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The Evaluation Model of Suppliers Based on TOPSIS and Entropy Method

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Abstract: We established an evaluation index system and construct a comprehensive evaluation model to identify the most important suppliers. Firstly, a total of six indicators are extracted: total supply, total order, supplier supply error, and supply to order ratio, supplier supply day's continuity, and stability of supply. Then, a comprehensive evaluation model of TOPSIS based on the entropy weight method was established on this basis. After solving, the 50 most important suppliers were obtained.

1. Introduction

The supply characteristics of 392 suppliers are quantified and analyzed, and a mathematical model reflecting the importance of guaranteeing the production of enterprises is established, based on which the 50 most important suppliers are determined.

Firstly, from the relevant data of 392 suppliers, we analyzed the various characteristics of enterprise order quantity and supplier supply quantity. Nine characteristic indicators were extracted, and the importance of suppliers was comprehensively evaluated from three aspects of supplier strength, stability of the supply-demand relationship, and supplier credibility, respectively, and an evaluation index system was established to guarantee the importance of enterprise production, and an optimal model was built to determine important suppliers.

2. Selection of features and construction of evaluation system

Enterprises tend to purchase from suppliers with strong strength, stable supply-demand relationships, and high credibility. The following will start with these three aspects for the selection of indicators.

2.1 Supplier strength

In this paper, the total amount of suppliers' supply, and the total amount of enterprises' orders are selected as indicators to measure the size of suppliers' supply scale and the size of transaction volume.

1) Total supply volume

The higher the value, the larger the production and operation scale of the supplier, which can be

used as an effective indicator to measure the production scale of the supplier [1]. The specific calculation formula is $G_i = \sum_{j=1}^{240} W_{ij}$. G_i is the total quantity supplied by the *i*th supplier in 240 weeks. W_{ij} is the quantity supplied by the *i*th supplier in week *j*.

2) Total order quantity

The total number of orders is the sum of goods ordered by the company in 240 weeks. The higher the value, the higher the demand from the supplier, which can be used as a valid indicator of the size of the supplier's production. The specific calculation formula is $O_i = \sum_{j=1}^{240} V_{ij}$. O_i is the total amount of orders placed by the firm from the *i*th supplier in week 240 and V_{ij} is the number of orders placed by the firm from the *i*th company in week *j*.

2.2 Stability of supply and demand

1) Supplier's supply error

Although the supplier's weekly supply is the more the better, but not unlimited large, should be in the order and supply-demand range the greater the better, so we use the supplier's supply error to limit. The closer the error value is to zero, the better the effect is, and it is an intermediate variable.

$D_{ij} = |V_{ij} - W_{ij}|$. D_{ij} is the difference between the order and supply of the *i*th company in week *j*.

2) Supply quantity to order quantity ratio

The supply to order ratio also shows the degree of corporate order satisfaction, the larger the ratio the better, because not only to ensure that the week can be normal production, but also to ensure two weeks of inventory, that is, each time the supplier to provide us with a certain degree of goods, the more the better, so it can be used as an effective indicator to measure the credibility of the supplier. Its specific calculation formula is $F' = \frac{G_{ij}}{O_{ij}}$. *F'* represents the ratio of supply to order quantity for the *i*th company in week *j*.

2.2.1 Supplier credibility

1) Supplier delivery time continuity

Continuity of supply means that the supplier can continuously supply to the enterprise and guarantee the production of the enterprise, which means the more the enterprise trusts the company and can be used as an effective indicator to measure the credibility of the supplier. The specific calculation formula is $GC_i = \sum_{j=1}^{392} g_{ij}$. If the *i*th supplier supply to the enterprise in week *j*, g_{ij} equals one; else, g_{ij} equals zero. GC_i represents the number of deliveries of the *i*th supplier in 240 weeks.

2) Stability of supply

Companies produce products all year round, so they need to ensure that they order every week and get the goods every week, so the supplier's supply stability can be used as an effective indicator to measure the stability of suppliers. To avoid that some weekly deliveries are very large and some are very small, the variance of all the deliveries of each supplier is used to decide, the smaller the variance the better, the more stable the supply.

3. Establishment of TOPSIS model based on entropy weight method

First, the weights of each indicator need to be determined. To avoid the influence of subjectivity on the quantitative results, we use a data-driven weighting method based on the entropy weighting method to assign weights and use TOPSIS to quantify the importance of each supplier after obtaining the weights.

3.1 Entropy weight method to calculate the weight

Calculate the weight of the *j*th supplier under the *i*th supplier importance indicator and consider it as the probability (p_{ij}) in calculating the information entropy. $p_{ij} = z_{ij} \sum_{i=1}^{392} z_{ij}$.

