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Research on optimal raw material decision for manufacturing enterprises

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Abstract: This paper deals with the ordering and transportation of raw materials in a building and decorative plate enterprise. Quantitative analysis and analytic hierarchy process and TOPSIS algorithm are used to analyze the relevant materials and information of each supplier[1]. The grey prediction model are used to comprehensively evaluate each supplier and transshipment, and the most economical raw material ordering plan and the transport plan with the least loss are worked out[2]. Research on this issue can improve the efficiency and quality of raw material decision-making of domestic manufacturing enterprises, improve the increasingly fierce market competition environment faced by manufacturing enterprises, and further promote economic development.

1. Background

At present, with the rapid development of various manufacturing enterprises and increasingly fierce market competition, the raw material cost, transportation cost, storage cost and other expenses of enterprises are constantly increasing, and the potential economic pressure is also increasing. How to reduce all kinds of costs, choose appropriate suppliers and changers, and develop the most economical raw material ordering scheme and the least loss of transport scheme under the premise of ensuring the normal production of enterprises is an important topic for the development of each enterprise.

2. Modeling and solving of problem 1

2.1 Model preparation

The first problem to be solved is the evaluation problem. First of all, the characteristics of the importance of enterprise production are obtained from the enterprise order and supplier order. The supply characteristics of the supplier are evaluated comprehensively from four aspects: the production and supply capacity of the supplier, the cooperative relationship between the supplier and the enterprise, the reputation of the supplier and the enterprise's choice of the materials to be supplied, and a supplier supply characteristic index evaluation system is established. Then the analytic hierarchy Process (AHP) was used to assign weights to each indicator. Finally, TOPSIS method was used to quantify the importance of each supplier to ensure the enterprise's production, and the quantified value of each supplier's supply characteristics was ranked from superior to inferior, and the 50 most important suppliers were obtained.

2.2 Model Establishment

The key point of this problem is to extract the supply characteristics which can be used to measure the comprehensive capability of suppliers from the data information of 402 suppliers with transaction records in the past five years, and to construct the comprehensive evaluation system of supplier indicators. Indicators are selected from the following aspects:

Supplier strength:

$$F_i = \sum_{k=1}^{240} p_{ik} \tag{1}$$

Partnership:

$$R_i = f(k) \tag{2}$$

Supplier's reputation:

$$C_i = \frac{t_i(k)}{q_i(k)} \tag{3}$$

Analytic hierarchy process (AHP) is a comprehensive evaluation method which combines qualitative analysis with quantitative analysis. Firstly, a hierarchical structure model is established based on the index system extracted above, and pairwise comparison matrix is constructed by using relative scale to compare each index.

$$A = \begin{bmatrix} a_{11} & a_{12} & a_{13} & a_{14} \\ a_{21} & a_{22} & a_{23} & a_{24} \\ a_{31} & a_{32} & a_{33} & a_{34} \\ a_{41} & a_{42} & a_{43} & a_{44} \end{bmatrix} = \begin{bmatrix} 1 & 7 & 3 & 3 \\ 0.14 & 1 & 0.20 & 0.25 \\ 0.33 & 5 & 1 & 2 \\ 0.33 & 4 & 0.50 & 1 \end{bmatrix} \tag{4}$$

The unique non-zero characteristic root of the inverse matrix A is n, $A\vec{w} = n\vec{w}$, and the corresponding eigenvector of the non-zero characteristic root n can be used as the weight vector after normalization. The maximum characteristic root λ=4.0992, and the weights of the four indexes are respectively:

Table 1: Index weight table

index	Supplier strength	Partnership	reputation	Raw material preference
weight	0.5273	0.0540	0.2517	0.1670

2.3 Model Solution

TOPSIS method is a commonly used intra-group comprehensive evaluation method, and its results can accurately reflect the gap between evaluation programs[3].

First of all, the index data should be standardized to find out the maximum value and minimum value of each evaluation index to form a vector

$$Z_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{402} {x_{ij}}^2}} \tag{5}$$

$$Z^+ = ({z_1}^+, {z_2}^+, {z_3}^+, {z_4}^+) \qquad Z^- = ({z_1}^-, {z_2}^-, {z_3}^-, {z_4}^-) \tag{6}$$

The forward and negative distances of the supplier i are defined as ${D_i}^+$ and ${D_i}^-$, and the calculation formula is:

$$D_i^- = \sqrt{w_1 \times (z_1^- - z_{i1})^2 + w_2 \times (z_2^- - z_{i2})^2 + w_3 \times (z_3^- - z_{i3})^2 + w_4 \times (z_4^- - z_{i4})^2}$$

$$D_i^+ = \sqrt{w_1 \times (z_1^+ - z_{i1})^2 + w_2 \times (z_2^+ - z_{i2})^2 + w_3 \times (z_3^+ - z_{i3})^2 + w_4 \times (z_4^+ - z_{i4})^2} \quad (7)$$

The score of the i supplier is defined as Si:

$$Si = \frac{D_i^-}{D_i^+ + D_i^-} \quad (8)$$

The closer Si is to 1, the closer supplier i is to the ideal target, and the more important the supplier is to the enterprise. The overall score of the top 50 suppliers is shown in the table.

