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# Study on model evaluation and selection of logistics service supplier based on hybrid value decision information

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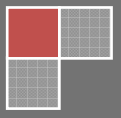
## ABSTRACT

In cooperation of supply chain, evaluation and selection of product supplier is a key element and core task for assuring whole supply chain to operate orderly and normally. The study analyzed and studied model of hydrid value decision information according to its logistics service form in supplier evaluation and selection. Study on supplier selection was divided into three methods: qualitative studying method, quantitative studying method, interrelated qualitative and quantitative studying method. In models of supplier selection, no matter which model of supplier is selected eventually, it will be dependent on basic data of decision information and will need to borrow the information data for multiple supplier evaluation to a certain degree. With relevant calculation methods and specific examples, the study proved that there were two main kinds of information in decision information of supplier selection model: fixed value data and interval data. According to this analysis, the study conducted supplier selection method based on hybrid value decision information. Selecting method was used for analysis and study on model of logistics service supplier evaluation and selection. With deciding method of maximization of division grade and probability difference, the study multiply analyzed and studied logistics service supplier selection, explained and introduced specific calculating methods, and conducted further discussion with relevant examples.

## KEYWORDS

Supplier selection; Interval value; Hybrid number, Calculating method.





## INTRODUCTION

There were certain disadvantages in former multiple supplier evaluation. The main element which caused disadvantages was that weight of supplier's attribute index was not completely accurate or correct, final result of evaluation might be unreasonable at some points; as a result, decision matrix of supplier's attribute value was limited relevantly and qualitative index of supplier was not accurate or precision.

## ANALYSIS AND STUDY ON SUPPLIER SELECTION METHODS BASED ON HYDRID VALUE DECISION INFORMATION

### Disadvantages of supplier selection method

Disadvantages of multiple evaluation mentioned above ws summarized into two big aspects as follows:

(1) The main reason which caused deviation of logistics service supplier evaluation was that weight of attribute index of supplier was not completely, reasonably or equally accurate. There are two ways to confirm attribute value of supplier: subjective and objective weighting approach. Subjective weighting approach refers that decision maker provides information directly, for example, specification vector method, minium square method, AHP calculating method and Delphi multiple calculating method; these methods are reasonable, doable and scientific at certain degree; however, there are also disadvantages and shortages about them more or less, the most obvious disadvantage is that index weighting is subjective at certain degree when it is assigned, deviation will appear eventually and bring influence on logistics service supplier evaluation methods. Objective weighting approach is a method completely based on decision matrix information, for example, fuzzy clustering method C23 applied in multiple supplier evaluation, optimization of multiple targets method, subjective elements analysis and etc. The biggest advantage of studying methods mentioned above is that they are objective, reasonable, doable and effective, that they can efficiently avoid some artificial and uncertain elements, objective degree and attribute value of logistics service supplier are related at certain degree.

(2) Supplier's attribute value based on decision matrix is greatly interfered by subjective elements. At the same time, it is difficult for qualitative index of multiple supplier evaluation to reach to some specific accurate value. The study analyzed and studied each attribute index of suppliers, analyzed each attribute value through decision matrix in studying way of quantization. The biggest advantage of applying decision matrix is that it is scientific, doable and reasonable, that it will not be interfered by subjective reasons, include personality, hobby, view of value, knowledge and etc. As society improves and develops constantly, people need to consider each factor of their lives multiply, they need to face, analyze and study influence caused by complicated and uncertain problems and fuzzy ideas to results. During process of making decision, specific objects will show various qualitative indexes which are mainly caused by quantitative results of decision matrix as described in the study. Normally, hydrid value information is used as decision matrix data of multiple supplier evaluation. It consists of two kinds of data information, fixed value data information and interval data information. Fixed value data information refers to quantitative index of supplier attribute index, for example, product price of supplier is a kind of fixed value data information. Interval data information refers to specific index of supplier attribute index which can be obtained through quantitative method, but information obtained eventually is uncertain and fuzzy.

