Evaluation and selection of auto spare parts suppliers in supply chain

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Abstract: In order to reduce the cost of automobile manufacturing, it combines with the improved multi-objective analytic hierarchy process (AHP), establishes a supplier evaluation system to make a choice of suppliers. Taking the procurement status of a specific company as an example, the rationality of the choice of parts suppliers is analyzed.

1. Introduction
Nearly 70% of the total cost of automobile manufacturing comes from purchased auto parts. If the procurement cost is reduced by 1%, the profit will be increased by 5% to 10%, which shows that the evaluation and selection of auto parts suppliers in the supply chain sector is of great significance to automobile manufacturers. Therefore, a scientific supplier evaluation system should be established, and then the supplier should be evaluated by reasonable methods[1-2].

2. Selection and Evaluation Supplier System
2.1 improved multi-objective AHP
The traditional analysis hierarchical method uses nine scales to compare the indicators of the same level, and the actual operation is more difficult[3]. The improved analysis hierarchical method uses three scales, the two comparisons only judge whether it is important or not, or equally important. Here are the steps.

(1) Confirm the target hierarchy
The target to be evaluated is layered, divided into the highest, middle and bottom ground according to the target influencing factors.

(2) Constructing a judgment matrix
After the establishment of the multi-hierarchy model, the two factors of the same level are compared with each other, and the relative scale is used to obtain the comparison matrix C.

\[ C = \begin{bmatrix}
    a_{11} & a_{12} & \cdots & a_{1n} \\
    a_{21} & a_{22} & \cdots & a_{2n} \\
    \vdots & \vdots & \ddots & \vdots \\
    a_{n1} & a_{n2} & \cdots & a_{nn}
\end{bmatrix} \]

Scale scales are based on the following comparison matrix:

\[ C_{ij} = \begin{cases} 
2 & i \text{ is more important than } j \\
1 & i \text{ is as important as } j \\
0 & i \text{ is not important than } j 
\end{cases} \quad (i,j=1,2,3,\ldots,n) \]

Sort the importance of individual elements with the following formula:
\[ F_i = \sum_{j=1}^{n} c_{ij} (i = 1, 2, \ldots, n) \]  

(1)

\[ \text{f}_{\text{max}} \text{ is the max Sorting Index, f}_{\text{min}} \text{ is the minimum Sorting Index, C}_{\text{max}} \text{ is the max factor in the ranking index, C}_{\text{min}} \text{ is the minimum factor in the ranking index, and the two factors as the basic comparative factors, after the managers compare, assess their relative importance B}_m \ (>1) \text{, and then use the following conversion formula to find the relative importance between the elements:} \]

\[ \text{f}_{ij} = \frac{\text{f}_{\text{max}} - \text{f}_{ij}}{\text{f}_{\text{max}} - \text{f}_{\text{min}}} (B_m - 1) + 1(\text{f}_{ij} - \text{f}_{ij} \geq 0) \]

(2)

The corresponding judgment matrix:

\[
\begin{bmatrix}
f_{11} & f_{12} & \cdots & f_{1n} \\
 f_{21} & f_{22} & \cdots & f_{2n} \\
 \vdots & \vdots & \ddots & \vdots \\
 f_{n1} & f_{n2} & \cdots & f_{nn}
\end{bmatrix}
\]

Solve feature vector w

First calculate the product of each row of elements of the judgment matrix F, then calculate the three square root \( W_i \) of \( M^i \), and then normalize the vector (so that the sum of the elements in the vector is equal to 1)

\[ \bar{W}_i = \frac{W_i}{\sum_{j=1}^{n} W_j} \]  

(3)

This gives you the individual proportion of each metric in each layer, as well as the weight between the layers.

Consistency test

First of all, the maximum characteristic value of the judging matrix is determined \( \lambda_{\text{max}} \):

\[ \lambda_{\text{max}} = \frac{1}{n} \sum_{i=1}^{n} (F \cdot w) \]

(4)

\[ (F \cdot w \text{ means the product of the judgment matrix and the characteristic vector.}) \]

\[ \bar{W}_i \text{ means the ith element of the feature vector w.} \]

Then the consistency indicator can be calculated: \( \text{CI} = \frac{\lambda_{\text{max}}}{\sum_{j=1}^{n} \bar{W}_j} \)  

(5)

(\text{CI represents consistency indicator, CI equals 0 is completely consistent, CI close to 0 means to have satisfactory consistency, the greater the CI inconsistency is more serious})

Then calculate the test coefficient: \( \text{CR} = \frac{\text{CI}}{\text{RI}} \)  

(6)

(\text{RI represents a random consistency indicator, CR represents a test coefficient, and when CR 0.1, the result of the judgment matrix passes the consistency test; if the CR is 0.1, then the judgment matrix does not meet the consistency test, and the decision matrix is invalid.})

2.2 The establishment of the supplier evaluation system

In the selection of suppliers[4], the establishment of the first-level indicators to be able to truly reflect the actual situation of suppliers, the paper intends to choose the quality (mark A), delivery capacity (mark B), price (mark C), technical level (mark D) and service level (mark E) of these five as a first-level
indicators, and the second-level are Product pass rate (mark A), Quality inspection capability (mark A), Quality certification (mark A), Timely delivery (mark B), Accurate delivery (mark B), Delivery efficiency (mark B), Product prices (mark C), Price stability (mark C), Terms of payment (mark C), Self-design (mark D), Degree of automation (mark D), Infrastructure (mark D), Technical improvement capabilities (mark D), Service response time (mark E), Level of after-sales service (mark E), Service attitude (mark E).

