

## ***The Third-Party Reverse Logistics Service Provider Selection of Automobile Manufacturing Based on Analytic Hierarchy Process***

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**Abstract:** With the development of society, people have gradually realized the importance of saving resources. With the improvement of the relevant system, enterprises must recognize their social responsibility, especially the automobile manufacturing enterprises who has outstanding problems about recycling of resources and waste recycling products. In order to reduce costs and focus on the development of their core business, many small and medium enterprises choose professional third-party reverse logistics service providers. This thesis analyses the characteristics and present situation of the reverse logistics of automobile manufacturing industry, then designs and establishes the evaluation index system of the third-party reverse logistics service provider from the perspective of automobile manufacturing industry, which shows the true level of service providers and business conditions. And then it uses the analytic hierarchy process to determine the weight of the factors, and evaluates the choice through the fuzzy comprehensive evaluation of third-party reverse service providers. Reasonable evaluation system and methods choose the best solution for third-party reverse logistics service providers.

### **1. INTRODUCTION**

With the development of society, people are increasingly aware of the importance of environmental protection. Harmony of human and environment, the relationship between resources, not only for the long-term stability of human society development is of great significance, but also related to the progress of human civilization. Therefore, the protection of the environment in today's times, the rational use of resources has become everyone, each group can not ignore the responsibility (Huali Sun,2011).

In 2016, China's gross domestic product reached 74412.7 billion RMB. It is increase of 6.7% over the previous year. Among the annual sales of 260.4 million vehicles, the growth rate of about 6%. To maintain such a speed, China's automobile production and sales in 2020 are expected to reach 43.1 million and 42.86 million units. The rapid growth of automobile consumption, 2013 China's "motor vehicle mandatory retirement standards" in the specified passenger and truck life is generally 10-15 years (Huijuan Yu,2010). This means that China began to enter the car scrapped the peak period. Followed by the recovery of products, materials and recycling issues, which in order to protect the environment to improve the utilization of resources, circular economy will become an important part of future economic development (Yixin Zhu,2012). At the same time, for example :due to the technical update, the flexibility of the production process, the product life cycle is shortened, the product design is more customer-centric, that the annual performance and value due to replacement, return, over-production, recall, scrapping and damage losses are growing at an alarming

rate(Mengting Wu,2015).In this context, more and more enterprises aware of the need for reverse logistics, business development of reverse logistics, reduce operating costs, and more resources on the core competitiveness of the increase. And the development of reverse logistics to achieve the re-use of resources to protect our living environment, which conform to the concept of sustainable development.

Compared with the general logistics, reverse logistics has more uncertainty, complexity and scale of non-economic. In the classification testing and recycling of reflow products,it need for professional equipment and technical personnel. For different product features and the number, it may require different processing equipment. In the establishment of reverse logistics management system, the technical resources and hardware resources are demanding. But companies tend to put all the energy into their own core competitiveness of the development.

### **2. RESEARCH STATUS**

The concept of reverse logistics was first proposed by the American scholar in a report, he believes that reverse logistics is the raw materials and finished products from the consumer to the initial flow of the planning, implementation and control process, and it with high efficiency, low cost characteristics. Chinese scholars Hu Jailing(2004) think that reverse logistics is the process of returning the raw materials, semi-finished products, final products and information resources from the downstream of the supply chain in order to realize the secondary use value of the products and to deal with the discarded products(Zhengxin Ding,2014).Waste logistics refers to the loss of value of the items, according to the actual

needs to the specialized processing sites for collection, classification, processing, packaging, handling, storage. The paper analyzes the three modes of operation of reverse logistics, and constructs a multi-level, multi-stage reverse logistics network system based on the uncertainty of reverse logistics, considering the recycling problem of waste products (Xiao Yan, 2011).

