ISSN: 1813-4890

# Research on Enterprise Supply Planning based on Linear Programming Model

Xinyi Zeng, Yishan Chen, Yuxuan Zhang and Li Chen*

College of Media Engineering, Communication University of Zhejiang, Hangzhou, China

*cuzmath@126.com

## Abstract

**In daily life, major enterprises often face problems such as production, supply and transportation. They should design and select the optimal solution according to specific needs, and usually obtain the comprehensive optimal solution based on linear programming model and other extension methods. Facing the complex reality at this time, the final research goal is divided into two problems. The 0-1 programming model is established to solve them step by step, simplify the solution process, and find the supplier and forwarder with the lowest economic cost, so as to meet the needs of enterprise supply planning. Finally, the advantages and disadvantages of the scheme are evaluated and the sensitivity of the model is analyzed.**

## Keywords

**Linear Programming Model; Supply Characteristic Index; Supply Completion Error Rate; Optimal Scheme.**

## 1. Introduction

With the progress of science and technology, the degree of socialization and specialization of production is constantly improving, and people's research on transportation problems is also deepening. Some scholars classify the transportation problems according to various constraints, and explore many simple solutions on the basis of classical algorithms. However, there is no systematic summary of all kinds of transportation problems and their algorithms. Therefore, the research on the generalization and algorithm of transportation problem is of great significance. [1]

This paper mainly discusses the application of linear programming model in transportation problems, and discusses how to apply linear programming model to optimize and analyze the optimization decision-making problem in transportation system, so as to obtain the optimization scheme and reasonably solve the transportation problem.[2] Understand and expand to genetic algorithm. The application research of genetic algorithm is richer than theoretical research, and has penetrated into many disciplines. [3] It is necessary to use matlab to calculate the best result according to the theory of genetic algorithm.[4] Finally, the sensitivity values of the design parameters are processed in a unified dimension by the sensitivity analysis method to determine the sensitivity order of the parameters to be corrected.[5]

For construction enterprises and decorative plate enterprises, there are many kinds of raw materials used. It is assumed that the production is arranged in weeks. Due to the uncertainty of raw materials, the supplier cannot guarantee to supply goods strictly according to the order quantity, and the actual supply quantity may be more or less than the order quantity. In order to meet the needs of normal production, the enterprise should formulate a 24-week ordering and transportation plan in advance, and maintain the inventory of raw materials that meet the production needs of two weeks as much as possible. Therefore, it is assumed that the enterprise will always purchase all the raw materials actually provided by the supplier. In the actual transfer process, there will be a certain loss of raw materials.

From the actual investigation, the ordering quantity and supply quantity data of 402 raw material suppliers and the transportation loss rate data of 8 Forwarders of an enterprise in recent 5 years are obtained. The supply characteristics of 402 suppliers are quantitatively analyzed, and a mathematical model reflecting the importance of ensuring enterprise production is established. On this basis, 50 most important suppliers are determined, and the results are presented in the form of tables.

With reference to the factors listed above, the minimum number of suppliers selected by the enterprise can be calculated when the raw materials may meet the production demand. For these suppliers, we have also formulated the most economical raw material ordering scheme for the enterprise every week in the next 24 weeks, and based on this, we have formulated the transshipment scheme with the least loss. Finally, the implementation effect of ordering scheme and transshipment scheme is analyzed.

## 2. Model Establishment

### 2.1. Model Assumptions

(1) Assume that the total amount of raw materials A, B and C in the first week of the enterprise is 0.

(2) It is assumed that the enterprise should maintain the inventory of raw materials that meet the production demand of two weeks at least, that is, it needs to hold the production demand of the current week and the next week.

(3) It is assumed that the order quantity of the enterprise can be equal to or slightly exceed the actual supply quantity.

(4) When solving the first two parts of the second question, the transportation loss can not be considered, but it can not be directly ignored. Therefore, the loss rate of all forwarders is assumed to be $\partial = 5\%$ .

