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Order and Transportation Design of Enterprise Raw Materials based on the Logit Regression Model

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Abstract In order to reduce enterprise production costs and increase enterprise profits, study the supply chain system formed by enterprises for the ordering and transportation of raw materials, and consider how to maximize profits in this system. First, build a minimum supplier model for 402 suppliers, maximize production capacity when multiple constraints are met, and minimize transfer losses by building a 0-1 matrix of suppliers and carriers. Finally, using the improved Logit regression model to simulate capacity improvements, Matlab's simulation resulted in a weekly production capacity of about 5,94 million square meters, which could increase weekly earnings by 30 percent.

Keywords 0-1 Matrix, Minimum Supplier Model, Logit Return Model, Matlab

1. Introduction

Supply chain management is an important part of market competition today. In order to make supply chain systems healthier and more sustainable, companies often need to plan, evaluate, analyze and optimize them in advance to serve consumers at lower costs and more efficiently under reasonable conditions. The competition between companies has turned from product competition to supply chain system competition. Only a more efficient supply chain system can bring more profit to the enterprise, so that it can be more efficiently invested in the supply Chain system to maintain efficient operation, in order to a good cycle.

2. Maximum Supply Matrix and Minimum Supplier Model

2.1 Maximum Supply Matrix

In the actual operation of the enterprise, it is often necessary to choose the least number of suppliers, that is, the suppliers selected to try to supply the production company as much as possible. The loss rate of raw materials during transportation is 2%. According to the three types of raw materials, 402 suppliers are separated, and the different types of supplies are still sorted from small to large according to the serial number of the original suppliers.

The matrix of the supply of each supplier's first week is set to be $\mathrm{G_A}$, Simultaneously set $\mathrm{G_B}$ and $\mathrm{G_C}$ .the maximum value of the amount of supply that the store has delivered in that period of the past year. Therefore, each supplier annually sets a maximum value for the supply ceiling for the period. At this time, there were a total of 146 supplies of A raw materials, The maximum supply of these suppliers per week is set in Matrix MAX_A, matrix MAX_A is a matrix of 146 rows and 24 columns. 146 lines representing 146 suppliers, and 24 rows representing the maximum value at that point of time each year, so

$$MAX_A = \begin{pmatrix} 2 & 0 & \cdots & 1 \\ 65 & 64 & \cdots & 84 \\ \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \cdots & 1 \end{pmatrix}$$

Similarly, matrix MAX_B and matrix MAX_C can be obtained, specifically as follows:

$$MAX_B = \begin{pmatrix} 5 & 0 & \cdots & 4 \\ 180 & 184 & \cdots & 251 \\ \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \cdots & 0 \end{pmatrix}$$

$$MAX_C = \begin{pmatrix} 11 & 38 & \cdots & 52 \\ 2 & 1 & \cdots & 1 \\ \vdots & \vdots & \ddots & \vdots \\ 3 & 0 & \cdots & 1 \end{pmatrix}$$

2.2 Minimum Supplier Model Construction

Data from 146 suppliers who supplied Class A raw materials was selected to matrix S_A the supply of these suppliers over 24 weeks. This is a 0-1 matrix, taking the position of 1 represents the choice of the supplier, and asking for the maximum supply of goods, take the position 0 represents no goods.

Add the 24 data in each column of a supplier, and if the result is less than zero, it is selected. Similarly, matrix S_B and matrix S_C can be obtained, specifically as follows:

$$S_A = \begin{vmatrix} 2000 & 1130 & \cdots & 1210 \\ 1 & 160 & \cdots & 630 \\ \vdots & \vdots & \vdots & \vdots \\ 1 & 0 & \cdots & 0 \end{vmatrix}$$

$$S_B = \begin{vmatrix} 550 & 7870 & \cdots & 6800 \\ 40 & 600 & \cdots & 520 \\ \vdots & \vdots & \vdots & \vdots \\ 1 & 0 & \cdots & 0 \end{vmatrix}$$

$$S_C = \begin{vmatrix} 910 & 1210 & \cdots & 1410 \\ 140 & 550 & \cdots & 650 \\ \vdots & \vdots & \vdots & \vdots \\ 0 & 0 & \cdots & 1 \end{vmatrix}$$

The minimum supplier model expressions z are:

$$\min z = num\left(\sum_{i=1}^{24} (S_A)_{ij} \neq 0\right) + num\left(\sum_{i=1}^{24} (S_B)_{ij} \neq 0\right) + num\left(\sum_{i=1}^{24} (S_C)_{ij} \neq 0\right)$$

3. Order and transportation design of enterprise raw materials

3.1 Pre-processing of order data

In the enterprise order volume data, there are many quantitative inconsistencies, obviously an error data, the subsequent data analysis and processing will therefore be greatly affected, so the data pre-processing phase will be filtered and eliminated for these abnormal data, and the data after processing is clustered.