### Study on model evaluation and selection of logistics service supplier based on hydrid value information

In study on model evaluation and selection of logistics service supplier based on hydrid value information, a large number of documents were used for explanation and analysis. About supplier selecting method based on interval decision information, scholar Zeshui XU believed that supplier attribute index should be analyzed and studied through interval multi-attribute decision method. In study of supplier selecting method, the scholar used multi-attribute decision method which focused on big deviation of division degree and probability; this method was scientific, reasonable, doable and it suited for interval numbers. However, it was not completely applicable for hydrid value decision information. In the study, interval data information of decision matrix and fixed value data information were analyzed and studied multiply, supplier selection method based on hydrid value decision information was applied eventually. The biggest advantage of the method was that real decision information of decision matrix could be used for expressing and describing; then weight vector of decision matrix was obtained through interval division degree method; artificial uncertain and fuzzy elements of supplier attribute index were avoided efficiently so that eventual result of supplier evaluation was scientific and efficient. In normal life, there are two kinds of supplier selection methods based on decision information: weight vector of supplier attribute index and value assignment of relevant supplier attribute index through quantitative study method mentioned above. At the same time of obtaining decision information, efficient information decision method could be used for multiple analysis and evaluation. There are good and bad results in multiple supplier evaluation, specific evaluation result depend on accuracy and reliability of primary decision information applied in evaluation method for supplier selection. In another word, result of supplier evaluation and accuracy of decision information are related and interacted at certain degree. In the study, analysis was conducted on basis of former supplier evaluation method; disadvantages of supplier evaluation were found and analyzed. The main reason of disadvantages was that weight vector of supplier attribute index was not completely accurate or precision, eventual result was unreasonable at certain degree, decision matrix of supplier attribute value was limited relatively, at the same time supplier qualitative index was not completely accurate and precision.

**Analysis of specific process**

Usually, manufacture needs to conduct multiple evaluation of decision on purchasing in order to select reasonable and proper supplier. It conducts multiple evaluation and analysis of four big modules: business operating module in product supplier's operation, producing potential in product manufacture, product quality security system and enterprise environment of supplier. Eventually, supplier selection is analyzed and decided reasonably. Main operation process of model of logistics evaluation and selection based on hydrid value information was summarized as follows:

(1) On aspect of supplier selecting, assume X, U, $\tilde{A}$, $\tilde{R}$ and $\phi$ which refer to supplier object set, supplier price index set, supplier decision matrix, supplier generalized decision matrix and supplier attribute weight interval number set. In this study, n suppliers were assumed to participate in selection, m index in supplier evaluation index set, include $m_1$ set-value index and $m_2$ interval index, and $m_1 + m_2$ =m. Formula of decision matrix was $\tilde{A} = (a_{ij})_{n\times m_1} = [(a_{ij})_{n\times m_1}, (a_{ij}^L, a_{ij}^U)_{n\times m_2}]$, formula of normalized decision matrix was $\tilde{R} = (\tilde{r}_{ij})_{n\times m} = [(r_{ij})_{n\times m_1}, (r_{ij}^L, r_{ij}^U)_{n\times m_2}]$.

(2) Built single target optimization model with maximization ideas of interval distance degree and project attribute deviation.

$$\max D(\omega) = \sum_{i=1}^{n}\sum_{j=1}^{m} n\sum_{k=1}^{n} \left\| \tilde{r}_{ij} - \tilde{r}_{kj} \right\| \omega_i =$$

$$\sum_{i=1}^{n}\sum_{j=1}^{m_1}\sum_{k=1}^{n} (\left| r_{ij} - r_{kj} \right|)\omega_i + \sum_{i=1}^{n}\sum_{j=m_1+1}^{m}\sum_{k=1}^{n} (\left| r_{ij}^L - r_{kj}^L \right| + \left| r_{ij}^U - r_{kj}^U \right|)\omega_j \quad \textbf{(1)}$$

$$s.t. \omega \in \Phi$$

Solve problem with this model, weight vector of supplier attribute could be obtained and represented by $\omega$;

(3) With following formula (2), multiple attribute value of each supplier's project could be obtained and represented by $\tilde{z}_i(\omega)(i \in N)$.

$$\tilde{z}_i(\omega) = \sum_{j=1}^{m} \omega_i \tilde{r}_{ij} \quad \textbf{(2)}$$

(4) Supplier attribute index could be obtained through formula (3) and (4), compared multiple attribute values of each projects, probability grade was expressed as $p_{ij} = p[\tilde{z}_i(\omega) \geq \tilde{z}_j(\omega)](i, j \in N)$, formula of probability grade matrix was $p = [p_{ij}]_{n\times m}$.