Choose a third party reverse logistics service providers, it need to establish a suitable evaluation index system. In the design of the evaluation system, Jiang (2009) put forward the comprehensive consideration from the six aspects of management level, basic logistics ability, cost advantage, information level, customer service level and enterprise reputation. Lu Juan (2010) and Zhao Li'e (2011) used the AHP method to select the cost, environmental performance, service ability and enterprise basic quality as the index of the reverse logistics service provider when choosing the reverse logistics service provider of the automobile manufacturing enterprise. In determining the weight of the evaluation index, many scholars use analytic hierarchy process to solve the problem. American operations scientist Saaty in the 20th century decomposes the decision-making factors into the levels of objectives, criteria and schemes, followed by quantitative, qualitative analysis, systematic, flexibility and simplicity (Biyun Liang, 2013). Chen Yuemei (2012) comprehensive use of analytic hierarchy process and fuzzy evaluation method of two methods, analysis of the reverse logistics service providers to choose. Shao Hua (2011) uses the fuzzy comprehensive evaluation method to construct the comprehensive evaluation model, and chooses the alternatives synthetically. Based on the membership degree theory of fuzzy mathematics, fuzzy comprehensive evaluation method combines qualitative and quantitative, and makes an overall evaluation of objects subject to multiple factors, which is suitable for solving various non-deterministic problems (Saurabh A., et al, 2016).

In this paper, through the analysis of the current situation of reverse logistics market in China, combined with the market professionals to determine the investigation, to complete the third-party reverse logistics service provider evaluation index system design. Finally, the fuzzy comprehensive evaluation method is used to evaluate the alternatives of the third party reverse logistics service providers of automobile manufacturing industry. In the construction of judgment matrix, due to the relatively important degree of factors is difficult to determine and the impact on the follow-up results, this paper uses a questionnaire survey method, to engage in reverse logistics industry staff, the reverse logistics has great demand for automobile manufacturing Industry staff and related fields of experts and scholars conducted a survey and analysis. And further through the fuzzy comprehensive evaluation method to calculate the membership of the options in the case, to its comprehensive sort, find the best solution.

### 3. EMPIRICAL ANALYSIS

#### 3.1 AHP to determine the weight

The core part of the analytic hierarchy process is the establishment of the judgment matrix, but when the factors are too many, people's thinking is prone to chaos leading to the deviation of the results. Therefore, in order to ensure the reliability of the results, in the calculation of weight after the need to confirm the consistency of the matrix test. AHP implementation steps are as follows:

(1) Analyze the problem, according to the decision-making objectives, considerations and decision-making relationship between the establishment of hierarchical model.

(2) The unity of the two factors compared to build a judgment matrix.

(3) Level single order. Calculate the relative weights of the factors at this level.

(4) To conduct a consistency test. Consistency test index  $CI = \frac{\lambda_{max} - n}{n - 1}$ , calculate the average random consistency ratio  $CR = \frac{CI}{RI}$ , where RI is the same order average consistency index, when  $CR < 0.1$  that the judgment matrix is consistent, otherwise adjust the judgment matrix.

The weight of each factor is obtained, and then the fuzzy comprehensive evaluation method is used to further analyze the alternatives.

#### 3.2 Selection of third party reverse logistics service by Fuzzy Comprehensive Evaluation Method

Using the fuzzy comprehensive evaluation method to evaluate the third party reverse logistics service providers, the implementation steps are as follows:

(1) Determine the set of evaluation factors according to the evaluation index system.

$U = \{U_1, U_2, U_3, U_4\}$

(2) to determine the rating level =  $\{v_1, v_2, v_3, v_4, v_5\}$

(3) to establish fuzzy relations matrix.

(4) to determine the weight of the evaluation factor vector.

(5) The results of fuzzy comprehensive evaluation are analyzed.

