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Capital Turnover Model Based on Genetic Algorithm and Multi-objective Programming

Yiming Zhao, Yunjing Zhang, Yuxiang Zhang

Qingdao Institute of Software, School of Computer Science and Technology, China University of Petroleum, Qingdao, China

Abstract: *A capital turnover model is established and three main problems are solved. First, select the suppliers that guarantee the production of the enterprise at least as much as needed. Second, develop the most economical material ordering scheme and conduct the scheme analysis. Third, develop the lowest loss material transfer scheme and conduct the scheme analysis. All three problems are planning problems. First, we construct a 0-1 planning model. Then, based on the principle of the lowest total purchase price, we build an objective planning model for the ordering scheme, obtain the most economical ordering scheme by genetic algorithm, and compare it with the least economical scheme and random scheme. Moreover, following the principle of lowest transit loss, we build an objective planning model of transportation scheme based on the most economical ordering solution and compare and analyze with the solution with the highest loss and random solution.*

Keywords: *0-1 Planning; Genetic Algorithm; Goal Planning*

1. Introduction

Firstly, we select the minimum number of suppliers needed to secure production for the business based on the results of the evaluation. Then, we develop the most economical ordering scheme for the materials and the transfer scheme with the least losses and the ordering and transfer schemes are analyzed. The model is divided into the following three steps.

(1) Select the least number of suppliers to meet the demand as the goal and construct a 0-1 objective planning model.

(2) A weekly ordering scheme is modeled to minimize the total purchase price. The effect of the implementation of the ordering scheme is analyzed.

(3) A weekly transfer scheme is modeled to minimize losses. The effectiveness of the implementation of the transfer scheme is analyzed.

2. Model Establishment and Solution

2.1. 0-1 Planning Model for Selecting Suppliers

2.1.1. Objective Function

Introduce the 0-1 variable p_i, i for a supplier. When supplier i is not selected, p_i equals zero. And when the supplier i is selected, p_i equals one. To select the least number of suppliers to guarantee the production of the enterprise, the decision variables are obtained as:

$$\min \sum_{i=1}^{N_A} p_i + \sum_{i=1}^{N_B} p_i + \sum_{i=1}^{N_C} p_i \tag{1}$$

Among them, N_A, N_B, N_C are the number of suppliers who provide A, B, and C materials respectively.

2.1.2. Constraint

(1) Maintain a material inventory of not less than two weeks of production demand as much as possible. When ordering in the first week, the company needs to order two weeks' worth, and after that, the company only needs to order one week's worth of materials. Considering the total amount of products

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produced from materials A, B, and C, the quantity needs to meet the two-week production capacity. Assume here that the attrition rate is 1.5%.

$$(1-1.5\%)(q_A/0.6+q_B/0.66+q_C/0.72)\geq 5.64\times 10^4 \tag{2}$$

Where q_A, q_B, and q_C indicate the supply of materials of A, B, and C respectively.

(2) The order quantity of material A, B, C is obtained by summing up the maximum supply quantity of all the selected suppliers of material A, B, C.

$$q_A=\sum_{i=1}^{N_A} M_i\, p_i, q_B=\sum_{i=1}^{N_B} M_i\, p_i, q_C=\sum_{i=1}^{N_C} M_i\, p_i \tag{3}$$

Where M_i represents the maximum quantity of supplier i.

(3) The total quantity of material A, B, C (q_A, q_B, q_C) cannot exceed the sum of the maximum supply quantities of all suppliers providing material A, B, C.

$$0\leq q_A\leq 7392, 0\leq q_B\leq 20030, 0\leq q_C\leq 10219 \tag{4}$$

2.1.3. Calculation Results

We calculate that at least 9 suppliers are required to guarantee the production needs of the company.

2.2. Goal Planning Model for Ordering Program

2.2.1. Objective Function

Assume that the unit price of materials of A, B, C is 1, 1.2, 1.1 units respectively. The objective is to make the lowest total purchase price (w).

$$\min w=1.2q_A+1.1q_B+q_C \tag{5}$$

The supply quantity of each supplier $q_i=a_i q_l\leq M_i$, l=A, B, C. After finding q_A, q_B, q_C, according to each percentage of the supplier (a_i) given specifically by constraint (4) below, we can give the supply quantity of each supplier, i.e., the company's order quantity from each supplier.

