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Quantification of supply reasonableness based on TVM important score model

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Abstract: This paper presents the development of a raw material ordering and transportation plan for a manufacturing company under different scenarios. In order to quantify the supply characteristics, based on the data of order quantity and supply quantity in Annex I, eight indicators such as total past supply, supply accuracy, and market share are quantified with "guaranteeing production" as the core, which are divided into three dimensions: past transaction volume, transaction security, and business strength, and the same dimensional indicators are quantified using The TVM-based importance rating model was established to select the most important 50 suppliers by combining the indicators of the same dimension using the $TOPSIS$ method. The rational analysis shows that our index selection can make the high and low importance among different suppliers.

1. Introduction

We identified the 50 most important suppliers based on the orders from 402 suppliers over the past 240 weeks and their actual deliveries to ensure the company's production. The key is to quantify the indicators that reflect the supplier's supply characteristics and to develop an evaluation model for "importance". Based on the literature [1], we additionally highlight risk avoidance and production protection.

The volume of past transactions with suppliers, security of transactions, and operational strength are the three dimensions of the evaluation.

The total number of past supplier deliveries is used to measure the volume of past transactions. Transaction security is the focus of question 1. The quantification of "risk" is of great importance in the production and operation of enterprises. For example, in the case of a manufacturing company, it is necessary to take into account the risk of production delays due to the discrepancy between the quantity supplied by the supplier and the demand[2]. We introduce "security" as a dimension that corresponds to "riskiness". In order to guarantee sufficient supply, only orders that meet a higher supply quantity than the order quantity, or a lower supply quantity than the order quantity but within a certain range, can be called "safe". In addition, the deviation of all valid transactions is averaged to measure the accuracy of supply in general, and the variance is taken to measure the stability of supply. In particular, in order to "reward" suppliers for adequate supply, the percentage of orders that can be supplied to meet the order quantity is also used as an indicator[3]. These four small indicators together measure the "security of trade". The business strength of the company is measured by market share and the average volume of products produced per delivery, so that comparisons can be made between suppliers producing similar products and among all suppliers. In addition, although the capacity constraint of suppliers is also an important basis for measuring their unit production capacity, we do not include it in the evaluation system because it cannot be measured directly by the given data[4].

The specific definition of each indicator and the basis for its selection are described in the model building section. $TOPSIS$ method[5] is widely used in dealing with multi-attribute decision problems. For each dimension, we use it to give a score. In order to integrate the three dimensions, we borrow the TVM model and vectorize the space with the three-dimensional axes corresponding to the past transaction volume, transaction security, and business strength of each supplier. In this way, both the total score of each supplier and the deviation from the optimal development direction are taken into account, and the results are more reliable. Considering that the unit price of B is slightly higher than that of A and C, we multiply the importance score of suppliers producing B by 0.95. We take three different values for the parameter α in the TVM model. Then two-by-two take the intersection to determine the most important fifty firms.

2. Indicator selection and basis

We divided the evaluation indicators into seven indicators and three dimensions.

1) Past transactions T_1.

In order to measure past transactions, either the number of transactions or the number of transactions can be used. But the number of transactions has been involved in the calculation of the indicator several times, and then it will be a separate indicator will lead to The number of transactions has already been covered several times in the calculation of the indicator, so that a separate indicator would lead to overlap. Therefore, only the total number of suppliers supplied in the past M is used to characterize the volume of past transactions.

$$M = \sum_{i=1}^{240} S_i \tag{1}$$

2) Transaction security T_2.

According to the analysis of the problem, "security" is the positive version of "riskiness", which consists of the following four sub-indicators.

Number of secure transactions q.

If a transaction satisfies.

$$\frac{S_i - S_i}{S_i} \le 0.1 \quad OR \quad (S_i - S_i) > 0 \tag{2}$$

Then the transaction is said to be "secure" and the total number of all secure transactions is q.

Accuracy of supply γ.

If the supplier's supply always does not match the ordered quantity, it either causes waste of raw materials or delays in production.

For this reason, we take the average of the deviation rates (absolute values) of all transactions and measure the overall deviation rate of suppliers. Supply

Accuracy is the result of a positive deviation rate.

$$\gamma = 1 - \left(\sum_{i=1}^{240} \frac{\left| S_i - S_i \right|}{S_i} \right) / q \tag{3}$$

Supply stability λ.