Solved problem with formulas mentioned above, analyze interval data of supplier, assume $\tilde{a} = [a^L, a^U], \bar{b} = [b^L, b^U]$, analyzed fixed value data and express as follows,

$$p(\tilde{a} \geq \tilde{b}) = \frac{\min\{(a^U - a^L) + (b^U - b^L), \max((a^U - a^L, 0))\}}{(a^U - a^L) + (b^U - b^L)} \quad \textbf{(3)}$$

There were 2 real numbers in fixed value data information, represented by $\tilde{a}, \tilde{b}$, they satisfied following relationship:

$$p(\tilde{a} > \tilde{b}) = \begin{cases} 1, \tilde{a} > \tilde{b} \\ 0.5, \tilde{a} = \tilde{b} \\ 0, \tilde{a} > \tilde{b} \end{cases} \quad \textbf{(4)}$$

(5) In permutation matrix, supplier probability grade matrix P based on multiple value could be obtained through formula (5), order vector of the matrix was $v = (v_1, v_2, \cdots, v_n)$, compared individual weight of projects and obtain final project, represented as:

$$v_i = \frac{1}{n(n-1)}(\sum_{j=1}^{n} p_{ij} + \frac{n}{2} - 1) \quad \textbf{(5)}$$

## ANALYSIS AND STUDY ON SPECIFIC EXAMPLE ALGORITHM

### Analysis of specific example algorithm

This specific example analyzed car assembly. Some car factory in China needed to select a partner among four gearbox components suppliers which were represented as $s_1, s_2, s_3, s_4$. Car factory needed to conduct multiple molecule study on following indexes: price of gearbox components supplier, delivery term, quality security of products and delivery reliability; except four multiple indexes mentioned above, reputation and development potential of suppliers needed to be analyzed as well. In this study, supplier's decision was represented by fixed value data information of fixed value study method; qualitative indexes were expressed by points which ranged from 1 to 10, 1 point represented bad suppliers while 10 points represented optimistic evaluation result. Besides, price of gearbox components and supplier's delivery term were cost indexes in multiple value decision; four multiple index: quality security of product, reliability, enterprise reputation and development potential were considered as efficiency indexes. What it showed in TABLE 1 was an index matrix of four gearbox components suppliers.

**TABLE 1 : Index matrix of four gearbox components suppliers $\tilde{A}$**

| Gearbox Components Suppliers | Quantitative Index (Fixed Value) | | | | Qualitative Index (Interval Style) | |
|---|---|---|---|---|---|---|
| | Price of Gearbox Components / RMB | Delivery Lead Time / D | Product Quality | Delivery Reliability | Enterprise Reputation | Development Potential |
| $S_1$ | 225 | 19 | 0.92 | 0.94 | [8, 9] | [7, 8] |
| $S_2$ | 208 | 20 | 0.98 | 0.96 | [5, 6] | [6, 7] |
| $S_3$ | 200 | 22 | 0.9 | 0.8 | [7, 9] | [8, 9] |
| $S_4$ | 235 | 24 | 0.99 | 0.88 | [5, 7] | [6, 8] |

Weight information of suppliers' multiple indexes were represented as:

$$\begin{aligned}&\Phi = \{\omega = (\omega_1, \omega_2, \cdots \omega_6) \,|\, 0.15 \le \omega_1 \le 0.18,\\ &0.16 \le \omega_2 \le 0.17, 0.17 \le \omega_3 \le 0.18,\\ &0.14 \le \omega 4 \le 0.19, 0.13 \le \omega_5 \le 0.16,\\ &0.16 \le \omega_6 \le 0.12, \sum_{j=1}^{6} \omega_j = 1\}\end{aligned} \quad \textbf{(6)}$$

TABLE 2 is the analysis of efficiency values in multiple evaluation of suppliers from different probability grades.