The information entropy e_i of the *j*th supplier importance indicator is calculated and the corresponding information utility value d_j=1-e_i is calculated to positively measure the information entropy. The larger the information utility value, the more information it corresponds to.

$$e_{i,j} = -\frac{1}{\ln n} \sum_{j=1}^{m} P_{ij} \ln(p_{ij}) \quad (1)$$

By normalizing the information utility values, the entropy weight (W_j) of each indicator can be obtained as follows: $W_j = d_j \sum_{j=1}^{m} d_j$.

After calculating, the weights of the six indicators is listed in .

Table 1: The weights of the six indicators

Indicators	1	2	3	4	5	6	Sum
Weights	0.4200	0.4705	0.0001	0.0048	0.0038	0.1008	1

3.2 TOPSIS Method to Quantify Supplier Importance

Find the maximum value of each column, i.e., each importance indicator, and denote it as z_i^+, to form a vector $Z^+ = \{z_1^+, z_2^+, \ldots, z_{392}^+\}$. This vector represents the ideal supplier. Similarly, find the minimum value of each column, which is also the minimum value of each indicator, and denote it as z_i^-, to form the vector $Z^- = \{z_1^-, z_2^-, \ldots, z_{392}^-\}$. This vector represents the least desirable firm, i.e., each of the indicators after forwarding is minimized. Define the distance between the *i*th supplier and the desired target as $D_i^+ = \sqrt{\sum_{j=1}^{392}(z_{ij} - z_j{}^+)^2}$, and the distance between the *i*th supplier and the desired target as $D_i^- = \sqrt{\sum_{j=1}^{392}(z_{ij} - z_j{}^-)^2}$.

Calculate values of important indicators for each supplier. That is the score $W_i = \frac{D_i^-}{D_i^+ + D_i^-}$. Rank the options in order of preference from largest to smallest of W_i.

The larger the various types of indicators, the closer the state of the evaluated supplier is to the ideal solution, and the larger the comprehensive evaluation value obtained. Then use the entropy weighting method to weigh the evaluation indicators. Calculate the distance from the maximum and minimum values, and then calculate the score, and the top 50 are selected by the score and ranked in Figure 1.

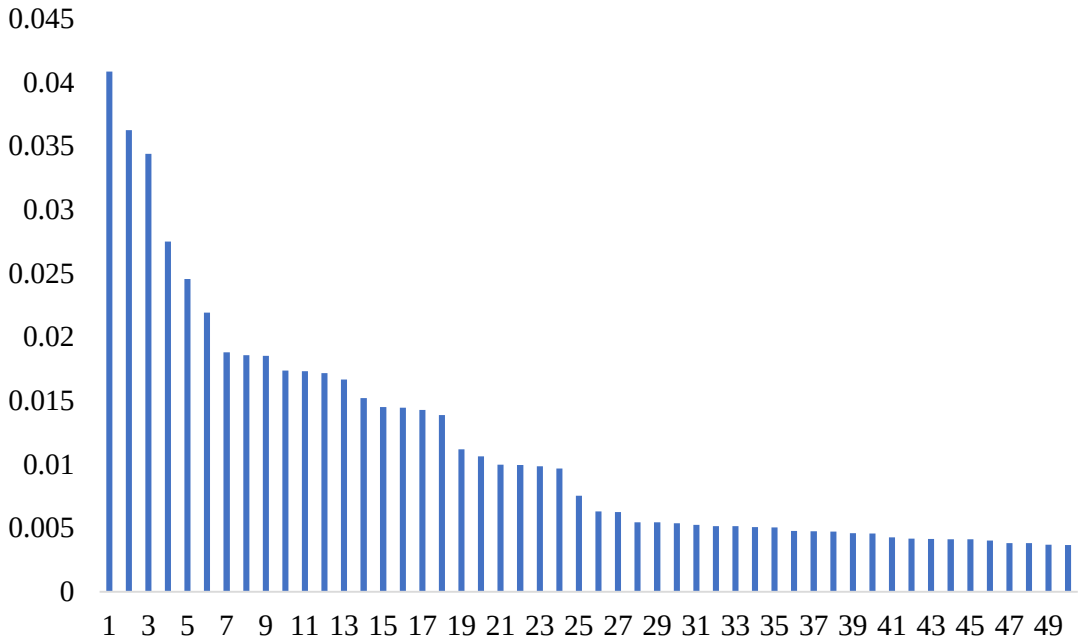

Figure 1: Top 50 supplier scores

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