In order to minimize the production risk of the enterprise, it is also necessary that the deviation rate of each supply from the supplier does not fluctuate significantly. Let the first l transaction occurs in week i and the deviation rate is $\alpha^{(l)}{}_i$, $1 \leqslant l \leqslant q$ and $1 \leqslant i \leqslant 240$. Then.

$$aligned \alpha_i^{(l)} = \frac{\left| S_i - S_i \right|}{S_i} \lambda = \frac{1}{q} \sum_{l=1}^{j} \left(\alpha_i^{(l)} - \overline{\alpha_i^{(l)}} \right)^2 aligned \tag{4}$$

The percentage of transactions where the supply quantity can meet the order quantity β

Although the supply quantity is larger than the order quantity affects the accuracy of the enterprise's supply γ, the supply quantity is more in line with the question to guarantee

The requirement of enterprise production. Therefore, we introduce β to balance the resulting low supply accuracy score and to distinguish the positive and negative supply deviations.

$$\beta = \frac{\overline{q}}{q} \tag{5}$$

3) Business strength T_3.

Market share r.

First, the suppliers producing A, B, and C are compared internally: let the supplier X_j supply A class materials. Then.

$$r_j = \frac{\sum_{i=1}^{240} S_{ij}}{\sum_{X_j \in A} \sum_{i=1}^{240} S_{ij}} \tag{6}$$

The average amount of product that can be produced per supply m.

Then consider that the number of units of product needed to produce varies by type. So we convert the supplier's average quantity per delivery into product quantity. We still consider only the weeks in which we have transactions.

3. Model construction and solving

3.1 Importance scoring model

The scoring for each supplier is divided into three steps.

First, for a given dimension, we use the $TOPSIS$ method to evaluate each indicator within the dimension, thus obtain three sub-dimension scores $T1$, $T2$, $T3$; then, we use the TVM model to consider the supplier's development capability and direction in these three dimensions development capacity and development direction to obtain a composite score; finally, since the use of BB category raw materials with the highest cost Finally, since the use of raw materials in the B category is the most costly and contributes the least to the economic efficiency of production, we downgraded the rating for suppliers of raw materials in the B category by 0.05.

The specific construction process of the scoring model is as follows.

1) $TOPSIS$ model calculates the sub-dimensional scoring: taking transaction security as an example.

The four indicators are the number of secure transactions qe, the accuracy of supply γ, the stability of supply λ, and the percentage of transactions where the supply meets the order quantity λ

The percentage of transactions in which the volume of goods can meet the order quantity β.

In fact, the supply stability λ is also the only negative one among all seven indicators.

Since the indicators each have different directions and magnitudes, they need to be normalized and normalized. Let the four dimensions be processed values are the attribute variables xl, l = 1, 2, 3, and 4, respectively, using the standard 0-1 transformation.

For example, for the benefit category indicator q

$$x_1 = \frac{\tilde{q} - q_{\min}}{j_{\max} - j_{\min}} \tag{7}$$

For example, for the cost category λ

$$x_3 = \frac{\lambda_{\max} - \lambda}{\lambda_{\max} - \lambda_{\min}} \tag{8}$$

For the jth supplier, the maximum value of each attribute is denoted as Z_l^+, and the minimum value is denoted as Z_l^-, l = 1, 2, 3, 4. Using the Euclidean distance, the distances to the positive and negative ideal solutions are.

$$\begin{aligned} D_j^+ &= \sqrt{\sum_{l=1}^{4}\left(Z_l^+ - z_{jl}\right)^2} \\ D_j^- &= \sqrt{\sum_{l=1}^{4}\left(Z_l^- - z_{jl}\right)^2} \end{aligned} \tag{9}$$

Then $T_{2j} = \dfrac{D_j^-}{D_j^+ + D_j^-}$.

Clearly, the T2 value thus obtained is between 0 and 1.

Similarly, the score T3 can be calculated for the third dimension of operating strength. For the first dimension, there is only one efficiency category indicator, which can be obtained by simply applying the 0-1 standard transformation according to (1) T1.

2) TVM model to calculate the overall score.

