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Ordering and transportation decision based on single objective and multi-objective programming

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Abstract: Aiming at the decision-making problem of ordering and transportation of raw materials in production enterprises, based on the comprehensive evaluation of suppliers, this paper establishes a mathematical model, gives the most economical ordering scheme and the transportation scheme with less loss rate for enterprises. Firstly, a hierarchical model is constructed to select the top 50 most important suppliers through the importance rating ranking.Since the consumption of each type of raw materials is different, an objective function is constructed to meet the production demand, and it is calculated that at least 23 suppliers are required to supply.On this basis, the single objective programming is constructed, from which the most economical order scheme can be formulated.

1. Establishment and solution of model

1.1 Hierarchical model

(1) According to the data processing results, a hierarchical model is established

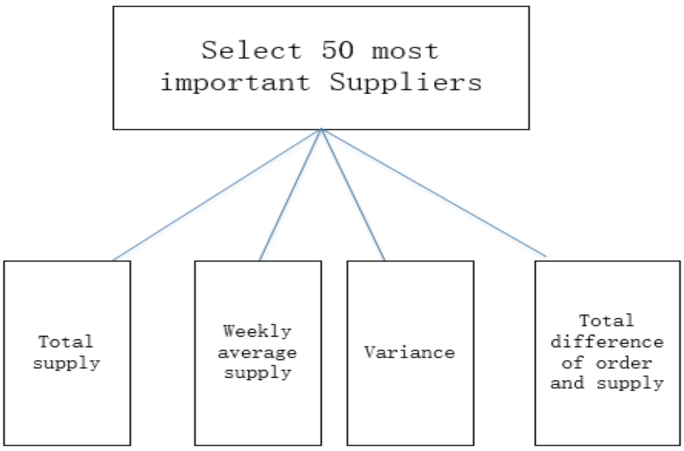

Figure 1: Hierarchy model

(2) The judgment matrix is constructed, and the paired comparison matrix is established by

comparing the factors.That is, select factors x_i and x_j each time ,and $a_{i,j}$ represents the ratio of x_i and x_j to one factor.According to the meaning of scale, weigh the mutual importance of the four criteria, and list the relevant judgment matrix.

1. The consistency of the judgment matrix is tested, According to the consistency matrix, one eigenvalue $\lambda_{max}$is = n, the other eigenvalues are 0, and when the eigenvalue of the matrix is n, the corresponding eigenvector is:

$$k[\frac{1}{a_{12}},\ldots,\frac{1}{a_{1n}}]^T, (k \neq 0) \quad (1)$$

Calculate consistency index CI and the consistency ratio CR:

$$CI = \frac{\lambda_{max} - n}{n-1} \quad (2)$$

$$CR = CI/RI \quad (3)$$

Because the calculation result CR = 0.0191 < 0.10, the judgment matrix is acceptable

2. The weight can be obtained by normalizing the obtained feature vector.

Table 1: Weight of each criterion

Guideline B	Total supply	Weekly average supply	variance	Total order difference
Weight e	0.5462	0.0838	0.1377	0.2323

In the idea of linear weighting, the score g of each supplier is calculated according to the weight. Because the variance is the deviation degree of the research data, that is, the smaller the value, the more stable it is.

$$G = B_1 \times e_1 + B_2 \times e_2 - B_3 \times e_3 + B_4 \times e_4 \quad (4)$$

Get the top 50 suppliers according to the score.

1.2 Objective planning model

(1) Build 0-1 planning model to find the most economical number of suppliers

Record decision variables $i = 1,2,3,\ldots,50$, 50 suppliers respectively;Note that class A, class B and class C raw materials are j = 1, 2 and 3 respectively.Introducing 0-1 variables $x_{i,j}$, if a supplier I supplies J raw materials, record $x_{i,j}$ =1. Otherwise, record $x_{i,j}$ =0,So Minx= $\sum_{i=1}^{50}\sum_{j=1}^{3} x_{ij}$ is the objective function of the problem.

According to the requirements of production, x_{ij} Constraints should be met:

$$\sum_{i=1}^{50} C_{i1}\, x_{i1}/0.6 + \sum_{i=1}^{50} C_{i2}\, x_{i2}/0.66 + \sum_{i=1}^{50} C_{i3}\, x_{i3}/0.72 \geq 28200/(1 - S_{min}) \quad (5)$$

Where C_{ij}(i=1,2...50, j=1,2,3) is the weekly average supply, S_{min} Is the sum of the minimum weekly loss rates.

The first mock exam is subdivided into the model and the 0-1 table obtained by lingo is used to select MinX=23 suppliers to supply raw materials to meet production needs.