**TABLE 2 : Analysis of efficiency values in multiple evaluation of suppliers from different probability grades**

| $\lambda_0$ Supplier | 0 | 0.1 | 0.2 | 0.3 | 0.4 | 0.5 | 0.6 | 0.7 | 0.8 | 0.9 | 1 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0.7984 | 0.8148 | 0.8322 | 0.8506 | 0.8701 | 0.8908 | 0.9068 | 0.9239 | 0.9427 | 0.9632 | 0.9855 |
| 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0.9937 | 0.9842 | 0.9749 | 0.9658 |
| 3 | 0.9997 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 4 | 0.9264 | 0.9377 | 0.9495 | 0.9653 | 0.9848 | 1 | 1 | 1 | 1 | 1 | 1 |
| 5 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 6 | 0.7885 | 0.7890 | 0.7895 | 0.7900 | 0.7905 | 0.7909 | 0.7914 | 0.7918 | 0.7923 | 0.7927 | 0.7931 |
| 7 | 0.9996 | 0.999 | 0.9996 | 0.999 | 0.9997 | 0.997 | 0.9997 | 0.997 | 0.9997 | 0.997 | 0.9998 |
| 8 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |

As shown in Figure 1, it was a curve Figure of relative efficiency value in supplier selection and it was based on analysis of comparative efficiency value in multiple evaluation of suppliers,

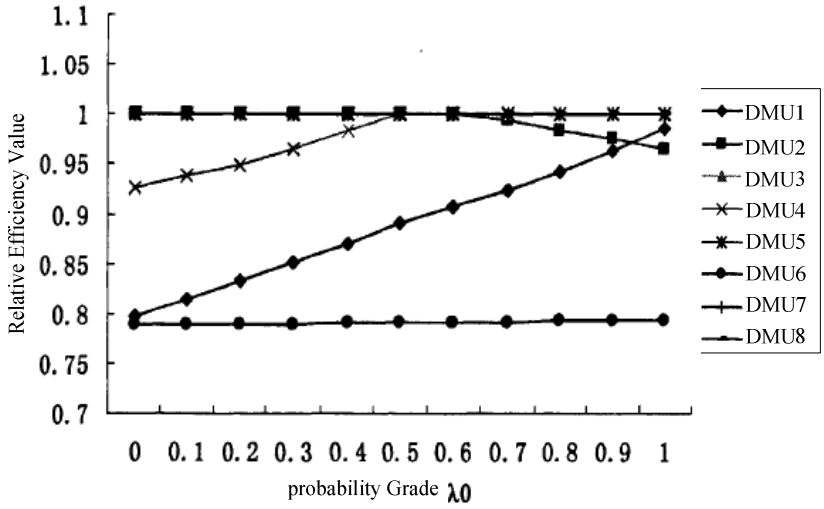



**Figure 1 : Curve figure of relative efficiency value in supplier selection**

It is a flow Figure of relative logistics service supplier selection shown in Figure 2.