### 4. EXAMPLE APPLICATION

M enterprises are China's medium-sized automobile manufacturing enterprises. The company intends to outsource the reverse logistics business to a professional third party reverse logistics provider. There are currently three third party reverse logistics service providers  $P_1, P_2, P_3$  to choose from. Which  $P_1$  has 74 operations center, access to a number of countries and regions.  $P_2$  enterprises adhere to customer demand as the core, and actively expand diversified business.  $P_3$  enterprises covering 31 provinces and Hong Kong, Macao and Taiwan regions. As M companies want to establish long-term cooperative relationship with service providers, and ultimately decided to use the Analytic Hierarchy Process to determine the weight, fuzzy comprehensive evaluation method for reverse logistics service providers

to evaluate the selection. The process is as follows.

#### 4.1 AHP to determine the weight

The first step, according to the third chapter of the establishment of the evaluation index system to build the hierarchical model (Figure 1).

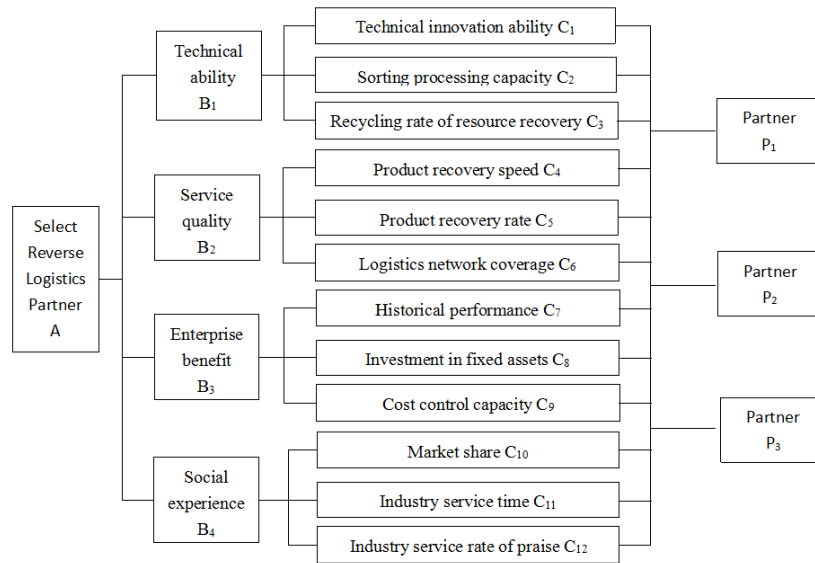


Fig 1 Evaluation index system Hierarchical model

In the second step, when building the judgment matrix, in order to determine the relative importance of the factors between the two, I have taken the form of a questionnaire surveyed by employees engaged in reverse logistics and automobile manufacturing, as well as reverse logistics and automobile manufacturing Industry

experts and scholars.

In order to facilitate statistical analysis, the questionnaire survey issued a total of 100 copies of the questionnaire, the recovery of 97, a total of 95 valid questionnaires. The survey results are as follows.

Table 1 Survey results

| comment content                     |                                     | Evaluation results |                |                   |                | Weights |
|-------------------------------------|-------------------------------------|--------------------|----------------|-------------------|----------------|---------|
| index                               | index                               | same important     | More important | obvious important | very important |         |
| technical skills                    | service quality                     | 42                 | 52             | 1                 | 0              | 2       |
|                                     | Business efficiency                 | 0                  | 38             | 57                | 0              | 4       |
|                                     | Social experience                   | 0                  | 60             | 35                | 0              | 4       |
| service quality                     | Business efficiency                 | 2                  | 69             | 26                | 0              | 3       |
|                                     | Social experience                   | 0                  | 40             | 53                | 2              | 4       |
| Business efficiency                 | Social experience                   | 71                 | 24             | 0                 | 0              | 2       |
| Sorting processing capacity         | Technical innovation ability        | 0                  | 25             | 68                | 2              | 4       |
| Recycling rate of resource recovery | Technical innovation ability        | 0                  | 39             | 54                | 2              | 4       |
| Sorting processing capacity         | Recycling rate of resource recovery | 40                 | 55             | 0                 | 0              | 2       |
| Product recovery rate               | Product recovery speed              | 0                  | 6              | 33                | 56             | 6       |
|                                     | Logistics network coverage          | 44                 | 51             | 0                 | 0              | 2       |
| Product recovery speed              | Logistics network coverage          | 0                  | 34             | 52                | 9              | 5       |
| Investment in fixed assets          | Historical performance              | 28                 | 67             | 0                 | 0              | 3       |
|                                     | Historical performance              | 0                  | 28             | 46                | 21             | 5       |
| Cost control                        | Investment in fixed assets          | 64                 | 27             | 4                 | 0              | 2       |
| Market share                        | Industry service time               | 59                 | 36             | 0                 | 0              | 2       |
| Industry service rate of praise     | Market share                        | 28                 | 65             | 2                 | 0              | 3       |
|                                     | Industry service time               | 0                  | 26             | 58                | 11             | 4       |

