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The Evaluation and Selection of Third-Party Logistics Service Vendor

YAN Wei, HE Jia-lin and HE Jun-liang

Engineering Research Center of Container Supply Chain Technology, ministry of education, shanghai maritime university, shanghai 201306
weiyan@shmtu.edu.cn, jialin416@163.com, jlhe@shmtu.edu.cn

Abstract

With the gradual increase of number of third-party logistics service vendors, if evaluation system and evaluation method for third-party logistics service vendor are not complete, it is difficult for enterprises to choose the most appropriate vendor. To solve the problem, by analyzing research status about evaluation and selection of third-party logistics service vendor and combining the actual service needs of enterprises, construct an evaluation index system from four factors of transportation capability, storage capacity, service level and operational efficiency. For selection of evaluation methods, this paper using two algorithms which are AHP and fuzzy comprehensive evaluation method. In addition, a foreign trade company of Shanghai is taken as an example to illustrate the feasibility of the evaluation system.

Keywords*: Third-party logistics, service vendors, AHP, fuzzy comprehensive evaluation*

1. Introduction

With the trend of economic globalization and level of science and technology are rising, competition among enterprises has become increasingly fierce. To achieve a certain competitive advantage in the market, enterprises can outsource non-core business to a professional third-party logistics service vendor. Currently, a large number of enterprises choose to cooperate with third-party logistics service vendors to reduce resource consumption, logistics costs and risks of potential loss. However, enterprises in the process of selection of logistics service vendors merely rely on subjective judgments and lack a scientific evaluation index system. With the rapid development of modern logistics industry and the increasing number of indicators of third-party logistics service vendors, it is essential for enterprises to construct a comprehensive and scientific evaluation index system.

2. Literature Review

Domestic and overseas scholars conducted some research in the selection of indicators. In terms of third-party logistics selection criteria, Aguezzoul (2014) found that cost was the most widely adopted criterion, followed by relationship, services, and quality. Each criterion was defined by a set of attributes. For third-party logistics vendor selection, Li et al. (2012) proposed that systems considerations, objectivity, scientific basis, independence property and forward-looking property should be taken into consideration in selecting the indicators Ghodsypour and Brien (2001) from the perspective of the total cost to study the selection of third-party logistics vendors. To explain how to choose logistics service vendors, Ken (2000) proposed fourteen evaluation indicators, such as inventory management skills, order processing abilities, value-added service capabilities and so on. In terms of the analysis of the characteristics of logistics outsourcing industry, Peng (2012) put forward that the evaluation index system including logistics cost, the logistics

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operation efficiency, the basic qualities of service vendors and logistics technology level had more pertinence and practicability. Menon et al. (1998), who thought four factors influenced selection of logistics service vendors via questionnaires as well as the factor analysis method. These factors were the efficiency of work, operational capabilities, the price of logistics service and the macro environment. Qureshi et al. (2008) considered that ten elements should be taken into account when enterprises chose third-party logistics vendors. These elements included the quality of service and management, information technology and the ability of information sharing, financial stability and service diversity, *etc.* Ma et al. (2003) conducted a comprehensive evaluation for selection of third-party logistics service vendors in terms of the potential for development, logistics technology, equipment condition and quality of service. Wei et al. (2003) were based on extension theory and analytic hierarchy process, summarized a number of quantitative indicators for evaluation and selection of third-party logistics service vendors which were the quality of service, technical equipment, the development potential and the mode of transport. Through the analysis of logistics service providers, Zhou et al. (2003) constructed an index system which contained market and technological strength, ability to organize and coordinate and management level.

The paper proposes a comprehensive evaluation index system by reading literatures at home and abroad and considering the existing problems of indicators. Corporate executives and experts can select three vendors from a number of third-party logistics service vendors according to their own experience and the index system. After the preliminary selection, further evaluation and selection can be accomplished by using AHP to calculate weights of specific indicators, and then using fuzzy comprehensive evaluation method to do the final comprehensive evaluation.

3. Construction of Evaluation Indicators of Third Party Logistics Service Vendors

3.1. Problem Description

The procedures for evaluation and selection of third-party logistics service vendors can be divided into four steps:

Step 1: Analyzing the condition of vendors and screening some candidate enterprises.

Step 2: Building a systematic and comprehensive evaluation index system.

Step 3: Selecting appropriate evaluation methods.

Step 4: Comparing and selecting out the final results.

Constructing an appropriate evaluation index system plays a particularly crucial role in above four steps. So far, the existing index system provides some good ideas, but it still has the following disadvantages:

1. A majority of enterprises always consider some indicators including service cost, service quality, service technology, *etc*, which lack a holistic point of view.

2. When selecting the evaluation index system, most enterprises only consider the level of business capability of service vendors while ignore its ability to cooperate and coordinate with partners.

3. An assessment of informatization ability of vendors can be easily neglected in most evaluation index system of vendors.

