ISSN: 1813-4890

Enterprise Supplying and Transportation Planning based on Linear Optimization

Yishan Chen, Xinyi Zeng, Yuxuan Zhang and Min Zhao*

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

*cuzmath@126.com

Abstract

We often need to find optimal solutions to practical problems in business production and transportation, and the most common and simpler to use linear programming is often chosen by people. In order to satisfy the need to find the lowest economic cost supplier and forwarder in line with the needs of enterprises, we have established a linear programming model to find the lowest economic cost supplier and forwarder, mainly using the 0-1 planning model to simplify the solution process, aiming to obtain the optimal solution to the supply or transport planning problem based on the complex reality of the situation, satisfying to obtain the enterprise. The problem is a bi-objective planning problem, which is first solved by converting to a single-objective planning model, modeling the objective function as the minimum value of the transshipment loss rate, obtaining the solution with the lowest cost transshipment provider, and finally performing a model sensitivity analysis for all solutions.

Keywords

Linear Optimization; Supply Characteristics Indicators; Supply Completion Error Rate; Optimal Solution.

1. Introduction

In one specific scenario, a manufacturing company has a production schedule of 48 weeks per year and needs to plan 24 weeks in advance for the ordering and forwarding of raw materials. According to the research, the company knows the order quantity and supply quantity of all raw material suppliers for the last 5 years, but in the actual transfer process, there is a certain loss of raw materials (the loss quantity as a percentage of the supply quantity is called "loss rate"), and the actual quantity of raw materials delivered to the company's warehouse by the forwarder is called "received quantity ". At the same time, given the uncertainty of raw materials in practice, suppliers cannot guarantee that they will supply strictly according to the order quantity, and the actual quantity supplied may be more or less than the order quantity.

Supplier selection is an important part of the purchasing decision. The choice of transport mode requires scientific decision making, which is based mainly on the above-mentioned functional relationships in the conditions of the basic principles of transport through the trade-offs of the transport database [1]. For most enterprises, procurement costs account for more than 70% of the total cost of the product. A reasonable choice of supplier will have a direct impact on reducing costs, increasing flexibility and improving the competitiveness of the enterprise [2].

We will consider optimization solutions from a cost perspective. Optimization methods are the product of combining mathematical models with applied science and technology and mainly include linear programming methods, optimization under constraints, optimization without constraints, quadratic programming under linear constraints, discrete programming optimization, integer programming optimization and multi-objective programming

ISSN: 1813-4890

optimization. This leads to the development of new ordering solutions and transit solutions and the analysis of the effectiveness of their implementation [3,4,5].

2. Model Building and Solving

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. Assume that the enterprise has to maintain an inventory of raw materials that is not less than two weeks to meet its production needs, i.e., it needs to hold the current week's and next week's production requirements.

3. Assume that the company's order quantity can be equal to or slightly exceed the actual required supply quantity.

2.2. Description of Symbols

Table 1. Symbol description

Symbol	significance	unit
$a_i, i = 1,2,\ldots,240$	The order quantity of the enterprise	m^3
$b_i, i = 1,2,\ldots,240$	The supplier's availability	m^3
S_A, S_B, S_C	Matrices indicating the 24-week plans with the lowest raw material costs for A, B and C, respectively	\
AVE_A	Matrix of maximum weekly availability of raw materials	\
N_1	Minimum number of suppliers	number
$\partial_k, k = 1,2,\ldots,24$	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}	The decision variables remain the total weekly deliveries of raw materials A, B and C and the 0-1 planning matrix of the suppliers' choice of forwarders	\
T	Costs required by the business	yuan
$P_j, j = 1,2,3$	The unit prices of raw materials A, B and C	yuan

2.3. Model Solving

2.3.1. Problem Analysis

According to the meaning of the question here becomes a dual-objective planning, generally by switching to a single-objective planning model to solve, in determining the class A material more, less class C material, while selecting the transfer loss rate less than the transfer agent, then the loss of the least set as the objective function to solve.

2.3.2. Model Assumptions

According to the meaning of the question here becomes a dual-objective planning, generally by switching to a single-objective planning model to solve, in determining the class A material more, less class C material, while selecting the transfer loss rate less than the transfer agent, First, the suppliers are divided into A, B and C categories according to the materials provided, of which there 146 class A, 134 class B and 122 class C. Take A as an example, make a matrix to indicate the highest weekly supply, noted as $AVE_{A(24*146)}$, the week is expressed in rows, a total of 24 rows, suppliers are expressed in columns, a total 146 of columns, can be obtained.

$$AVE_{A(24*146)} = \begin{pmatrix} 0.3 & \cdots & 1527 \\ \vdots & \ddots & \vdots \\ 0.7 & \cdots & 60.8 \end{pmatrix} \tag{1}$$

Similarly, we get: $AVE_{B(24*134)} = \begin{pmatrix} 0 & \cdots & 54 \\ \vdots & \ddots & \vdots \\ 0 & \cdots & 60 \end{pmatrix}$ and $AVE_{C(24*122)} = \begin{pmatrix} 5.4 & \cdots & 0 \\ \vdots & \ddots & \vdots \\ 20.6 & \cdots & 0 \end{pmatrix}$

(1) Decision-making variables

The most economical case means that the 24-week plan with the lowest economic cost is developed, so 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), that is, a 0-1 matrix, 1 means that the supplier is selected this week, and 0 means that the supplier is not selected this week.