In order to integrate the three dimensions, we vectorize the space so that the three-dimensional axes correspond to the supplier. In order to integrate the three dimensions, we vectorize the space so that the three-dimensional axes correspond to the supplier's past supply, transaction security, and business strength. We define the standard vector (1, 1, 1), which represents the virtual supplier with the best capability and the best orientation in the three dimensions we study. It is the virtual supplier with the best capability and the best direction in the three dimensions we study, and it has the highest importance score.

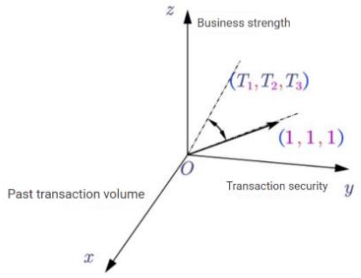

Figure 1 TVM Model schematic

For each supplier according to the first step of the calculation, a vector ($T1$, $T2$, $T3$) is obtained, as in Figure 1, which itself has a modal length and, at the same time, an angle between it and the standard vector exists, which have the following realistic meaning.

(a) Angle θ: indicates the deviation of the studied supplier from the direction of development of the supplier with the highest importance.

(b) Modal length: represents the development capacity of the studied supplier in terms of importance. Denote the importance score of the supplier by T. Considering that the closer the pinch angle and mode length are to the ideal situation, it means that the supplier the more important the supplier is to guarantee the production of the company, accordingly, the larger the value of T. Therefore, considering the pinch angle θ and die length together, α is introduced to measure the weight of this aspect. measure the weight to this aspect, there are.

$$T = \frac{\alpha \frac{|45^\circ - \theta|}{45^\circ} + \sqrt{\frac{\sum_{i=1}^{3} |T_i|^2}{3}}}{1+\alpha} \tag{10}$$

We take α = 0.8, 1, 1.2, respectively, calculate the importance score T, and then take the intersection between the more important firms obtained Then the intersection of the more important firms is taken in two. This reduces the bias caused by inappropriate values of α. See the model solving section for details.

3) Adjustment of B raw material supplier scores, in terms of the purchase cost required to produce one unit of product, the material cost of A and C is the same, while the material cost of B material cost is slightly higher. So, if the supplier produces B class material, we adjust its importance score T.

$$\bar{T} = 0.95 \times T \tag{11}$$

In order not to cause misunderstanding, and for the sake of conciseness, the two can be replaced approximately.

3.2 Confirmation of the most important fifty companies

Under the TVM model, we let α = 0.8, 1, 1.2 be computed three times and each time we select the top fifty suppliers based on the importance score T ranked from the largest to the smallest. Let the set obtained three times be Λi, i = 1, 2, 3. If a supplier appears more than 1 time in Λi, it is recognized as one of the fifty most important. The calculation shows that 46 suppliers appear 3 times, 4 appear 2 times and 4 appear 1 time. The total number of suppliers with more than one occurrence is exactly 50. In particular, α in all three cases, if two decimal places are kept, the ranking of the top 20 suppliers is identical. In particular, the ranking results for the top 20 suppliers are identical if two decimal places are retained in the three cases. Table 1 gives the importance scores of the top 10 suppliers before and after adjustment in the three cases.

Table 1 Supplier Importance Rating Scale (Top 10)

ID	Material Category	Original rating (α=0.8)	After adjustment (α=0.8)	Original rating (α=1)	After adjustment (α=1)	Original rating (α=1.2)	After adjustment (α=1.2)
S229	A	0.97	0.97	0.97	0.97	0.88	0.88
S140	B	0.88	0.88	0.89	0.89	0.81	0.81
S361	C	0.90	0.86	0.91	0.86	0.80	0.76
S108	B	0.78	0.78	0.78	0.78	0.71	0.71
S151	C	0.67	0.67	0.67	0.67	0.61	0.61
S282	A	0.63	0.63	0.62	0.62	0.57	0.57
S340	B	0.62	0.62	0.62	0.62	0.56	0.56
S329	A	0.60	0.60	0.60	0.60	0.54	0.54
S139	B	0.59	0.59	0.58	0.58	0.53	0.53
S275	A	0.61	0.58	0.60	0.57	0.53	0.51

The top 50 important suppliers are shown as Figure 2.

