4]. Among them, whether the supply quantity can reach the order quantity is particularly important for the production of the company. When the supply quantity can reach the order quantity, the more the quantity of materials that can be supplied at one time, the more the supplier can guarantee the production of the enterprise; when the supply quantity cannot reach the order quantity, the smaller the ratio between the difference between the supply quantity and the order quantity and the order quantity, the more the supplier can guarantee the production of the enterprise [5].

In order to guarantee the production of the enterprise, the evaluation value a is set to measure the importance of the supplier to guarantee the production of the enterprise.

Set the following evaluation mechanism.

Set the initial value a = 0; the supply quantity is g, the order quantity is d.

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1. judge whether the supply quantity g this week can reach the supply quantity d.
If this week's supply quantity g can reach the order quantity d, that is, g≥d, then.

$$a = a + 0.5 \tag{1}$$

If this week's supply g cannot reach the order quantity d, i.e., g < d, then.

$$a = a - \frac{g-d}{d} \times 100\% \tag{2}$$

2. If this week's supply quantity g can reach the order quantity d, compare the supply company can supply quantity g at one time.

$$\text{When } 1 \le g < 100, a = a + 0.5 \tag{3}$$

$$\text{When } 100 \le g < 200, a = a + 0.55 \tag{4}$$

……

$$\text{When } 900 \le g < 1000, a = a + 0.95 \tag{5}$$

……

That is, ignore the value of the supply g from the next highest to the last, noted as g', and express g' in scientific notation as $g' = x \times 10^n$.

$$a = a + 0.5 \times (n-1) + x \times 0.05 \tag{6}$$

50 suppliers were selected and their score curves are shown in Figure 1.

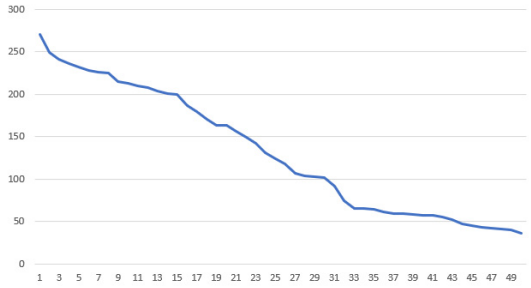

Figure 1. 50 supplier score curve

3.2. Development of the Most Economical Weekly Raw Material Program

The average weekly supply of 50 suppliers and the fitting results are shown in Figure 2. As can be seen from Figure 2, the higher the ranking of suppliers the greater the daily supply, in order to meet the production needs of the number of suppliers to provide raw materials as little as possible, using their average supply instead of the daily production, according to the ranking order, the raw materials supplied by each supplier to sum, until the number of raw materials to meet production needs. The company's order quantity for the next 24 weeks is shown in Figure 3.

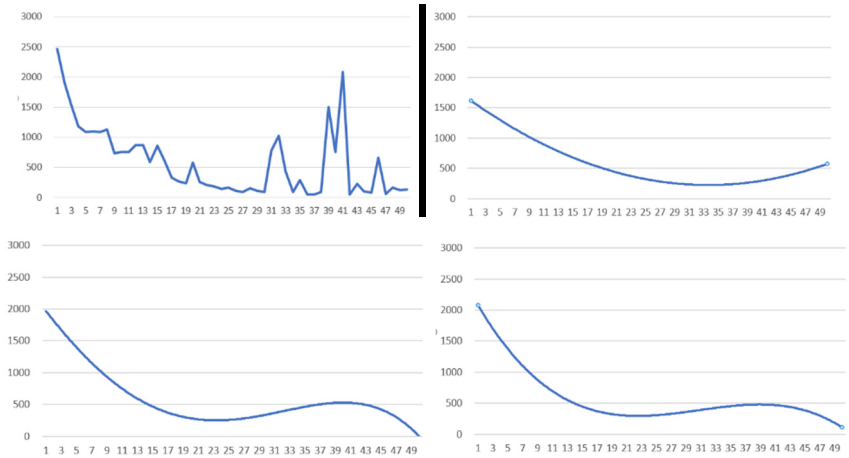

Figure 2. Average weekly supply of 50 suppliers and fitting results

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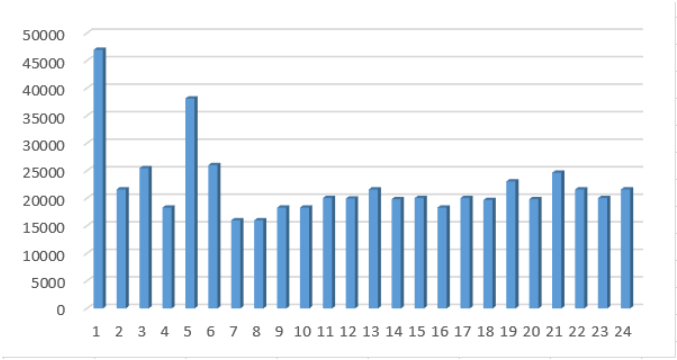

Figure 3. The company's order quantity for the next 24 weeks

Use asymptotic weights to determine supplier availability.

$$Hi \ldots (i = 1,2,3 \ldots 402) \tag{7}$$

$$H_i = w_1 h_{1i} + w_2 h_{2i} + w_3 h_{3i} + w_4 h_{4i} + w_5 h_{5i} \tag{8}$$

$$w_5 > w_4 > w_3 > w_2 > w_1 \tag{9}$$

It shows that the closer the year is to the present, the greater the weight is, and the more it can reflect the situation of suppliers, thus obtaining the required weekly supply for the next 24 weeks, which is shown in the figure above. Combining the data in the above chart and the average supply quantity of each supplier, and then using the evaluation system to determine the priority of supplier supply, to develop the ordering plan for the next 24 weeks.