3.2 Maximizing production capacity and minimizing transport losses

In the case of transportation and storage costs, the transfer loss rate is low, enterprises purchase as little as possible Class C and purchase as many Class A raw materials as possible, reducing their purchase costs. The enterprise’s raw materials produced by suppliers are the guidelines for all acquisitions, and the total cost depends on the supplier’s supply volume, not the enterprise's order volume. Based on the single price of raw materials A, B, C, the procurement function p is as follows:

$$\min p = 1.2\sum_{i=1}^{X}(G_A)_{ij} + 1.1\times\sum_{i=1}^{X}(G_B)_{ij} + 1\times\sum_{i=1}^{X}(G_C)_{ij}$$

Further calculations are required to meet several restrictive conditions. Adding the production capacity provided for the calculation of A, B, C raw materials, the final value must be greater than the required capacity of 2.79×10^4cubic meters. Considering that the first week requires the procurement of the raw materials needed for the first and second weeks, the corresponding production capacity is 5.74×10^4 cubic meters.

Based on the actual situation of the first week, build up capacity inequalities:

$$98\%\times\left(\frac{\sum_{i=1}^{X}(G_A)_{ij}}{0.6}+\frac{\sum_{i=1}^{X}(G_B)_{ij}}{0.66}+\frac{\sum_{i=1}^{X}(G_c)_{ij}}{0.72}\right)\geq 5.74\times10^4$$

The amount of supply received each week at any supplier shall not exceed the maximum supply available to the supplier each week. For example, for the first week, the specific mathematical expressions are:

$MAX_{A,1}$Represents the first column of the weekly supply ceiling matrix $MAX_{A,1}$ for the previously set supplier. The only decision variable is the transport scheme between the supplier and the carrier, i.e. the 0-1 planning question. Given that the loss rate of the shipment is seasonal, the company needs to determine the losses rate for the carrier based on the annual average of the loss.

For example, in the first week, the loss rate of each carrier is recorded as ζ, so there is

$$\zeta = \begin{pmatrix} 1.91 \\ 0.74 \\ \cdots \\ 0.64 \end{pmatrix}$$

Specific mathematical expressions are:

$$98\%\times\left(\frac{S_A\cdot MAX_A}{0.6}+\frac{S_B\cdot MAX_B}{0.66}+\frac{S_C\cdot MAX_C}{0.72}\right)\geq\begin{pmatrix} 5.74\times10^4 & & & \\ & 2.82\times10^4 & & \\ & & \cdots & \\ & & & 2.82\times10^4 \end{pmatrix}$$

Each supplier can only be transported weekly by a separate carrier, and other carriers are also required to assist them in completing the transfer. In short, each supplier's corresponding row, with a maximum of one location for non-zero elements, is mathematically:

$$\sum_{j=1}^{8}(S_l)_{ij}=1$$

According to the scheme given by the carrier, the actual transport capacity of each household is 6000, which is mathematically expressed as:

$$\begin{pmatrix} G_A \\ G_B \\ G_C \end{pmatrix}\cdot S_l \le \begin{pmatrix} 6000 \\ \vdots \\ 6000 \end{pmatrix}$$

For a raw material, take the first week for example, the matrix H_A consisting of the supply of each store's first week, which is a 146 line 1 column matrix. Defined H_B and H_C in the same way. At the same time, assume that the matrix of the 402 row 8 column S_Z is a cooperation matrix between suppliers and carriers, which is a 0-1 matrix.

Because the problem is a dual-target function problem, there are two functions.

