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Research on Raw Material Ordering and Transportation Model Based on Multi-objective Programming and ARIMA

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Abstract: *This paper studies the decision-making problem of raw material ordering and transportation in production enterprises, and establishes the optimal procurement scheme and optimal transportation scheme for production enterprises under different conditions based on genetic algorithm and multi-objective programming. Firstly, five factors affecting the company's decision-making are summarized; Secondly, the analytic hierarchy process (AHP) is used to determine the weight of each impact evaluation factor, and then the comprehensive effect measure matrix is obtained by combining with the multi-objective grey target decision model to rank 402 enterprises, and the 50 most important suppliers were selected.In order to better reflect the materials and transportation model required by the enterprise's production, the mean square deviation of the enterprise's output in the past five years is used to approximate its output in the next 24 weeks. The multi-objective optimization algorithm based on the combination of convergence criteria and genetic algorithm is used to obtain that at least 30 suppliers and 5 transporters should be selected; The sensitivity analysis and stability test of the model are carried out.*

Keywords: *Ordering and Transportation, Weighted Grey Target Decision Model, Genetic Algorithm, Multi-Objective Optimization Model*

1. Introduction

Raw material procurement is not only the starting point of enterprise production and operation, but also the focus of enterprise cost control [1]. Therefore, it is crucial for enterprise development to develop a more scientific and reasonable raw material ordering and transportation model to meet production demand and improve enterprise capacity.

For downstream production and processing enterprises, it faces according to current and future capacity requirements and suppliers for the ability to select suppliers, according to the weekly production requirements determine the raw material quantity, how to deal with supplier weekly output of raw materials is insufficient, how to choose transport business to reduce the transportation when the depletion of the challenge. Due to the difference of raw material price, transportation loss rate of transporters and the uncertainty of supply quantity of suppliers, the production status and economic benefits of enterprises will be changed.

2. Supplier selection model based on multi-objective weighted grey target decision

2.1. Determination of decision objective and analysis of influence mechanism

This paper focuses on the relationship between supply and demand to determine the decision-making target. Supply refers to the quantity of raw materials provided by raw material suppliers, reflecting the capacity of suppliers, and demand refers to the quantity of raw materials ordered by enterprises every week. Multi-objective grey target decision model has been widely used to solve various decision-making target selection problems. In order to solve problem 1, our team proposed a supplier selection model based on multi-objective weighted grey target decision model combined with weighted grey target decision model.

This paper sorted out the relevant factors affecting the decision-making of suppliers, as shown in the following table [2-4].

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Table 1: Statistical table of decision objectives

The decision goal	Unit	Description
The total order	m^3	The quantity of raw materials ordered by the supplier
Total supply	m^3	Quantitative indicators
Meet the rate	%	Total supply quantity/total order quantity
The order of variance	m^6	Quantitative indicators
The supply of variance	m^6	Quantitative indicators

2.2. The establishment of evaluation-decision model

Multi-objective grey target decision model [5] is a kind of based on four kinds of model of evaluation function of consistency, we will be combining analytic hierarchy process and multi-objective grey target method, to find the optimal empowerment model, structure, supplier evaluation decision model can help enterprises in the poor data, low information situation, choose the best from multiple decision objective decision objective, specific steps are as follows:

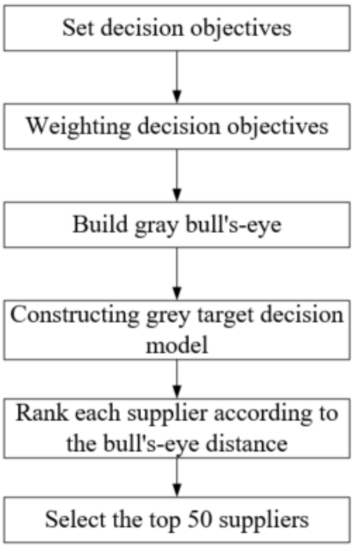

Figure 1: Flow chart of weighted grey target decision model

Step 1: In this paper, five decision objectives of total order quantity, total supply quantity, satisfaction rate, order variance and supply variance are determined.

Step 2: Determine the decision weight of the decision objective. The analytic hierarchy process is used to determine the weight of each decision objective $w_1, w_2, \cdots, w_s$. Construct the judgment matrix A, compare the five decision objects in pairs, and get the contrast matrix.

