Raw Material Ordering Model of Production Company Based on 0-1 Programming

Zihan Wang, Yu Sun

College of Maths, Hangzhou Normal University, Hangzhou 311121, China.

Abstract: In this paper, a comprehensive evaluation model is established for the ordering and transportation of raw materials in production enterprises. Topsis method is used to help production companies choose suppliers. A multi-objective programming model for ordering and transportation of raw materials is established according to production requirements to obtain the best solution. For the evaluation and selection of the first supplier, we preprocessed the supplier's historical supply and order data, and then made a quantitative analysis of the supply characteristics. After normalization, we established the supplier evaluation model by using Topsis method, and obtained the 50 most suitable suppliers for cooperation. Based on the in-depth analysis of the production demand of the production company in Question 2, the 0-1 planning model is established to determine the minimum number of suppliers in line with the reality, considering the practicability, economy and transportation security of production. Finally, we evaluate, optimize and promote the model.

Keywords: Ideal Number Method; Entropy Method; 0-1 Planning Model; Multi- Objective Programming Model

1. Restatement and analysis of the problem

1.1 Restatement of issues

A manufacturer needs to order A, B and C raw materials to meet its 48-week production capacity of 28,200 cubic meters per week, and it needs to make A 24-week raw material ordering and transfer plan in advance. The enterprise needs 0.6 cubic meters of raw materials A, or 0.66 cubic meters of raw materials B, or 0.72 cubic meters of raw materials C to produce each cubic meter of product. Considering the special circumstances and actual losses in transit, as well as raw material procurement costs, we need to take 402 suppliers into consideration.

Problem 1: Analyze the supply characteristics of all suppliers, establish a comprehensive evaluation system, and determine 50 suppliers.

Problem two: on the basis of problem one, establish the model of the minimum number of suppliers to meet the demand of production.

1.2 Problem Analysis

In question 1， problem is to establish a comprehensive evaluation system and quantitatively analyze the supply characteristics. The main ideas are as follows: data preprocessing, selection of determined indicators and establishment of Topsis model.

In question 2, the planning and optimization model is established, 0-1 integer programming is adopted, 50 suppliers selected in Question 1 are considered, the minimum number of suppliers is taken as the objective function, constraint conditions are constructed according to the question, and the solution is obtained.

2. Model establishment, solution and analysis

2.1 Establishment and solution of supplier evaluation model based on ideal number method

2.1.1 Establishment and solution of Topsis model

The supply characteristics of each supplier were determined by the annual order quantity, the mean quantity of supply and the guarantee rate of each supplier, Topsis model was established, and the weight was calculated by entropy weight method to select the best 50 suppliers.

(1) The canonical decision matrix is obtained by vector programming

Let the decision matrix of multi-attribute decision making problem $A=(a_{ij})_{m\times n}$, normalized decision matrix $B=(b_{ij})_{m\times n}$, where

$$b_{ij}=a_{ij}/\sqrt{\sum_{i=1}^{m} a_{ij}{}^{2}}, i=1,2,\cdots m; j=1,2,\cdots n$$

(2) Weight is calculated by information entropy method

$$E=-\frac{1}{Lnn}\sum_{i=1}^{n} a_i Lna_i$$

The bigger E is, the smaller the weight is.

The weight of total order quantity, total supply quantity and guarantee rate is E=(0.4860218，0.4718823，0.0420959)。

(3) Determine the positive ideal solution C^* and the negative ideal solution C^0.

Let the j^{th} attribute value of the positive ideal solution be c_j^*, and the j^{th} attribute value of the negative ideal solution be c_j^0, then

positive ideal solution $c_j^*=\begin{cases} \max_i c_{ij}, j \text{ is the benefit attribute,} \\ \min_i c_{ij}, j \text{ is the cost attribute,} \end{cases} \quad j=1,2,\cdots n$

negative ideal solution $c_j^0=\begin{cases} \min_i c_{ij}, j \text{ is the benefit attribute,} \\ \max_i c_{ij}, j \text{ is the cost attribute,} \end{cases} \quad j=1,2,\cdots n$

We found positive ideal solutions for three different indices $c_j^*=\sqrt{\sum_{j=1}^{n}(c_{ij}-c_j^*)^2}=$

$[0.039303509，0.041373444，0.000433828]$;

negative ideal solution $c_j^0=\sqrt{\sum_{j=1}^{n}(c_{ij}-c_j^0)^2}=[1.118569e-05，7.223753e-06，3.764641e-06]$。

(4) Calculate the distance between each scheme and the positive ideal solution and the negative ideal solution, construct the optimal and the worst solution and make an evaluation

The distance between alternative supplier and positive ideal solution is $s_i^*=\sqrt{\sum_{j=1}^{n}(c_{ij}-c_j^*)^2}, i=1,2,\cdots m$;

The distance between the alternative supplier and the negative ideal solution is $s_i^0=\sqrt{\sum_{j=1}^{n}(c_{ij}-c_j^0)^2}, i=1,2,\cdots m$;

(5) Calculate the comprehensive evaluation index of each scheme $f_i^*=s_i^0/(s_i^0+s_i^*), i=1,2,\cdots m$

Arrange supplier selection in order of f_i^* size.