It is now planned to purchase as little as possible Class C and as many Class A raw materials as possible. It is possible to give class C raw material weight 1, class A raw materials weight 100, that is, the expression of the design scheme for maximum production capacity M:

$$\max M = 100\times\sum_{i=1}^{146}(H_A) + 1\times\sum_{i=1}^{122}(H_C)$$

At the same time, the transfer loss rate of the carrier is as small as possible, so the design expression of the minimum transfer loss is m:

$$\min m = \begin{pmatrix} G_A \\ G_B \\ G_C \end{pmatrix}\cdot S_l \cdot \zeta$$

3.3 Calculation based on improved Logit regression models

Step 1: Logit regression model and establishment of non-importance probability

According to the Logit conversion, a Logit regression model can be obtained:

$$Logit(p) = \ln\left(\frac{\mathrm{p}}{1-\mathrm{p}}\right) = 1.214 - 0.280\mathrm{X}_1 - 0.066\mathrm{X}_2 + 0.219X_3 - 6.278\mathrm{X}_5$$

The equation turns the left pair into a natural pair $\ln = \log_{\mathrm{e}}$, and the equation changes the right side into a vector multiplication form, and it has the following deformation:

$$\log\left(\frac{p}{1-p}\right)=\theta X$$

$\theta = (1, \theta_1, \theta_2, \cdots, \theta_{\mathrm{n}})$, $\mathrm{X} = (1, x_1, x_2, \cdots, x_{\mathrm{n}})^{\mathrm{T}}$ among them, the result is:

$$p=\frac{e^{\theta X}}{1+e^{\theta X}}$$

The probability of nonimportance is:

$$p = \frac{\exp\begin{pmatrix}1.214 - 0.280\mathrm{X}_1 - 0.066\mathrm{X}_2 \\ + 0.219X_3 - 6.278\mathrm{X}_5\end{pmatrix}}{1 + \exp\begin{pmatrix}1.214 - 0.280\mathrm{X}_1 - 0.066\mathrm{X}_2 \\ + 0.219X_3 - 6.278\mathrm{X}_5\end{pmatrix}}$$

The above formula can be used to calculate the probability of non-importance of each supplier, i.e. the degree of trust of the enterprise in the individual supplier. Set 0.5 as a critical point, by comparing with it, to determine whether the enterprise chooses the supplier.

Step 2: The 0-1 matrix for building a supplier-transporter partnership

Suppose for a raw material, the first week as an example, the matrix consisting of the supply of each store's first week is a matrix of a 146 line 1 column. Defined in the same way.At the same time, assume that the matrix of the 402 row 8 column is a cooperation matrix between suppliers and carriers, which is a 0-1 matrix.

Step 3: Improved design for minimizing transport loss

By analyzing supply data, the company found that the total maximum supply per day is less than the range that transport can carry, ignoring the cost of transportation, then as long as the reduction rate can be reduced to a minimum.On the basis of the original assumption, taking the first week of supply of Class A raw materials as an example, the matrix of each supplier's first week supply is set as G_A, Simultaneously set G_B andG_C.Finally, the combined loss rate of the carrier in the week gets the final result.The calculation expression is:

$$\min m = \begin{pmatrix} G_A \\ G_B \\ G_C \end{pmatrix} \cdot S_Z \cdot \zeta$$

4. Simulated

First, filtering by non-importance probability, and then simulating based on the Logit regression model, the simulation process is as follows:

Use Matlab to simulate the above enterprise raw material ordering and transfer scheme, set the supply volume in the order volume 1.5% to 2.0% fluctuation, loss rate up to 1.5 to 2.5%, and the simulation is performed, the number of times is ten, the result is as follows in Table 3:

Table 3: Simulation of results

Number	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Two weeks of production capacity	YES	YES	YES	YES	NO	YES	YES	YES	YES	YES
Total supply errors	3.8%	2.9%	8.3%	1.5%	3.2%	4.1%	3.8%	0.3%	1.4%	3.8%
Average Transport Loss	0.78%	2.84%	1.37%	1.24%	0.90%	1.35%	4.73%	4.25%	1.5%	0.78%

The improved Logit regression model simulates capacity improvements, resulting in a weekly production capacity of approximately 5,94 million square meters, according to the Matlab simulation, with weekly earnings increasing by 30%.

5. Conclusions

By optimizing data through improved Logit regression models, enterprises empower raw materials A and C in the ordering process, building models. In the process of transportation, a planning model is established with the minimum transfer loss rate as the target function (0-1 planning model). Using Matlab for simulation, the simulation resulted in a weekly production capacity of approximately 5,94 million square meters, resulting in the company's weekly earnings increasing by 30 percent.

The improved Logit regression model overcomes the IIA characteristics of the traditional Logit model, compared with the conventional Logit models, with features of higher matching superiority.

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