According to the relative relationship between the factors, construct the A layer judgment matrix and

calculate:

Table 2 A layer judgment matrix

| A              | B <sub>1</sub> | B <sub>2</sub> | B <sub>3</sub> | B <sub>4</sub> | Weight |
|----------------|----------------|----------------|----------------|----------------|--------|
| B <sub>1</sub> | 1              | 2              | 4              | 4              | 0.475  |
| B <sub>2</sub> | 1/2            | 1              | 3              | 4              | 0.313  |
| B <sub>3</sub> | 1/4            | 1/3            | 1              | 2              | 0.128  |
| B <sub>4</sub> | 1/4            | 1/4            | 1/2            | 1              | 0.084  |

Calculate the maximum eigenvalue  $\lambda_{\max} = \sum_{i=1}^4$

$$\frac{(AW)_k}{nw_i} = 4.081. \text{Consistency test } CI = \frac{\lambda_{\max} - n}{n - 1} = 0.027,$$

$CR = \frac{CI}{RI} = 0.03 < 0.1$ . The results are consistent. Calculate the elements of layer B1:

Table 3 B1 judgment matrix

| B <sub>1</sub> | C <sub>1</sub> | C <sub>2</sub> | C <sub>3</sub> | Weight |
|----------------|----------------|----------------|----------------|--------|
| C <sub>1</sub> | 1              | 1/4            | 1/4            | 0.110  |
| C <sub>2</sub> | 4              | 1              | 2              | 0.544  |
| C <sub>3</sub> | 4              | 1/2            | 1              | 0.346  |

So,  $\lambda_{\max} = 3.054$ ,  $CI = 0.027$ ,  $CR = 0.047$ ,  $W_1 = [0.110, 0.544, 0.346]^T$

By the same method can be obtained:

$W_2 = [0.163, 0.729, 0.108]^T$ ,  $W_3 = [0.110, 0.308, 0.581]^T$ ,  $W_4 = [0.239, 0.136, 0.625]^T$

Table 4 Fuzzy membership of technical competence

|                                                      | v <sub>1</sub> (very strong) | v <sub>2</sub> (strong) | v <sub>3</sub> (general) | v <sub>4</sub> (weak) | v <sub>5</sub> (very weak) |
|------------------------------------------------------|------------------------------|-------------------------|--------------------------|-----------------------|----------------------------|
| u <sub>1</sub> (Technical innovation ability)        | 6                            | 2                       | 1                        | 1                     | 0                          |
| u <sub>2</sub> (Sorting processing capacity)         | 3                            | 3                       | 2                        | 2                     | 0                          |
| u <sub>3</sub> (Recycling rate of resource recovery) | 4                            | 4                       | 2                        | 0                     | 0                          |

It's obtain the single factor judgment matrix  $R_1 = (r_{ij}) (i=1,2,3; j=1,2,3,4,5)$  of U<sub>1</sub>. Where  $c_{ij}$  is the number of votes evaluated as  $v_j$ .