### 2.2. Symbol Description

**Table 1.** Symbol description

| Symbol | significance | unit |
|---|---|---|
| $a_i i = 1,2,\ldots,240$ | Enterprise order quantity | $m^3$ |
| $b_i i = 1,2,\ldots,240$ | Supplier's supply quantity | $m^3$ |
| $N_1$ | Minimum number of suppliers | number |
| $S_A$ | Matrix of 24 week plan | \ |
| AVE | Matrix of maximum weekly availability of raw materials | \ |
| $\partial_k, k = 1,2,\ldots,24$ | Average loss rate of freight forwarder | % |
| $X_{jk}, j = 1,2,3\ k = 1,2,\ldots,24$ | Total weekly supply of raw materials | $m^3$ |
| $R_{gk}$ | 0-1 plan matrix of supplier selecting freight forwarder | \ |
| T | Cost of business | yuan |
| $P_j, j = 1,2,3$ | Unit price of raw materials | yuan |

## 3. Problem Solving

### 3.1. First Question Solution

#### 3.1.1. Problem Analysis

First divide the suppliers into categories A, B and C according to the materials provided, then calculate the total supply, weekly maximum supply, difference (the difference between order quantity and supply quantity) and other data of each supplier respectively, conduct quantitative analysis on the supply characteristics of all suppliers, set conditions and rank each supplier, so as to draw a conclusion and determine the most important supplier.

### 3.1.2. Model Assumptions

Annex one gives the order quantity and supply quantity data of 402 raw material suppliers in recent 5 years (240 weeks). According to the data, two new indicators are formulated to judge the importance of suppliers.

Let the order quantity of the enterprise be $A_i, j = 1,2,...,240$ .The supply quantity of the supplier is $B_i, i = 1,2,...,240$.

Details of the two new indicators are as follows:

(1)Weekly maximum supply $b_{iMax}, i = 1,2,...,240$

$$b_{iMax} = \max b_i, i = 1,2,...,240 \tag{1}$$

Weekly maximum supply bi *M*ax refers to the largest supply quantity of each supplier in 240 weeks, and then multiple suppliers are selected according to the conditions that the supply quantity may meet the enterprise's weekly production capacity of 28200 cubic meters. The closer the supply quantity is to the production demand, the more qualified these suppliers are.

(2)Supply completion error rate H

$$H = [\sum_{i=1}^{240}(b_i - a_i)] \div 240 \div 100 \tag{2}$$

The supply completion error rate H represents the percentage of the difference between the weekly supply quantity and the enterprise's order quantity of all suppliers in 240 weeks. When the supply completion error rate is smaller, it means that the supply volume of the supplier meets the needs of the enterprise, which can not only avoid the influence of the enterprise on production due to insufficient raw materials, but also avoid the unnecessary loss caused by the enterprise buying too many materials.

### 3.1.3. Conclusion

The specific data are in the supporting materials (table), and it can be concluded that the maximum weekly supply $B_i \leq 2500m^3$, The supply completion error is between - 17 and 17, and the error rate is about 7%. The 50 suppliers that meet the above two constraints are the most important suppliers for the enterprise.

According to the above developed supplier importance comparison model, 50 suppliers are selected as follows:

**Table 2.** 50 most important suppliers

| supplier | supplier | supplier | supplier | supplier | supplier | supplier | supplier | supplier | supplier |
|---|---|---|---|---|---|---|---|---|---|
| S284 | S284 | S284 | S284 | S284 | S284 | S284 | S284 | S284 | S284 |
| S352 | S352 | S352 | S352 | S352 | S352 | S352 | S352 | S352 | S352 |
| S365 | S365 | S365 | S365 | S365 | S365 | S365 | S365 | S365 | S365 |
| S346 | S346 | S346 | S346 | S346 | S346 | S346 | S346 | S346 | S346 |
| S375 | S375 | S375 | S375 | S375 | S375 | S375 | S375 | S375 | S375 |

## 3.2. Solve the Second Question

### 3.2.1. Part One Model Establishment

In this question, only the minimum number of suppliers needs to be determined, then the supplier whose supply quantity can best meet the production needs of the enterprise should be selected. According to the data, the 240 week supply volume of each supplier can be divided into 10 groups, and the periodic changes can be analyzed with 24 weeks as the cycle. The average value of each group corresponding to each week is calculated as the maximum supply quantity of the supplier.