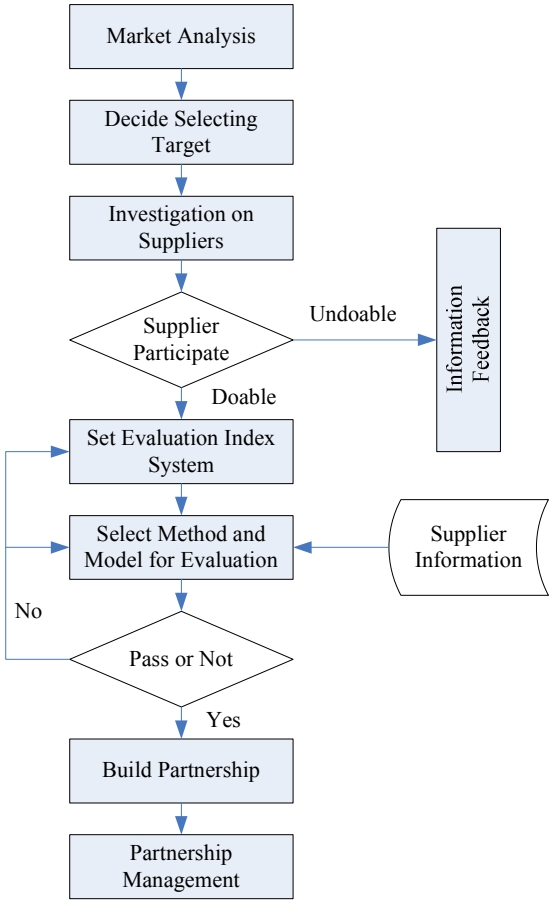



**Figure 2 : Flow figure of logistics service supplier selection**

**Matrix analysis of supplier selecting methods**

Following operations should be conducted according to multiple study and analysis of supplier selecting methods mentioned above:

(1) Calculated each index of suppliers according to efficiency style interval data information, programmed decision on interval data and calculate main selecting method with following formula. It was a decision matrix obtained through specification decision method as shown in TABLE 3.

**TABLE 3 : Decision matrix obtained through specification decision method $\tilde{R}$**

| Gearbox Components Suppliers | Quantitative Index (Fixed Value) | | | | Qualitative Index (Interval Style) | |
|---|---|---|---|---|---|---|
| | Price of Gearbox Components / RMB | Delivery Lead Time / D | Product Quality | Delivery Reliability | Enterprise Reputation | Development Potential |
| $S_1$ | 0.889 | 1.000 | 0.929 | 0.979 | [0.509, 0.705] | [0.436, 0.588] |
| $S_2$ | 0.962 | 0.950 | 0.990 | 1.000 | [0.318, 0.470] | [0.374, 0.515] |
| $S_3$ | 1.000 | 0.864 | 0.909 | 0.833 | [0.445, 0.705] | [0.498, 0.662] |
| $S_4$ | 0.851 | 0.792 | 1.000 | 0.917 | [0.318, 0.548] | [0.374, 0.588] |

(2) Analyzed each quality of suppliers through interval division grade method and eventually built optimization model which could be expressed as follows:

$$\begin{aligned} &\max D(\omega) = 1.04\omega_1 + 1.42\omega_2 + 0.668\omega_3 + 1.126\omega_4 + 3.124\omega_5 + 1.75\omega_6 \\ &s.t.\quad 0.15 \le \omega_1 \le 0.18, 0.16 \le \omega_2 \le 0.17, \\ &\quad 0.17 \le \omega_3 \le 0.18, 0.14 \le \omega_4 \le 0.19, \\ &\quad 0.13 \le \omega_5 \le 0.16, 0.16 \le \omega_6 \le 0.2, \\ &\quad \sum_{j=1}^{6} \omega_j = 1 \end{aligned} \tag{7}$$

During calculation, model of supplier multiple evaluation selection method was obtained through software LINGO 8.0, expression of optimization weight vector was $\omega = (0.15, 0.17, 0.17, 0.15, 0.16, 0.2)$.

Through formula (2) mentioned above, obtained multiple attribute value which could be expressed as $\tilde{z}(\omega)(i \in N)$, eventually obtained relative index expression which could be expressed as $\tilde{z}_1(\omega) = [0.776\ \ 74, 0.8385], \tilde{z}_2(\omega) = [0.74996, 0.8023], \tilde{z}_3(\omega) = [0.74716, 0.82156], \tilde{z}_4(\omega) = [0.69552, 0.77512]$.