The distance between each scheme and the positive ideal solution and the negative ideal solution was calculated. Finally, the comprehensive evaluation index was calculated according to the distance. Finally, the ID of 50 suppliers can be obtained

2.2 Problem two: construct order raw material scheme

For question 2, 0-1 model should be established, and then dual-objective programming model should be established, which should be considered comprehensively from procurement, transportation and storage.

2.2.1 Objective programming model based on 0-1 integer programming

From the perspective of "minimum supplier", there is the following analysis:

Step 1 Construct the objective function

From the 50 suppliers selected in question 1, select as few suppliers as possible to meet the production requirements, and construct the following objective function:

$$\min \sum_{i=1}^{50} x_{ij}$$

$$x_{ij} = \begin{cases} 0(\text{I Supplier is not available in week J}) \\ 1(\text{I Supplier is available in week J}) \end{cases}$$

x_{ij}Represents whether the ith supplier in the selected 50 suppliers supplies in week j.

In order to meet the production needs of each week, the maximum number of minimum suppliers for each week is finally solved.

Step 2 Construction constraints

1. Supply capacity of suppliers

In order to reduce the deviation, we need to study the periodicity and practicability, define buffer parameter B, B$\epsilon(0,1)$,stable supply capacity = maximum supply capacity ×B, and get B=0.1 through periodicity.

2. Storage capacity of the production company

Production company need to store two weeks production of raw materials, the raw material production enterprises in the first week of j with the first j - 1 week the rest of the raw materials inventory shall not be less than the sum of the enterprise quantity of materials required for the first week of j capacity, and to meet production needs for two weeks, to this, we will receive the corresponding conversion capacity and the quantity of inventory of raw materials:

$$\sum_{i=1}^{50} x_{ij} S_{ij} (1 - L_{ij}) f_{t_i} + R_{j-1} = P + S_{2w}$$

Where, $f_{t_i}$is the conversion function to convert the received and stored raw materials into production capacity. For class A materials,, $f_{t_i} = \frac{1}{0.6}$,for Class B materials, $f_{t_i} = \frac{1}{0.66}$,and for Class C materials,. $f_{t_i} = \frac{1}{0.72}$, S_{ij} Represents the supply quantity of the i^{th} supplier in week J, L_{ij} represents the loss rate of the ith supplier in the turnover process of week J, $R_j$represents the remaining stock of the enterprise in week J converted into energy production, p represents the capacity of the enterprise every week, S_{2w} represents the stock of raw materials to meet the production demand of the enterprise in two weeks.

So there is $S_{2w} = 2P$

In addition, the inventory surplus has the following iterative relationship:

$$\begin{cases} R_1 = \sum_i^{50} x_{i1} S_{i1} (1 - L_{i1}) f_{t_i} + R_0 - P \\ \vdots \\ R_{j-1} = \sum_i^{50} x_{i(j-1)} S_{i(j-1)} (1 - L_{i(j-1)}) f_{t_i} + R_{j-2} - P \\ R_j = \sum_i^{50} x_{ij} S_{ij} (1 - L_{ij}) f_{t_i} + R_{j-1} - P \end{cases}$$

Since two weeks of production needs to be prepared in advance, let's say the initial inventory of the enterprise is 56,400.

3. Transportation capacity of shippers

Take 24 weeks as the cycle, consider the average loss rate of goods in the transit process, namely, the average loss rate of 10 cycles:

$$L_{ij} = \bar{L} = \frac{\sum_{k=1}^{10} l_{ij}^{(k)}}{10}$$

Based on the above objective functions and constraints, this model is established as follows:

$$\min \sum_{i=1}^{50} x_{ij}$$

$$\text{s.t.}\begin{cases} \sum_{i=1}^{50} x_{ij} S_{ij}(1 - L_{ij}) f_{t_i} + R_{j-1} = P + S_{2w} \\ R_{j-1} = \sum_{i}^{50} x_{i(j-1)} S_{i(j-1)} (1 - L_{i(j-1)}) f_{t_i} + R_{j-2} - P \\ L_{ij} = \bar{L} = \frac{\sum_{k=1}^{10} l_{ij}^{(k)}}{10} \\ S_{2w} = 2P \\ R_0 = S_{2w} \\ S_{ij} = B \times \text{Maximum supply capacity} \end{cases}$$

2.2.2 Solution of 0-1 integer programming model

In order to cooperate with the least suppliers as much as possible, based on the mathematical model of 0-1 programming, Matlab software was used to solve and the minimum number of suppliers that met the production conditions was 45.

3. Model innovation and extension

The first model is to improve Topsis model with the help of entropy weight method. Its core idea is to approximate the ordering method of ideal solutions, which can accurately reflect the gap between evaluation schemes when solving comprehensive evaluation problems. Topsis can also be applied to the overall evaluation of Topsis medical institutions, such as the evaluation of the quality of health supervision in public places, which has popularization significance.

0-1 programming and integer programming can be used in single-objective, multi-objective programming and other kinds of programming, and play an important role in solving comprehensive evaluation problems, such as merchant selection, but most of them can only solve linear problems. For the model in this paper, the memory neural network model can be added to predict the supply characteristics of subsequent suppliers to optimize the model and test the results.

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