After understanding the characteristics of the supply chain, the next step is to determine the weight of the indicators. First of all, the above evaluation indicators, combined with the three scale method to construct the comparison matrix, to obtain the following table as shown:

|   | A     | B     | C     | D     | E     |
|---|-------|-------|-------|-------|-------|
| A | 1     | 2     | 2     | 2     | 2     | 9     |
| B | 0     | 1     | 2     | 2     | 2     | 7     |
| C | 0     | 0     | 1     | 2     | 2     | 5     |
| D | 0     | 0     | 0     | 1     | 2     | 3     |
| E | 0     | 0     | 0     | 0     | 1     | 1     |

Using formula (2) to obtain the judgment matrix \( F \) of the first-level indicator

\[
F = \begin{bmatrix}
1 & 1.25 & 1.5 & 1.75 & 2 \\
0.8 & 1 & 1.25 & 1.5 & 1.75 \\
0.67 & 0.8 & 1 & 1.25 \\
0.57 & 0.67 & 0.8 & 1 \\
0.57 & 0.67 & 0.8 & 1
\end{bmatrix}
\]

Using formula (3), the product of each row of the matrix is calculated, and the result is

\[
M_1 = 6.5625, M_2 = 2.625, M_3 = 1.005, M_4 = 0.3819, M_5 = 0.15276
\]

Add \( M_1 \) to \( M_4 \) and open the root three times to get \( \sum_{i=1}^{n} w_i = 5.5134 \)

Then \( \omega_1 = 0.3395, \omega_2 = 0.2503, \omega_3 = 0.1817, \omega_4 = 0.1316, \omega_5 = 0.0970 \)

So:

\[
F \cdot \omega = \begin{bmatrix}
1.3492 \\
1.1016 \\
0.9072 \\
0.7490 \\
0.6498
\end{bmatrix}
\]

The next step is to use formula (4) to calculate \( \lambda_{max} = 5.1855 \)

use formula (5) to calculate CI = 0.0464

use formula (6) to calculate CR = 0.0414

Sort out the judging matrix and weights shown in Table 2 below:

|   | A     | B     | C     | D     | E     | weight |
|---|-------|-------|-------|-------|-------|--------|
| A | 1     | 2.25  | 3.5   | 4.75  | 6     | 0.3395 |
| B | 0.44  | 1     | 2.25  | 3.5   | 4.75  | 0.2503 |
| C | 0.29  | 0.44  | 1     | 2.25  | 3.5   | 0.1817 |
| D | 0.21  | 0.29  | 0.44  | 1     | 2.25  | 0.1316 |
| E | 0.17  | 0.21  | 0.29  | 0.44  | 1     | 0.0970 |

\( b_{max} = 5, \lambda_{max} = 5.1855, CI = 0.0464, CR = 0.0414 \)

As a result of CI\(R\) = 0.0414 < 0.1, the constructed first-level indicator judgment matrix meets the consistency requirements.
Using the same methods and steps, the indicator weights of the secondary indicators are calculated.

After the weight of the evaluation index is established, the evaluation matrix $Q$ is constructed. Then, combined with the evaluation index comprehensive weight and evaluation matrix $Q$, the potential suppliers of their own scores.

The final score of the potential supplier is: $R = \omega \times Q \quad (7)$

3. Instance analysis
Taking the procurement management of gears of a car manufacturer as an example, it is reasonable to re-judge the supplier's choice. After selecting elimination at the procurement level, there are three potential suppliers left. A comprehensive score of 16 evaluation indicators for the three supplier spare parts factories is shown in the 3-1 evaluation matrix in table 3.

|   | Manufacturers 1 | Manufacturers 2 | Manufacturers 3 |
|---|----------------|----------------|----------------|
| $A_1$ | 6              | 4              | 5              |
| $A_2$ | 4              | 5              | 6              |
| $A_3$ | 6              | 5              | 5              |
| $B_1$ | 6              | 6              | 7              |
| $B_2$ | 7              | 5              | 6              |
| $B_3$ | 8              | 7              | 5              |
| $C_1$ | 8              | 6              | 7              |
| $C_2$ | 7              | 5              | 4              |
| $C_3$ | 8              | 7              | 7              |
| $D_1$ | 6              | 6              | 7              |
| $D_2$ | 7              | 5              | 8              |
| $D_3$ | 7              | 6              | 6              |
| $D_4$ | 9              | 5              | 7              |
| $E_1$ | 8              | 6              | 9              |
| $E_2$ | 5              | 9              | 6              |
| $E_3$ | 6              | 5              | 7              |

Using formula (7), the comprehensive score $R$ of the three suppliers was derived

$R = \omega \times Q = (6.4291, 5.4647, 6.2402)$, Thus, Supplier 1 has the highest score, and the car manufacturer should select Supplier 1 as its best supplier of gears. In fact, the company's previous lying supplier was also this one, indicating that the evaluation system was reasonable.

4. Conclusions
Using the improved hierarchical analysis method, this paper re-establishes the five first-level indicators of quality, delivery capacity, price level, technical capability, service level, etc., quality inspection system, quality certification, delivery timeliness, delivery accuracy, delivery efficiency, product price, price stability, payment terms, independent design, The respective weights of 16 secondary indicators, such as automation degree, infrastructure scale, technology improvement capability, service response time, after-sales service level, service attitude, etc., and the evaluation matrix $Q$ and scoring system $R$ are constructed for evaluation and selection of potential suppliers. It can make the subjective factors of decision makers be greatly reduced, the evaluation results can be more scientific and objective, the credibility can be improved, and the accuracy of the system is verified by example, which provides a reference for the automobile manufacturers' purchasing management of auto parts.

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