Firstly, the suppliers are divided into categories A, B and C according to the materials provided, including 146 in Category A, 134 in category B and 122 in category C. Take A as an example, make a matrix to represent the maximum weekly supply, which is recorded as $\mathrm{AVE}_{\mathrm{A}(24\times146)}$. The week is represented by rows, a total of 24 rows, and the supplier is represented by columns, a total of 146 columns. You can get:

$$\mathrm{AVE}_{\mathrm{A}(24\times146)} = \begin{pmatrix} 0.3 & \cdots & 1527 \\ \vdots & \ddots & \vdots \\ 0.7 & \cdots & 60.8 \end{pmatrix} \tag{3}$$

Get the same reason: $\mathrm{AVE}_{\mathrm{B}(24\times134)} = \begin{pmatrix} 0 & \cdots & 54 \\ \vdots & \ddots & \vdots \\ 0 & \cdots & 60 \end{pmatrix}$ and $\mathrm{AVE}_{\mathrm{C}(24\times122)} = \begin{pmatrix} 5.4 & \cdots & 0 \\ \vdots & \ddots & \vdots \\ 20.6 & \cdots & 0 \end{pmatrix}$

(1)Decision variables

In this question, the decision variable is only the number of suppliers. Similarly, three matrices $S_A$, $S_B$ and $S_C$ with 24 rows and 146 columns need to be established, that is, 0-1 matrix, where 1 means to select the supplier this week and 0 means not to select the supplier this week.

(2)Objective function

Set the objective function as $N_1$ to represent the minimum number of suppliers, and write the mathematical expression as follows:

$$\mathrm{MinN_i} = \det(\mathrm{S_A}) + \det(\mathrm{S_B}) + \det(\mathrm{S_C}) \tag{4}$$

(3)Constraint condition

Considering that the weekly production capacity of the enterprise is 28200 cubic meters, and it is necessary to ensure that there is no less than two weeks of raw material inventory. Assuming that the inventory in the first week is 0, the segmented expression is as follows:

$$\text{First week:}\left(\frac{\mathrm{S_A}*\mathrm{AVE_A}}{0.6} + \frac{\mathrm{S_B}*\mathrm{AVE_B}}{0.66} + \frac{\mathrm{S_C}*\mathrm{AVE_C}}{0.72}\right) \times \partial \geq 2.82 \times 104\times 2 \tag{5}$$

$$\text{Second to twenty fourth weeks:}\left(\frac{\mathrm{S_A}*\mathrm{AVE_A}}{0.6} + \frac{\mathrm{S_B}*\mathrm{AVE_B}}{0.66} + \frac{\mathrm{S_C}*\mathrm{AVE_C}}{0.72}\right) \times \partial \geq 2.82 \times 104 \tag{6}$$

It should be noted that since the total amount of raw materials A, B and C in the first week has been assumed to be 0 before establishing the model, the enterprise needs to order raw materials from the supplier for two weeks in the first week. In this question, transportation loss can not be considered, but it can not be directly ignored. Therefore, the loss rate of all forwarders is assumed to be $\partial = 5\%$ .

### 3.2.2. Part One Conclusion

According to the 0-1 model developed above, 100 suppliers are selected as follows:

ISSN: 1813-4890

**Table 3.** 100 selected suppliers

| supplier | supplier | supplier | supplier | supplier | supplier | supplier | supplier | supplier | supplier |
|---|---|---|---|---|---|---|---|---|---|
| S218 | S080 | S324 | S075 | S152 | S362 | S358 | S044 | S013 | S296 |
| S247 | S123 | S098 | S213 | S030 | S133 | S301 | S305 | S337 | S349 |
| S365 | S007 | S141 | S067 | S379 | S386 | S026 | S110 | S062 | S397 |
| S031 | S189 | S092 | S342 | S036 | S188 | S351 | S033 | S316 | S052 |
| S374 | S329 | S310 | S318 | S193 | S353 | S225 | S203 | S016 | S180 |
| S294 | S076 | S237 | S149 | S053 | S254 | S122 | S303 | S027 | S120 |
| S306 | S221 | S113 | S253 | S336 | S206 | S264 | S081 | S060 | S116 |
| S268 | S175 | S392 | S216 | S106 | S128 | S383 | S011 | S236 | S132 |
| S275 | S174 | S025 | S178 | S050 | S286 | S321 | S270 | S014 | S255 |
| S005 | S169 | S172 | S256 | S357 | S135 | S298 | S073 | S381 | S377 |

### 3.2.3. Part Two Model Establishment

(1)Decision variables

The most economical situation means to make a 24 week plan with the lowest economic cost. Therefore, it is also necessary to set up three matrices: $S_A$ (24 rows and 146 columns), $S_B$ (24 rows and 134 columns), $S_C$ (24 rows and 122 columns), which is 0-1 matrix. 1 means to select the supplier this week, and 0 means not to select the supplier this week.

Suppose the total weekly supply of raw materials A, B and C is $X_{jk}$, $j = 1,2,3$ $k = 1,2,\ldots,24$.

Take the supply of material a in the first week as an example, write the expression $X_{11}$:

$$X_{11} = S_A * AVE_A \quad (7)$$

(Note: the first row of matrix $S_A$ indicates whether to select the supplier in the first week, and all except the first row are 0. Similarly, the weekly supply of materials A, B and C in 24 weeks can be calculated)

Let the unit price of raw materials A, B and C be $P_j$, $j = 1,2,3$. $P_1 = 1$, $P_2 = 2$.

(2)Objective function

Let the cost required by the enterprise be T. in order to obtain the lowest cost, write the mathematical expression as follows:

$$\text{Min } T = \sum_{\substack{j=1 \\ k=1}}^{3} P_j * X_{jk} \quad (8)$$

(3)Constraint condition

Considering that the weekly production capacity of the enterprise is 28200 cubic meters, and it is necessary to ensure that there is no less than two weeks of raw material inventory. Assuming that the inventory in the first week is 0, the segmented expression is as follows:

$$\text{First week:} \left(\frac{X_{11}}{0.6} + \frac{X_{21}}{0.66} + \frac{X_{31}}{0.72}\right) \times \partial \geq 2.82 \times 104 \times 2 \quad (9)$$

Second to twenty fourth weeks:

$$\left(\frac{X_{1k}}{0.6} + \frac{X_{2k}}{0.66} + \frac{X_{3k}}{0.72}\right) \times \partial \geq 2.82 \times 104, \text{ k=2,3, ...,24} \quad (10)$$

$$AVE_A \leq b_i Max \quad (11)$$

### 3.2.4. Part Three Model Establishment

According to the data, the loss rate of each forwarder for 240 weeks can also be divided into 10 groups, and the periodic change can be analyzed with 24 weeks as the cycle. Calculate the average value of each group corresponding to each week, and take it as the average loss rate of the forwarder, which is recorded as $\partial_k$, $k = 1,2,...,24$. Taking the first week as an example, the loss rate of each forwarder is expressed in 8 rows and 1 column matrix, as follows:

$$\partial_k = \begin{pmatrix} 1.8 \\ \vdots \\ 0.6 \end{pmatrix} \tag{12}$$

(1)Decision variables

According to the conditions established in the previous question, this problem only needs to match the supplier with the forwarder, and add the loss rate to calculate the most economical transshipment order scheme, which can also be regarded as a 0-1 programming problem. Make a $402 * 8$ matrix Rgk to indicate whether the supplier chooses the forwarder, 0 means the supplier chooses the forwarder, and 1 means the supplier does not choose.