Table 2: Contrast matrix

	The total order	Total supply	Meet the rate	The order of variance	The supply of variance
The total order	1	2	6	7	8
Total supply	1/2	1	4	2	3
Meet the rate	1/6	1/4	1	2	3
The order of variance	1/7	1/2	1/2	1	2
The supply of variance	1/8	1/3	1/3	1/2	1

The normalized operation [6-7] mean values of n row vectors are almost as weighted and double vectors $w_i = \left(0.509, 0.236, 0.114, 0.087, 0.055\right)^T$:

$$w_i = \frac{1}{n}\sum\nolimits_{j=1}^{n} \frac{a_{ij}}{\sum\nolimits_{k=1}^{n} a_{kj}} \left(i = 1, 2, \ldots, n\right) \tag{1}$$

Step 3**:** Gray target center is constructed

$$U^k = (u_{ij}^{(k)}) = \begin{bmatrix} u_{11}^{(k)} & u_{11}^{(k)} & & u_{11}^{(k)} \\ u_{11}^{(k)} & u_{11}^{(k)} & \cdots & u_{11}^{(k)} \\ \vdots & \vdots & \vdots & \vdots \\ u_{11}^{(k)} & u_{11}^{(k)} & \cdots & u_{11}^{(k)} \end{bmatrix} \tag{2}$$

Step 4: The comprehensive effect measure matrix is calculated: $r_{ij} = \sum_{k=1}^{s} w_k \cdot r_{ij}^{(k)}$

Step 5**:** Make decisions, rank:

$$R = (r_{ij}) = \begin{bmatrix} r_{11} & r_{12} & & r_{1m} \\ r_{21} & r_{22} & \cdots & r_{2m} \\ \vdots & \vdots & \vdots & \vdots \\ r_{n1} & r_{n2} & \cdots & r_{mm} \end{bmatrix} \tag{3}$$

Judge whether the grey target is hit according to the comprehensive effect measure value. When $r_{ij} \in [0,1]$, it means hitting the gray target, and when $r_{ij} \in [-1,0]$, it means miss; At the same time, the closer r_{ij} is to 1, the more important the supplier is to the manufacturer.

3. Multi-objective optimization model based on genetic algorithm

Suppose x_{ij} is the m^3 required for the j_{th} raw material in week i, and p_j is the price of the j_{th} raw material. T_{kj} is the quantity of the j_{th} raw material transported by the k_{th} transportation company, and C_k is the consumption rate of the k_{th} company, which is the supply volume of each supplier in the first five years. $i = 1, 2, 3 \cdots 240$ constructs a multi-objective planning model as follows:

3.1. Determination of the minimum supply quotient to satisfy production demand

According to the preliminary experimental results, the average supply quantity of the supplier is taken as the supply data of the following 24 weeks, and the total supply often cannot meet the production demand of the enterprise. Therefore, we select the root mean square of supplier's supply quantity data in the past five years as the supply data of the following 24 weeks. The root mean square is obtained by taking the sum of squares of all values, then taking the mean and taking the square, namely:

$$y_{rms} = \sqrt{\frac{1}{N} \sum_{i=1}^{N} y_i^2} \tag{4}$$

$$s.t.\{ \begin{matrix} x_{ij} \le y_{rms} \\ x_{iA} / 0.6 + x_{iB} / 0.66 + x_{iC} / 0.72 \ge 28200 \end{matrix} \tag{5}$$

3.2. The optimization goal

To determine the best ordering solution, the business can use this model to maximize the business's weekly profit for the next 24 weeks. The purpose is to get the appropriate order quantity to meet the weekly production capacity, while making the order of raw materials as economical as possible and shipping loss as small as possible, which is a multi-objective optimization problem.

(A) Raw material purchase cost

The cost of raw material purchase is the product of the volume of each raw material per week and the price of each raw material and the sum of the total number of weeks and the total number of raw materials $\sum_{i=1}^{24} \sum_{j=1}^{3} x_{ij} \cdot p_j$.

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(B) Material loss in transit

The total loss obtained by multiplying the quantity of raw materials transferred by each company by the transportation consumption rate of each company is $\sum_{j=1}^{3}\sum_{k=1}^{8}T_{kj}\cdot C_k$.