2.2.2. Constraint

(1) Keep as much material in stock as possible for not less than two weeks of production needs. When ordering in the first week, the company needs to order two weeks' worth of quantity, and after that, the company only needs to order one week's worth of materials, where the attrition rate is assumed to be 1.5%.

$$(1-1.5\%)(q_A/0.6+q_B/0.66+q_C/0.72)\geq N \tag{6}$$

N=5.64×10^4 for the first week and N=2.82×10^4 for other weeks.

(2) Total amount of materials A, B, and C.

(3) Same as the constraint (3) in 2.1.2.

(4) The supply quantity of a supplier cannot exceed its maximum supply quantity.

$$q_i=a_i q_l\leq M_i, l=A,B,C \tag{7}$$

$$a_i=h_i/(h_i+h_{i-}+h_{i+}), h_i=\sum\nolimits_{y=1}^{5} m_{iy} \tag{8}$$

h_i denotes the total supply quantity of supplier i in the same week of the recent 5 years. h_{i-}, h_{i+} denotes the total supply quantity of two suppliers of the same category of materials as supplier i in the same week of the recent 5 years. m_{iy} denotes the supply quantity of supplier i in a week of the yth year.

2.2.3. Calculation Results

The genetic algorithm [3] is used to solve the problem, and the parameters of the solution process are shown in Table .

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Table 1: Parameters in the solution process of genetic algorithm

Population size	Maximum number of evolutions	Differential Evolution in Parameters	Reorganization probability	Target dimension	Decision Variables
100	500	0.5	0.4	1	3

The average objective function value of the population individuals and the change in the objective function value of the optimal individual solved by the genetic algorithm are shown in Figure 1.

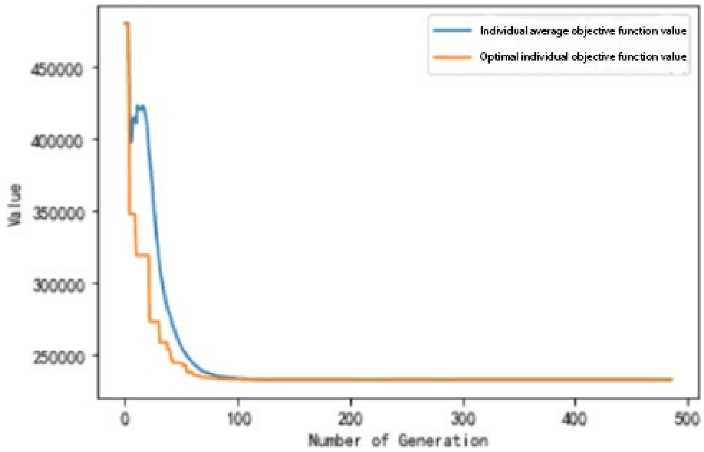

Figure 1: The average and optimal individual objective function value

2.2.4. Analysis of the Effect of Ordering Program Implementation

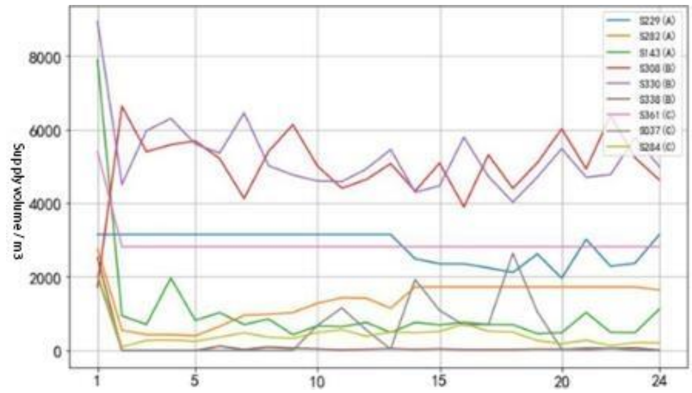

Figure 2: Ordering plans

Visualize the ordering scheme to obtain Figure 2. We can see that the order quantity of S229 has been more stable among material A, the order quantity of S338 has been less stable among material B, and the order quantity of S361 has been more stable among the material C.