(4) Compared multiple attribute values of suppliers and built probability matrix which could be expressed as follows:

$$p = \begin{bmatrix} 0.5 & 0.7760 & 0.6708 & 1 \\ 0.2240 & 0.5 & 0.4351 & 0.8093 \\ 0.3292 & 0.5649 & 0.5 & 0.8184 \\ 0 & 0.1907 & 0.1816 & 0.5 \end{bmatrix} \tag{8}$$

(5) Order weight vector P could be obtained through formula (4) and expressed as follows:

$$v = (0.3289, 0.2474, 0.2677, 0.1560) \tag{9}$$

According to order vector V and Matrix P, order of interval number could be obtained as follows: $\tilde{z}_i(\omega)(i = 1, 2, 3, 4)$

$$\tilde{z}_1(\omega) \underset{0.6708}{\ge} \tilde{z}_3(\omega) \underset{0.5649}{\ge} \tilde{z}_2(\omega) \underset{0.8093}{\ge} \tilde{z}_4(\omega) \tag{10}$$

Compared values of $\tilde{z}_i(\omega)(i = 1, 2, 3, 4)$ and obtained comparison of suppliers:

$$s_1 \underset{0.6708}{\ge} s_3 \underset{0.5649}{\ge} s_2 \underset{0.8093}{\ge} s_4 \quad (11)$$

According to above multiple analysis of specific example we can see that analysis of final selecting result is as follows: Supplier 1 had probability of 0.6708 which was higher than Supplier 3; Supplier 3 had probability of 0.5649 which was higher than Supplier 2; and Supplier 2 had probability of 0.8093 which was higher than Supplier 4. It means that the final best selection of gearbox components supplier as partner of the enterprise was Supplier 1. On basis of analysis above, flow figure of relevant task assignment in logistics service was built as shown in Figure 3.

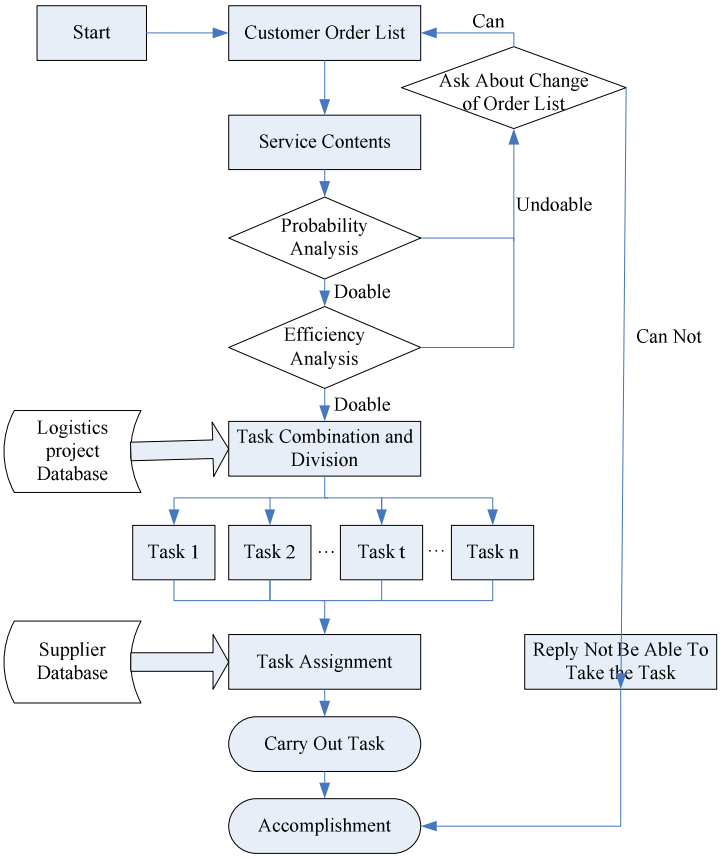



**Figure 3 : Flow figure of relevant task assignment in logistics service**

## CONCLUSION

The study analyzed and studied selecting methods of hybrid value decision information suppliers, found out disadvantages of former multiple evaluation of suppliers, made use of hybrid value decision information method, and studied multiple evaluation model of logistics service suppliers. The method of making decision on maximization of division grade and probability deviation was applied, specific calculating steps based on multiple analysis and evaluation of logistics service suppliers were explained and introduced, on basis of this, relevant examples were used for further discussion. Compared with former multiple evaluation selecting model of logistics service suppliers, the most creative part of this study was that, weight vector was obtained through decision matrix, atmosphere which did not suit reality was avoided, serious consequence caused by deviation of decision information was prevented, scientific and reasonable multiple evaluation of suppliers was conducted eventually.

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