1—10	11—20	21—30	31—40	41—50
S229	S131	S352	S067	S197
S140	S308	S143	S064	S388
S361	S330	S307	S174	S310
S108	S356	S239	S076	S263
S151	S268	S266	S126	S189
S282	S306	S218	S075	S007
S340	S201	S169	S141	S186
S329	S395	S202	S113	S376
S139	S194	S221	S066	S092
S275	S348	S392	S157	S291

Figure 2 50 supplier selection results

The darker color is the one that appears 3 times in Γi, i = 1, 2, 3, and the lighter color is the one that appears 2 times. The three species α differ only in the selection of suppliers in the lower ranking (among the top 50). This indicates that the selection of our indicators can make the gap between different suppliers almost independent of the value of α within a certain range.

4. Models and Rational Analysis

We identified the most important fifty suppliers through the importance scoring model, and to verify the rationality of the evaluation model, in order to verify the rationality of the evaluation model, we cross-sectionally compared the total rating of all suppliers, the number of secure transactions, the accuracy of supply, the volume of products produced per supply, and the market share. In order to verify the rationality of the evaluation model, we cross-sectionally compared the total rating, the number of secure transactions, the accuracy of supply, the volume of products produced per supply, and the market share of all suppliers, and visualized the data.

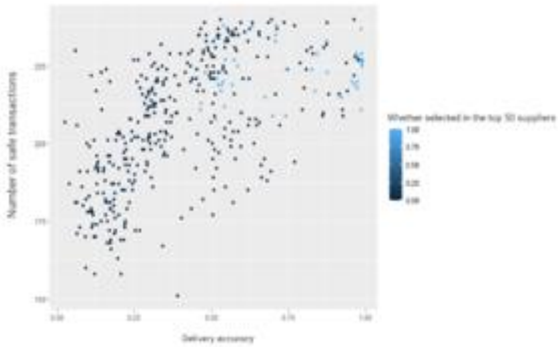

Figure 3 Accuracy of supply, number of secure transactions

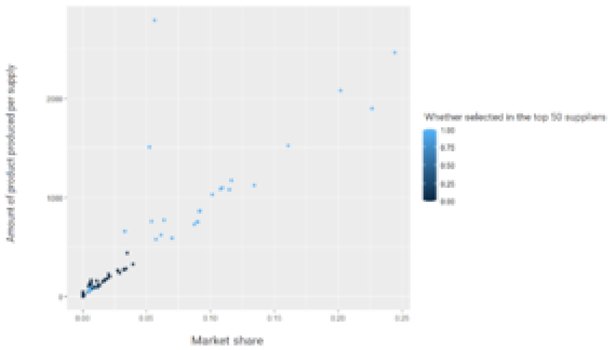

Figure 4 Market share, volume of products per supply

In Figure 3, Figure 4, the lighter the blue color, the higher the importance score. We found that our selection of the more We found that the more important companies we selected have better supply accuracy, number of secure transactions, market share, and the corresponding product volume per supply. We find that the more important companies we selected have a better profile in terms of supply accuracy, number of secure transactions, market share, and volume per supply.

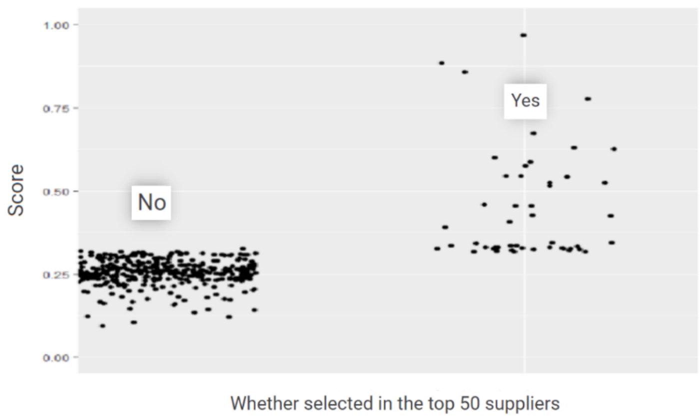

Figure 5 Top 50 vs. other supplier ratings

In addition, analyzing Figure 5, the overall ratings of all fifty suppliers are significantly higher than the rest of the suppliers. The indicators we have chosen can successfully separate the more important suppliers from the others. Therefore, both in terms of (positive) secondary indicators, the results are in line with the objective pattern, both in terms of the values of the (positive) secondary indicators and the differences between the scores, proving that our scoring model is reasonable and correct. Our scoring model is reasonable and correct.

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