Table 2: Weekly average quantity supplied by suppliers

supplier	Weekly average Supply quantity	supplier	Weekly average supply	supplier	Weekly average supply
S005	28.80	S216	1.77	S294	78.51
S007	28.95	S218	64.51	S306	525.40
S031	171.70	S247	236.24	S310	1.69
S080	80.15	S266	27.16	S324	1.77
S098	1.72	S268	540.78	S329	652.16
S123	26.87	S275	660.64	S365	173.46
S141	1.75	S282	705.58	S392	1.72
S189	37.05	S284	194.15		

(2) Making the most economical ordering plan can be divided into two steps

① According to the supplier's 240 week weekly supply, a time series model can be established, and the broken line chart can be predicted by curve fitting method. By observing the peak value of the broken line chart, it is estimated that the supply period is 24 weeks.The weighted moving average method is used to predict the supply in the next 24 weeks.

Set the time series as y_1, y_2,...,y_t,...; The weighted moving average formula is:

$$M_{tw} = \frac{w_1 y_t + w_2 y_2 + \cdots + w_N y_{t-N+1}}{w_1 + w_2 + \cdots + w_N}, t \geq N \tag{6}$$

Where M_{tw} is the weighted moving average of T period; w_i is the weight, which reflects the corresponding y_t importance in the weighted average.The weighted moving average is used for prediction, and the prediction formula is:

$$\hat{y}_{t+1} = M_{tw} \tag{7}$$

② Constructing single objective programming model

Let the quantity of class a ordered per week be V_1, the purchase unit price is m_1, the quantity of class B ordered per week is V_2, the purchase unit price is m_2, the quantity of class C ordered per week is V_3, the purchase unit price is m_3.

In order to ensure the most economical ordering scheme, the total weekly ordering amount is set as W_i(i=1,2,...,24), the objective function is easily obtained:

$$\text{Min}W_i=\sum_{i=1}^{3}\sum_{j=1}^{24} V_{ji} * m_i \tag{8}$$

To meet production requirements:

$$V_1/0.6+V_2/0.66+V_3/0.72=28200 \tag{9}$$

The purchase unit price of class III raw materials shall meet the following requirements:

$$m_1=120\%m_3 \ , \ m_2=110\%\text{m3} \tag{10}$$

By predicting the supply data in the next 24, the total weekly supply of every class are calculated by Excel .The ratio of weekly supply of class A to the total output value of class A is calculated through the predicted value and recorded as β_{1i}(i=1,2,...,24), the ratio of weekly supply of class B to the total output value of class B is recorded as β_{2i}(i=1,2,...,24), the ratio of weekly supply of class C to the total output value of class C is recorded as β_{3i}(i=1,2,...,24).

Then the weekly order quantity of each type can be got:

$$O_{ji}=\beta_{ji}*V_{ji}(\ j=1,2,3,\ \ i=1,2,...,24\ ) \quad (11)$$

Calculate the results with Excel.

(3) Develop a transfer plan with the least loss

Since there are many optional items and there are 8 options, there are 28-1 combinations, which is very time-consuming and laborious to list one by one. [5] Therefore, build a 0-1 planning model.

The average loss rate per week calculated according to Appendix 2 is$t_i(i = 1,2,3...,8)$

Table 3: Weekly average loss rate

Forwarder ID	Weekly average loss rate
T1	1.9048
T2	0.9214
T3	0.1861
T4	1.5705
T5	2.8898
T6	0.5438
T7	2.0788
T8	1.0103

Record decision variables $i = 1,2,3...,8$,8 Forwarders respectively; 23 suppliers $S_j(j = 1,2,...,23)$. Introducing 0-1 variablesx_{ij}, if a forwarder I transfers J supplier's raw materials, record x_{ij}=1. Otherwise, recordx_{ij}=0, then build the objective function: Min G = $\sum_{i=1}^{8}\sum_{j=1}^{23} t_i * y_{iz} * x_{ij}$

The constraints of the model are:

$$\sum_{i=1}^{8} x_{ij} = 1;\ \sum_{i}^{8}\sum_{j=1}^{23} y_{i\,z} \le 6000 \quad (12)$$

Import the data into LINGO to obtain the 0-1 matrix, and formulate the transportation scheme with the least loss through the matrix.

1.3 Analysis and test of decision implementation effect

As the weighted moving average method is used to analyze the supply in the next 24 weeks, there is an error in the predicted value. Therefore, the ordering scheme and transshipment scheme are ideal, and the error is not considered.

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