4. When selecting evaluation index system, enterprises rarely take the fact into account that the change in external environment will affect the choice of service vendors.

To overcome above deficiencies of the index system and choose the most appropriate vendor for the operation and development of enterprise, evaluation and selection of third-party logistics service vendors can follow above four steps and combine with the actual service demand of enterprise.

3.2. Selection of Indicators

For most enterprises, especially storage enterprises have its own warehouse and directly deliver goods from the warehouse after receiving customer's orders. With the increasing number of orders, costs of transportation and warehousing rise gradually. Hence, two vital indicators must be considered which are transportation capability and storage capacity. Each secondary indicator which is subordinate to above two first-grade indicators also builds based on the specific demand for service vendors in the actual work process. Level of service and operating efficiency are another two first-grade indicators, which aim at overcoming the problems of existing index system. The two first-grade indicators also include some secondary indicators, for example, the extent of informatization is an indicator which is easily overlooked, but level of informatization has a greater impact on service capability of vendors; The ability to cooperate is an indicator that measure the degree of adaptation between third-party logistics service vendors and service demand enterprises; The market share can embody that service vendors have an influence on the external environment, thereby reflecting the operational effectiveness of enterprises from the side. On the whole, as observed in Table 1, not only did the index system consider level of service vendors but also try to make the index system reflect the various aspects of vendors, so as to construct a more complete, objective, scientific and practical index system to adapt to the competitive market environment

Table 1. Comprehensive Evaluation Index System

First-grade indicators	Secondary indicators	Detailed descriptions
Transportation capability	Loading efficiency	Number of loading cargoes / number of total cargoes
	Delivery accuracy	(Number of times of total delivery- number of times of wrong delivery) / number of times of total delivery
	Rate of on-time delivery	Number of on-time delivery / number of total cargoes
Storage capacity	Utilization rate of warehouse space	Space of cargoes / gross space of warehouse
	Intact ratio of cargoes	Number of intact cargoes / number of total cargoes
	Time utilization ratio of equipment	Actually usage time of devices each year / total planning usage time
Level of service	Time flexibility	Reflecting the ability of variable time of enterprises
	Cooperative ability	Coordinative and cooperative ability with service demand of enterprises
	Degree of informatization	Degree of using modern information technology in logistics enterprises
Operational efficiency	Market share	Proportion of company's sales in the total market sales
	Profit ratio of sales	Measuring the income level of sales revenue
	Ratio of liabilities to assets	Proportion between total assets and total liabilities

4. Methods of Evaluation of Third Party Logistics Service Vendors

4.1. Introduction of AHP

Analytic Hierarchy Process is a popular tool to construct indicators and make a decision, it includes four steps which are building a hierarchical structure, pairwise comparing the importance of each factor to get a judgment matrix, calculating local weights and checking the consistency, and calculating the total weights. The specific process can be stated as follows:

1. Establish hierarchical structure

A simple AHP model has three levels (target, criteria and alternatives), while more complex models with more levels could be formulated (Figure. 1) (Subramanian and Ramanathan, 2012)

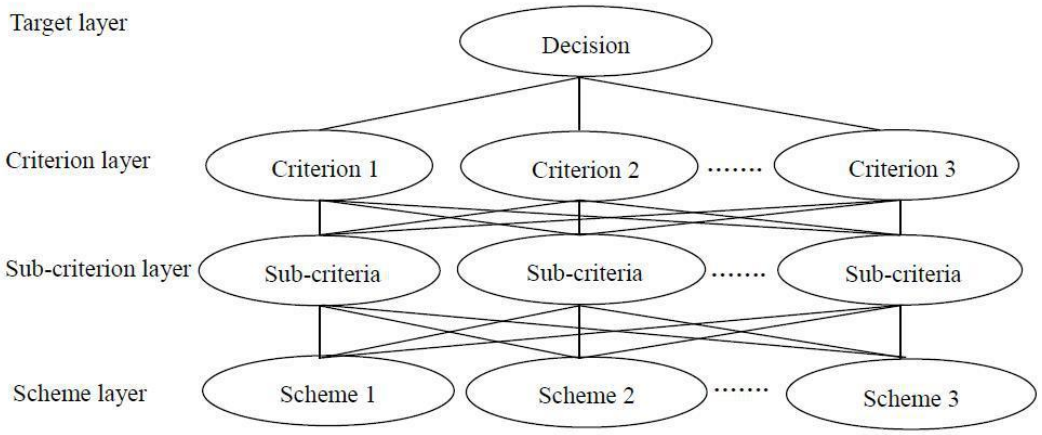

Figure 1. Hierarchy Chart

2. Construction of judgment matrix

The element values of judgment matrix are generally indicated by using 1 to 9 and its reciprocal:

Table 2. Pairwise Comparison of Matrix

Scale	Implication
1	The importance of two factors is the same by comparing with each other.
3	A factor is a bit important than another factor by comparing with each other.
5	A factor is obvious important than another factor by comparing with each other.
7	A factor is strongly important than another factor by comparing with each other.
9	A factor is extreme important than another factor by comparing with each other.
2,4,6,8	The Intermediate value of two adjacent judgments.
Reciprocal	A_{ij}: The factor judgment of m and n. $A_{ji}=1/A_{ij}$: The factor judgment of n and m.