It is concluded from the previous question that the most economical situation required by class A means to formulate a 24 weeks plan with the lowest economic cost. Therefore, it is also necessary to establish three matrices: $S_A$ (24 rows and 32 columns), $S_B$ (24 rows and 32 columns), $S_C$ (24 rows and 36 columns), which is 0-1 matrix. 1 means to select the supplier this week, and 0 means not to select the supplier this week.

Suppose the total weekly supply of raw materials A, B and C is $X_{jk}$, $j = 1,2,3$ $k = 1,2,...,24$.

Take the supply of material a in the first week as an example, write the expression $X_{11}$:

$$X_{11} = S_A * AVE_A \tag{13}$$

(Note: the first row of matrix $S_A$ indicates whether to select the supplier in the first week, and all except the first row are 0. Similarly, the weekly supply of materials A, B and C in 24 weeks can be calculated.)

(2)Objective function

Let the cost required by the enterprise be T. in order to obtain the lowest cost, write the mathematical expression as follows:

$$\text{Min } T = \sum_{\substack{j=1 \\ k=1}}^{3} P_j * X_{jk} * \partial_k \tag{14}$$

(3)Constraint condition

Considering that the transportation capacity of each forwarder is 6000 m³ / week, the constraints are as follows:

$$\sum_{g=1}^{100}(Rgk) = 1 \tag{15}$$

$$\begin{pmatrix} AVE_A \\ AVE_B \\ AVE_C \end{pmatrix} \times Rgk \leq \begin{pmatrix} 6000 \\ \vdots \\ 6000 \end{pmatrix} \tag{16}$$

### 3.2.5. The Final Conclusion of the Second Question

Considering the economic cost, the minimum number of suppliers is 100 (shown in Figure 3) by establishing a 0-1 planning model to meet the production demand. At the same time, when considering the following two parts, these 100 suppliers should be preferred. The optimal scheme is calculated by MATLAB, and only 100 of the 402 suppliers are selected (including 32 class a merchants, 32 class B merchants and 36 class C suppliers), which can control the lowest cost on the basis of the least suppliers. Finally, the loss rate calculation needs to be added, and the 0-1 planning is still selected to control the minimum loss in the transfer process. It is not difficult to find that if 24 weeks is taken as the cycle time series, the supply provided by most suppliers also changes periodically, so the operation calculation results are more consistent with the production demand of the enterprise and will not cause large losses to the production of the enterprise.

# 4. Model Analysis

## 4.1. Advantages and Disadvantages of the Model

### 4.1.1. Advantages

1. Adopt linear programming model with unified algorithm and simple model.

2. On the basis of assumptions, the transshipment loss rate is temporarily set as a fixed value, so as to determine the most economical order plan first, and then determine the transshipment scheme with the lowest transshipment loss rate.

### 4.1.2. Disadvantages

1. The amount of data required is large and the amount of calculation is large.

2. Planning constraints can only be applied to linear problems.

3. The consideration of the situation is not comprehensive enough.

### 4.1.3. Sensitivity Analysis

In dealing with the linear programming problem of materials supplied by enterprises, the objective function T (enterprise cost) is generally related to the market conditions such as the ordering demand of enterprises and the supply characteristics of suppliers. Therefore, we select the supplier's supply quantity from multiple variables, change it, and observe the originally established 0-1 programming model. The sensitivity values of the design parameters are uniformly dimensioned to determine the sensitivity order of the parameters to be corrected, so as to test the sensitivity and feasibility of the model.

## 4.2. Promotion and Improvement

Linear programming model is a mathematical model widely used in scientific research, economic management, engineering technology and military operations. However, the linear programming model can only deal with the limitation of linear relationship, which can be improved by genetic algorithm. The application of genetic algorithm can be divided into three parts according to its way, that is, genetic based optimization calculation, genetic based optimization programming and genetic based machine learning. According to the theory of genetic algorithm, the best result is calculated by MATLAB. The optimization algorithm based on the principle of genetics is widely used to solve transportation problems, supply chain network problems and location allocation problems, which will improve the solution speed and wider application range, and can deal with the actual situation of nonlinearity.

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