Table 2: Comprehensive evaluation table for each supplier

supplier	score	supplier	score	supplier	score
S299	0.993	S348	0.287	S055	0.149
S361	0.922	S352	0.281	S346	0.146
S140	0.852	S143	0.265	S218	0.142
S108	0.684	S307	0.253	S080	0.141
S151	0.557	S201	0.239	S294	0.141
S340	0.495	S395	0.238	S244	0.137
S282	0.49	S247	0.209	S086	0.132
S275	0.461	S374	0.197	S007	0.13
S329	0.455	S284	0.192	S114	0.13
S139	0.433	S037	0.186	S266	0.13
S131	0.404	S365	0.18	S067	0.128
S308	0.403	S031	0.177	S098	0.128
S330	0.402	S126	0.172	S291	0.128
S356	0.386	S040	0.16	S003	0.127
S268	0.304	S364	0.159	S239	0.126
S306	0.375	S338	0.156		
S194	0.312	S367	0.152		

3. Modeling and solving of problem 2

3.1 Model preparation

The improvement of productivity is an important way for enterprises to expand scale, increase income and profit. Science and technology are the primary productive forces. The enterprise has the potential to improve production capacity through continuous technological transformation and upgrading. The key to solve this problem is to determine the production capacity of the enterprise in the next 24 weeks according to the actual situation of the existing raw material suppliers and transporters, so this problem can be transformed into a new planning problem based on the prediction problem[4].

3.2 Model Establishment

Grey prediction method is a method to predict the future development trend of things by identifying the different degree of development trend among system factors, looking for the law of system change, generating data series with strong regularity, and establishing the corresponding differential equation model.

In order to ensure the feasibility of GM(1,1) modeling method, it is necessary to test the known data. Let the original data be $x^{(0)} = (x^{(0)}(1), x^{(0)}(2), \ldots, x^{(0)}(10))$. The level ratio of the sequence is:

$$\lambda(k) = \frac{x^{(0)}(k-1)}{x^{(0)}(k)}, k = 2,3,\ldots,10 \tag{9}$$

After the test, all the grade ratios fall within the tolerable coverage interval $X = (e^{\frac{-2}{11}}, e^{\frac{2}{11}})$, then the GM(1,1) model can be established for data column$x^{(0)}$, and gray prediction can be made.

It is verified that $x^{(0)} = (x^{(0)}(1), x^{(0)}(2), \ldots, x^{(0)}(10))$meets the above requirements, and the GM(1,1) model $x^{(0)}(k) + az^{(1)}(k) = b$ is established with it as the data column. The estimated values of a and b are obtained by regression analysis.

$$a = 0.0034 \qquad b = 4.5195\text{e} + 05$$

Establish the corresponding bleaching model:

$$\frac{dx^{(1)}(t)}{dt} + 0.0034x^{(1)}(t) = 4.5195e + 05 \tag{10}$$

So get the predicted value:

$$\hat{x}^{(1)}(k+1) = (x^{(0)}(1) - \frac{b}{a})e^{-a(k)} + \frac{b}{a}, k = 1,2,\ldots,n-1 \tag{11}$$

Thus, the predicted value can be obtained accordingly:

$$\hat{x}^{(0)}(k+1) = \hat{x}^{(1)}(k+1) - x^{(1)}(k), k = 1,2,\ldots,n-1 \tag{12}$$

3.3 Model Solution

Residual test: calculate the relative residual:

$$\varepsilon(k) = \frac{x^{(0)}(k) - \hat{x}^{(0)}(k)}{x^{(0)}(k)}, k = 1,2,\ldots,n \tag{13}$$

By the inspection all $|\varepsilon(k)| < 0.1$, to achieve high requirements

Stage ratio deviation value test:

$$\rho(k) = 1 - \frac{1-0.5a}{1+0.5a}\lambda(k) \tag{14}$$

By the inspection all $|\rho(k)| < 0.1$, to achieve high requirements

Therefore, it can increase the capacity of 118,000 cubic meters per week.

4. Evaluation of Model

4.1 Advantages

(1) In the establishment of the quantitative model of supplier supply characteristics, reasonable, effective and available indicators can be selected through full demonstration to effectively quantify the supply characteristics.

(2) Combining the ANALYTIC hierarchy Process (AHP) and TOPSIS algorithm scientifically, the comprehensive evaluation model of indicators is creatively established.

4.2 Disadvantages

(1) The factors considered in the model are not comprehensive enough and the distance between

the enterprise and each supplier is not taken into account.

(2) When calculating enterprises' preference for raw materials, assignment is subjective to a certain extent and there is room for improvement.

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