$$R_1 = \begin{bmatrix} 0.6 & 0.2 & 0.1 & 0.1 & 0 \\ 0.3 & 0.3 & 0.2 & 0.2 & 0 \\ 0.4 & 0.4 & 0.2 & 0 & 0 \end{bmatrix}$$

The same method was used to obtain the other three factor sets U<sub>2</sub>, U<sub>3</sub>, U<sub>4</sub> single factor evaluation matrix.

$$R_2 = \begin{bmatrix} 0.1 & 0.2 & 0.4 & 0.3 & 0 \\ 0.5 & 0.3 & 0.2 & 0 & 0 \\ 0 & 0.2 & 0.6 & 0.2 & 0 \\ 0.1 & 0.2 & 0.6 & 0.1 & 0 \end{bmatrix}$$

$R_3 =$

$$R_4 = \begin{bmatrix} 0 & 0.1 & 0.4 & 0.5 & 0 \\ 0 & 0.2 & 0.4 & 0.4 & 0 \\ 0.5 & 0.4 & 0.1 & 0 & 0 \end{bmatrix}$$

According to the previous analytic hierarchy process, we can know the weights of U<sub>1</sub>, U<sub>2</sub>, U<sub>3</sub>, U<sub>4</sub> are:

$B_1 = (C_1, C_2, C_3) = (0.110, 0.544, 0.346)$

$B_2 = (C_4, C_5, C_6) = (0.163, 0.729, 0.108)$

$B_3 = (C_7, C_8, C_9) = (0.110, 0.308, 0.581)$

$B_4 = (C_{10}, C_{11}, C_{12}) = (0.239, 0.136, 0.625)$

Then the second factor set is evaluated synthetically,

## 4.2 Evaluate the strength of alternative enterprises by using fuzzy comprehensive evaluation method

Step1: combined with the previous automobile manufacturing industry to select the third party reverse logistics service provider evaluation index system, determine the evaluation factor set as follows:

Level 1 Factor Set:

$U = \{U_1, U_2, U_3, U_4\} = \{\text{technical ability, service quality, enterprise benefit, social experience}\}$

Level 2 Factor Set:

$U_1 = \{\text{technical innovation ability, sorting processing capacity, recycling resource recycling rate}\}$

$U_2 = \{\text{product recovery rate, product recovery rate, logistics network coverage}\}$

$U_3 = \{\text{historical performance, net fixed assets, cost control}\}$

$U_4 = \{\text{market share, industry service time, industry service rate of praise}\}$

Step2: the third party reverse logistics service providers to grab the strength of the five levels, that is, evaluation set  $V = \{v_1, v_2, v_3, v_4, v_5\} = \{\text{very strong, strong, general, weak, very weak}\}$

Step 3: Find 10 professionals to set up an assessment team and judge the factors. First of all, the third party reverse logistics service provider P1 evaluation.

(1) The panel evaluates each factor in the second-level factor, for example, the three factors in the factor set  $U_1 = \{\text{technological innovation capability, sorting processing capacity, recycling resource recycling rate}\}$  The results are shown in Table 4-4:

and the model  $M (\wedge, \vee)$  is used to calculate.

$B_i \circ R_i = D_i, (i=1,2,3,4)$

$D_1 = (0.346, 0.346, 0.2, 0, 0)$

$D_2 = (0.5, 0.3, 0.2, 0.163, 0)$

$D_3 = (0.1, 0.308, 0.5, 0.3, 0)$

$D_4 = (0.5, 0.4, 0.239, 0.239, 0)$

Then got the fuzzy evaluation of the third party reverse logistics service provider P<sub>1</sub> in four aspects: technical ability, service quality, enterprise benefit and social experience.