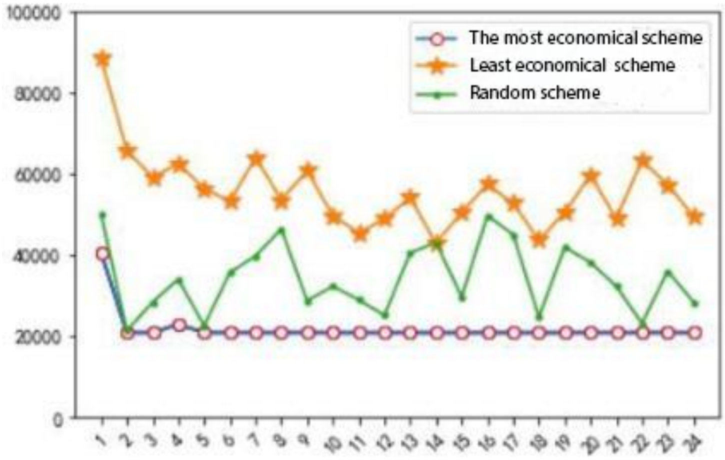

Figure 3: Comparison of the three ordering options

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Visualize the most economical ordering scheme, the least economical ordering scheme, and the random ordering scheme to obtain Fig, where the horizontal axis represents the number of weeks and the vertical axis represents the total purchase price. It can be seen that the total purchase price is higher in the first week and stabilizes in the end. This is because two weeks of materials need to be purchased in the first week. The least economical ordering scheme is calculated by replacing the weekly maximum order with the order of other suppliers for the week. Then a random set of material ordering schemes is generated according to the constraints, and it can be seen that the randomly generated set of ordering schemes is not better than the most economical scheme. In summary, the ordering scheme obtained in this paper is the most economical.

2.3. Goal Planning Model for Transportation Scheme

The objective is to minimize the loss.

$$\min \sum_{i=1}^{8} s_i z_i \, , s_i = \sum_{y=1}^{5} s_{iy} /5 \tag{9}$$

where z_i denotes the volume by transshipment agent i in a given week, and s_i denotes the loss rate of transshipment agent i in a given week, averaged by the loss rate of transshipment agent in the same week of each year. s_{iy} denotes the attrition rate of transshipment agents in the same week of the yth year.

The constraint is $0 \le z_i \le 6000$.

Visualize the maximum loss transfer scheme, the minimum loss transfer scheme, and the random scheme loss in Figure4, where the horizontal axis represents the number of weeks and the vertical axis represents the number of losses. The loss finally stabilizes. Then a random set of material transfer schemes is generated according to the constraints, and it can be seen that the randomly generated set of transfer schemes is not better than the minimum loss transfer scheme.

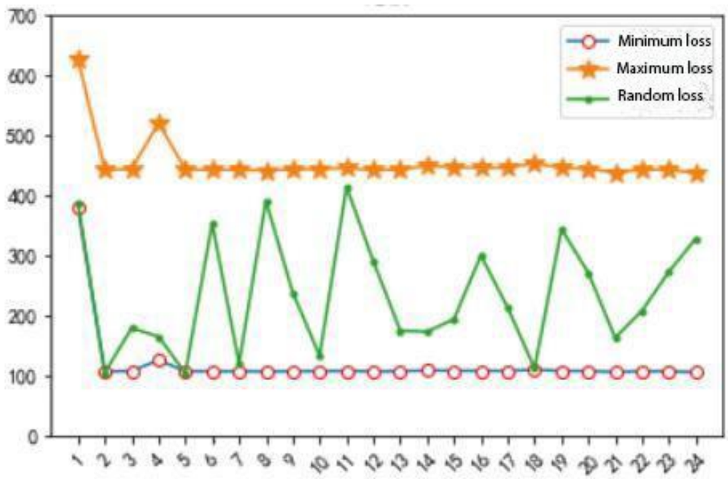

Figure 4: Comparison of the three ordering options

In calculating the maximum loss, for each week, all the transshipment volumes in the obtained transshipment scheme are summed up and then the maximum loss is calculated as a unit of 6000 m^3 to be transferred by the forwarder with a high loss rate respectively, and the forwarders are sorted by the loss rate from highest to lowest. The maximum loss is calculated. It can be seen that the maximum loss is always the largest in the scheme.

References

[1] Hu YH. Improvement of TOPSIS method for comprehensive evaluation[J]. Mathematical Practice and Understanding, 322002, (4): 572-575.
[2] Ni Jiupai, Li Ping, Wei Chaofu, et al. Evaluation of regional land development potential based on AHP and entropy weighting method [J]. Journal of Agricultural Engineering, 2009, 025(005): 202-209.
[3] Ji Genlin. A review of genetic algorithm research [J]. Computer Applications and Software, 212004, (2): 69-73.