Therefore, we determined that the total purchase cost of raw materials should be as little as possible, and the loss of raw materials during transportation should be as little as possible, thus obtaining the formula

$$\begin{gathered}\min\sum_{i=1}^{24}\sum_{j=1}^{3}x_{ij}\cdot p_j\\ \min\sum_{j=1}^{3}\sum_{k=1}^{8}T_{kj}\cdot C_k\end{gathered} \tag{6}$$

(C) Determination of constraint conditions

$$s.t.\begin{cases} x_{ij}\le y_{rms}\\ x_{iA}/0.6+x_{iB}/0.66+x_{iC}/0.72\ge 28200\\ \sum_{j=0}^{3}T_{kj}\le 6000\end{cases} \tag{7}$$

The limit on transshipment per transporter has been increased to 6000/ m3 / week per transporter.

4. Solution of multi-objective model

Genetic algorithm (*GA*) is derived from the computer simulation of biological systems. It draws lessons from Darwin's theory of evolution and Mendel's theory of heredity. In essence, GA is a parallel and efficient search method that obtains the best solution of the model in the process of adaptive search.

Genetic algorithm includes three basic operations: selection, mutation and crossover. There are many different methods for these basic operations, which make genetic algorithm have different characteristics in practice [8-9].

1) Selection: according to the fitness of each individual, through the rule of survival of the fittest, select some excellent individuals from the t generation population to inherit to the next generation t+1 population.

2) Chiasmosis: When two chromosomes are cut at the same location and the two strands cross back and forth to form a new chromosome. Individuals in a population are randomly paired up, with a probability of swapping chromosomes between them.

3) Variation A change in the value of one locus to the other alleles with a small probability for each individual in a population. Genetic algorithm is to imitate the biological evolution process, some errors occur in the replication process (that is, through the crossover and variation between chromosomes), the basic operation on the population, get a new generation of population, improve the ability of the population to adapt to the environment.

Ordinary steps:

(1) At the beginning of calculation, a certain number of N individuals, namely the population, are randomly initialized;

(2) The calculation of each individual fitness function, produce the first generation of

(3) If the optimization criteria are not met, individuals are selected according to fitness, and the parent generation requires gene recombination (crossover) to produce offspring.

(4) All offspring change at a certain probability

(5) Recalculate the fitness of the offspring

(6) The offspring are inserted into the population and replaced by the parent, forming a new generation, until optimization criteria are met.

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5. Conclusion

In today's society, with the continuous expansion of market players, how enterprises control production costs is of great significance to their sustainable development. Firstly, this paper summarizes five factors that influence the company's decision making based on relevant papers. Secondly, analytic hierarchy process is used to determine the weight of each impact assessment factor.Then, in order to better reflect the material and transportation model required by the production of enterprises, the number of suppliers should be selected at least 30, and the number of carriers is 5 by using the multi-objective optimization algorithm based on convergence criterion and genetic algorithm.

References

[1] Zhang Yuyan Thoughts on cost control strategy of enterprise raw material procurement [J]. Business news, 2021 (24): 137-139.

[2] Zhu Zhu Supplier selection model and learning mechanism in Collaborative Procurement Environment [J]. Control engineering 2018(08).

[3] Li Hao, Guo Gang, Xu Jianping, Shen Lei, Yang Juan Research on supplier management model of collaborative product development [J]. Journal of Chongqing University, 2010, 33 (03): 41-48.

[4] Zhong Jinhong, Bai Yang Improved BN model for supplier selection in complex product development [J]. Journal of mechanical engineering, 2016,52 (01): 175-183

[5] Zhang Wenjie, Yuan Hongping Research on energy saving service company selection based on multi-objective weighted grey target decision model [J]. China management science, 2019, 27 (02): 179-186.

[6] Wu Shihui, Liu Xiaodong, Jia Yueling, Guo Yakun An optimization method for adjusting AHP inconsistency judgment matrix [J]. Control and decision making, 2016, 31 (11): 2106-2112.

[7] Huang Decai, Xu Lin Proportional scale construction method of judgment matrix in AHP method [J]. Control and decision making, 2002 (04): 484-486.

[8] Zhou A, Zhang Q, Jin Y, et al. A model-based evolutionary algorithm for bi-objective optimization [C]. // IEEE Congress on Evolutionary Computation. IEEE, 2005.

[9] Zhou A, Jin Y, Zhang Q, et al. Combining model-based and genetics-based offspring generation for multi-objective optimization using a convergence criterion [C]. // IEEE Congress on Evolutionary Computation. IEEE, 2006.