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

Using the first week's supply of material A as an example, write the X_{11} expression.

$$X_{11} = S_A \times AVE_A \tag{2}$$

(p.s.: The first row of matrix S_A indicates whether the supplier is selected in the first week, except for the first row of all 0. Similarly, we can calculate the weekly supply of A, B, C three materials for 24 weeks)

Let the unit prices of three raw materials of A, B and C be P_j, $j = 1,2,3$, where $P_1 = 1.2$, $P_2 = 1.1$ and $P_3 = 1.2$.

(2) Objective function

Let the cost required by the firm be T. To find the lowest cost, write the mathematical expression as follows.

$$\text{Min } T = \sum_{j=1}^{3}(P_j \times \sum_{k=1}^{24} X_{jk}) \tag{3}$$

Since the plan needs to purchase as much raw material of category A and as little raw material of category C as possible, we can try to assign weights, where we set the weight of category A to 100 and the weight of category C to 1, we have the following mathematical expression:

$$\text{Max } T = \sum_{j=1}^{3}(P_j \times \sum_{k=1}^{24} X_{jk}) \tag{4}$$

$$\text{Max } b_i = 100 \times \sum_{i=1}^{146}(S_A) + 1 \times \sum_{i=1}^{122}(S_C) \tag{5}$$

(3) Constraints

Considering constraints such as a transportation capacity of 6000 m^3/week for each forwarder, write the constraints as follows.

$$\sum_{g=1}^{100}(Rgk) = 1 \tag{6}$$

$$\begin{pmatrix} AVE_A \\ AVE_B \\ AVE_C \end{pmatrix} \times Rgk \le \begin{pmatrix} 6000 \\ \vdots \\ 6000 \end{pmatrix} \tag{7}$$

2.3.3. Conclusion

In this model, the loss rate is taken as 5% to meet the production demand and try to assign weights, where the weight of class A is set to 100 and the weight of class C is 1. The results are obtained after running the program, and the procurement cost is significantly reduced compared with the random selection results. From 8 forwarders with average loss rate and standard deviation as the basis of comparison, 5 were selected as cooperative enterprises to meet the transportation demand and cost reduction.

3. Conclusion

3.1. Model Advantages and Disadvantages

3.1.1. Advantages

1. Using a linear programming model with a uniform algorithm and a relatively simple model.
2. The transshipment loss rate is temporarily set to a constant value on the basis of assumptions, thus determining the most economical ordering plan first and then the transshipment solution with the lowest transshipment loss rate.

3.1.2. Disadvantages

1. Being demanding in terms of the amount of data required and computationally intensive.
2. Planning constraints can only be applied to linear problems.
3. The situation is not considered comprehensively enough.

3.2. Sensitivity Analysis

In a linear programming problem dealing with the supply of materials to a firm, the objective function T (firm cost) is generally related to the market conditions such as the firm's own order demand and the supplier's supply characteristics. Therefore, we test the sensitivity and feasibility of the model by selecting the supplier's supply among several variables, changing them, and observing the originally established 0-1 planning model.

Since the objective function Min T $=\sum_{\substack{j=1\\k=1}}^{3} P_j \times X_{jk} \times \partial_k$, when the supplier's supply quantity X_{jk} is changed, when the summation operation is performed again, and according to the data in the table, it can also be concluded that there is a cyclical change in the supplier's supply, T will change greatly, which will affect the enterprise ordering planning.

3.3. Promotion and Improvement

The linear programming model is one of the methods to obtain static optimal mathematical planning in a decision-making system, which is widely applicable and can also be applied to military command, engineering construction, etc.

However, it is undeniable that the linear programming model has some limitations because it can only deal with linear relations, so if it needs to be improved, genetic algorithms can be used. The applied research of genetic algorithms is richer than the theoretical research and has penetrated into many disciplines. The applications of genetic algorithms can be divided into three major parts according to their modalities, namely, genetic-based optimization computation, genetic-based optimization programming, and genetic-based machine learning. By drawing on the principles of genetics, optimization algorithms are widely used to solve transportation problems, supply chain network problems, and site-selection and allocation problems, which will increase the speed of solution and have a wider range o f applications to deal with nonlinear practical situations.

References

[1] Hu, Songzhuan. A decision model for transportation mode selection [J]. Logistics Science and Technology, 2002(02):6-10.

[2] Liu Xiao, Li Haiyue, Wang Chengen, Chu Chengbin. A review of supplier selection models and methods [J]. DOI:10.16381/j.cnki.issn1003-207x.2004.01.025.

[3] Han JY, Huang HX. Optimization methods [M]. Beijing: Tsinghua University Press, 2004.

[4] Suo, Jin-Long, Wen, Ren-Kai. Linear programming theory and model applications [M]. Beijing: Science Press 2003.

[5] Chen, Qiu-Lian, Wang, Cheng-Dong. Optimization computation based on Matlab genetic algorithm toolbox [J]. Modern Electronics Technology,2007(02):124-126+129.DOI:10.16652/j.issn.1004-373x. 2007.02.042.