(2) The first level of the factors  $U = \{U_1, U_2, U_3, U_4\} = \{\text{technical capacity, quality of service, business efficiency, social experience}\}$  to do a comprehensive evaluation. It can be seen from the foregoing that the weight of the first factor  $A = \{B_1, B_2, B_3, B_4\} = \{0.475, 0.313, 0.128, 0.084\}$ . The general judgment matrix R is a fuzzy matrix with rows D<sub>1</sub>, D<sub>2</sub>, D<sub>3</sub>, D<sub>4</sub>.

$$R = \begin{bmatrix} D_1 \\ D_2 \\ D_3 \\ D_4 \end{bmatrix} = \begin{bmatrix} 0.346 & 0.346 & 0.2 & 0 & 0 \\ 0.5 & 0.3 & 0.2 & 0.163 & 0 \\ 0.1 & 0.308 & 0.5 & 0.3 & 0 \\ 0.5 & 0.4 & 0.239 & 0.239 & 0 \end{bmatrix}$$

Do a comprehensive evaluation,  $A \circ R = D = (0.346, 0.346, 0.2, 0.128, 0)$

In the comprehensive consideration of the technical capacity, service quality, business efficiency, social experience of these four aspects of the weight. The third party reverse logistics service provider  $P_1$  in the five grades of membership were 0.346, 0.346, 0.2, 0.128, 0.

Similarly. The third party reverse logistics service providers  $P_2$  and  $P_3$  fuzzy evaluation, the results are as follows:  $P_2: D=(0.2, 0.475, 0.346, 0.163, 0)$   $P_3: D=(0.108, 0.2, 0.475, 0.3, 0.1)$

Step4: evaluation of the results.

Get the third party reverse logistics business membership, the final use of the level of eigenvalues to determine the overall strength of the three alternative enterprises. Respectively, given the "very strong" "strong" "general" "weak" "very weak" five levels of eigenvalues of 100,90,80,70,60. Get  $P_1$ ,  $P_2$ ,  $P_3$  comprehensive score is calculated as follows:

$$M_1=100*0.346+90*0.346+80*0.2+70*0.128+60*0=90.7$$

$$M_2=100*0.2+90*0.475+80*0.346+70*0.163+60*0=99.84$$

$$M_3=100*0.108+90*0.2+80*0.457+70*0.3+60*0.1=92.36$$

As can be seen from the results, the overall strength of service providers  $P_2$  is the strongest of the three companies. M enterprises should choose service providers  $P_2$ , service providers  $P_3$  selected, service providers  $P_1$  last.

## 5. CONCLUSIONS

The rapid development of automobile manufacturing enterprises, it brought a lot of environmental protection aspects of thinking. Disposal of used parts, defective products such as the recall of the car manufacturing enterprises must face the problem, reverse logistics has gradually been taken seriously. Reverse logistics as a logistics field of economic growth, micro-improve the economic efficiency of enterprises, the macro to promote the recycling of resources, follow the concept of sustainable development. The choice of third-party reverse logistics service providers not only reduces the cost of enterprises, but also points out the market risk, so that automobile manufacturing enterprises have more human and material resources for the development of core competitiveness, protect the environment and improve the utilization rate of resources.

China has a great demand for reverse logistics. However, due to weak sense of the masses, high cost and lack of professionals, reverse logistics development as a whole backward, reverse logistics system is not perfect. China is currently in the golden stage of the development of automobile manufacturing enterprises, government-related policies under the positive guidance, the automobile industry reverse logistics system will be more and more perfect. At the same time through the economies of scale to reduce the cost of third-party reverse logistics enterprises, with its specialized equipment, personnel, complete and item recycling system will become the automobile manufacturing industry to develop the best logistics service providers. The method provided in this paper reduces the influence

of subjective factors and improves the utilization of data and the credibility of the results when choosing a third party reverse logistics service provider. However, there are still many shortcomings in this paper, the automobile manufacturing industry reverse logistics model analysis, only consider the self-employed and outsourcing two models, not related to other models, but also need further research and improvement.

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