This is an obvious objective optimization problem, and the supplier's supply quantity and the forwarder's forwarding quantity are discontinuous values, which means that a nonlinear integer programming model can be used to solve this kind of problem. For a particular forwarder and a particular supplier, there are only two cases between them: the supplier consigns the goods to this forwarder for forwarding and the supplier does not consign the goods to this forwarder for forwarding. In this case, 0-1 planning with only 0 or 1 decision variables is very suitable. 0-1 planning model is shown in Table 1.

Table 1. 0-1 planning model

	Suppliers 1	Suppliers 2	...	Suppliers m
Forwarder 1	X_{11}	X_{12}	...	X_{1m}
Forwarder 2	X_{21}	X_{22}	...	X_{n2}
...	...	...	...	...
Forwarder n	X_{n1}	X_{n2}	...	X_{nm}

X represents whether a supplier has selected a forwarder (X=1 or X=0)

if X_{11}=1, then a supplier with serial number 1 has selected a forwarder with serial number 1.

If X_{11}=0, then there is no selection.

Need to come up with a minimum loss of transshipment program, at this time, you can set the weekly supply of each supplier is y1, y2,y3.....ym, each forwarder's transport losses are J1,J2,J3,.....Jm, each product The unit price is A1,A2,A3. The objective function is then derived as.

$$MIN\ sum = J_1(y_1 \times A_? \times X_{11} + y_2 \times A_? \times X_{12} + \cdots \ldots + y_m \times A_? \times X_{1m}) + \cdots \ldots + J_n(\times A_? \times X_{n1} + y_n \times A_? \times X_{n2} + \cdots \ldots + y_m \times A_? \times X_{nm}) \tag{10}$$

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Also from the known conditions it follows that

(1) Each supplier should preferably choose one forwarder.

(2) The maximum transportation capacity of each forwarder is 6000 m3/week.

From this, we can establish the constraints.

$$X_{11} + X_{21} + \cdots + X_{n1} = 1 \tag{11}$$

$$X_{12} + X_{22} + \cdots + X_{n2} = 1 \tag{12}$$

$$\cdots\ \cdots$$

$$X_{1m} + X_{2m} + \cdots + X_{nm} = 1 \tag{13}$$

$$X_{11} + X_{12} + \cdots + X_{1m} \leq 6000 \tag{14}$$

$$X_{21} + X_{22} + \cdots + X_{2m} \leq 6000 \tag{15}$$

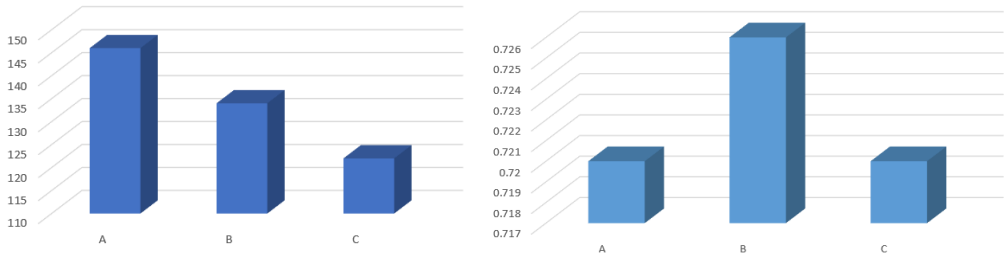
$$\cdots\ \cdots$$

$$X_{n1} + X_{n2} + \cdots + X_{nm} \leq 6000 \tag{16}$$

So far, 0-1 planning model construction is complete, the objective function, constraints and other required variables into matlab mathematics software, the use of its own solution mixed integer linear programming function intlinprog can be completed to solve the solution, to get the required transit scheme.

Based on the attrition rate of each forwarder in 240 weeks. It can be inferred that when the loss rate of a forwarder is 0 in a certain week, the most likely situation is that this forwarder did not receive any requests for forwarding goods in that week. So when we calculate the loss rate, we should discard the loss rate of 0, and then average the remaining loss rate of a forwarder. This will make the calculated loss rate closer to the real situation.

3.3. Analysis of the Implementation Effect



(a) (b)

a) The proportion of each type in the total of 42 suppliers, b) The cost of all kinds of raw materials needed to produce every 1 square meter of products

Figure 4. Implementation effect analysis chart

Implementation effect analysis chart is shown in Figure 4. In order to reduce the cost, we should purchase as much as possible of Class A and as little as possible of Class C raw materials. Therefore, on the basis of the above, the main factor affecting the selection of suppliers is changed from the amount of suppliers' supply to the type of raw materials, and the ordering scheme is developed again.

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3.4. Increase the Capacity of Suppliers' Deliveries

The average of the 50 weeks of the largest supply of 402 suppliers as the weekly output of the supplier, calculated to the maximum weekly order quantity of the enterprise Considering also that the weekly supply cannot remain constant, we add a random number of [-5,5] to the model (the supplier's supply is greater than 5) and run the program to derive the transit scheme Based on the already obtained ordering scheme, the optimized capacity of the enterprise is calculated to be 67,667.65 m3. Based on the formula, it is calculated that the enterprise's weekly capacity can be increased by 1.40 times.

4. Conclusion

This paper uses 0-1 planning and fitting methods to conduct a multi-factor analysis on the ordering, transportation, inventory and loss of raw materials encountered in enterprise production, including statistical analysis of the types of sources of 402 suppliers and the number of orders and actual shipments of a manufacturing enterprise over the past 5 years, as well as statistical analysis of the transportation capacity and transportation loss rate of 8 cargo forwarders and other data, and establishes Mathematical model, on the basis of which the most important 50 of 402 suppliers were found and calculated in order to 24 weeks the optimal ordering scheme and forwarding scheme.

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