3. Single criterion ranking and consistency check

Hierarchy single sorting is expressed by the judgment matrix eigenvectors and got by calculating the weight of the importance of each element. Consistency checking is an essential step to ensure the feasibility of the results.

Consistency Index: $CI = \frac{\lambda_{\max} - n}{n-1}$ (1)

The RI values of average random consistency index must be introduced to measure the

consistency of different stages of judgment matrix:

Table 3. Pairwise Comparison of Matrix

Judgment matrix order	1	2	3	4	5	6	7	8	9	10
RI	0	0	0.58	0.9	1.12	1.24	1.32	1.41	1.45	1.49

Random consistency ratio: $CR = \frac{CI}{RI} = \frac{\lambda_{\max} - n}{RI \cdot (n-1)}$ (2)

If CR<0.1, the hierarchy single sorting pass the consistency test.

4. Hierarchy total sorting and the consistency test

The meaning of hierarchy total sorting is the weight order of relative importance, which stepwise calculates all factors of the same hierarchy towards the topmost hierarchy.

4.2. Fuzzy Comprehensive Evaluation

Fuzzy comprehensive evaluation is a synthetical method which is based on fuzzy mathematics. To quantify some faintness factors, the method conduct a comprehensive evaluation for membership grade status from the perspective of multiple factors by using theory of fuzzy relation synthetic. This method can be roughly divided into three steps:

Step 1: Determining the evaluation factors and evaluation grade.

Various factors from the set $U=\{u_1,u_2,\cdots,u_m\}$ are set to evaluation indicators and sorts of elements from the set $V=\{v_1,v_2,\cdots,v_n\}$ are set to evaluation grade. Generally speaking, five levels can be used which are well satisfied, satisfied, basically satisfied, discontentment.

Step 2: Construction of the evaluation matrix and determination of the weights.

First, each element from the set U is evaluated. Then, the membership r_{ij} of the evaluation grade $V_j(j=1,2,\cdots,n)$ is made from the perspective of the set u_i in order to get the single factor evaluation of the u_i:$i=(r_{i1},r_{i2},\cdots,r_{in})$. Last, a total evaluation matrix R is constructed by some evaluation sets. That is to say, every object which is evaluated confirms a fuzzy relation matrix R from the set U to the set V (Wang, 2011).

$$R = \left(r_{ij}\right)_{m\cdot n} = \begin{bmatrix} r_{11} & r_{12} & \cdots & r_{1n} \\ r_{21} & r_{22} & \cdots & r_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ r_{m1} & r_{m2} & \cdots & r_{mn} \end{bmatrix} \left(i = 1,2,\cdots,m;\ j = 1,2,\cdots,n\right) \quad (((3)$$

(3)

Step 3: Fuzzy synthesis and decision making.

$B= (b_1, b_2\cdots b_n)$ is a fuzzy subset which is correlated to the set V. Under normal circumstances we can set B=A*R (The character "*" represents operator notation). The calculation method can be called fuzzy transformation. If the evaluation result is not equal to 1, the normalization processing should be carried out. Supposing $F= (F_1, F_2\cdots F_n)^T$ is a parameters column vector which is relative to each grade v_j. Results of level parameter evaluation can be get by setting $B*F^T=S$. In this equation, S is a real number and reflects some integrated information that hierarchical fuzzy subset B and level parameter vector F bring about (Wang, 2011).

5. Case Study

5.1. Company Background

A wood industry limited company in Shanghai, which is a warehousing foreign trade company. The major product of company is various kinds of hard timber. These materials can be procured from the United States, Canada and Brazil. The company is inclined to import timber from abroad by the most direct price to decrease cost. To supply Chinese customers with high-quality dry timber or deliver goods directly to customers from place of origin, the company usually needs warehouse inventory. At present, company has confronted with some logistics problems:

1. The warehouse is too small to have enough location to place lumber. During the peak season, the demand of customers cannot be well satisfied.

2. The space outside the warehouse is insufficient for handling of massive timber, which h may decrease the operation efficiency.

3. Because of the large amounts of wood, some errors cannot be avoided completely when transporting timber to and out of the warehouse.

4. The overall logistics cost is highly and the design of transportation routes lacks of scientific planning.

5.2. Determination of Weights of Evaluation Index Based on AHP

According to Table 1 and Figure 1, the establishment of the hierarchical model can be constructed as follows (the three vendors are represented by S_1、S_2、S_3):

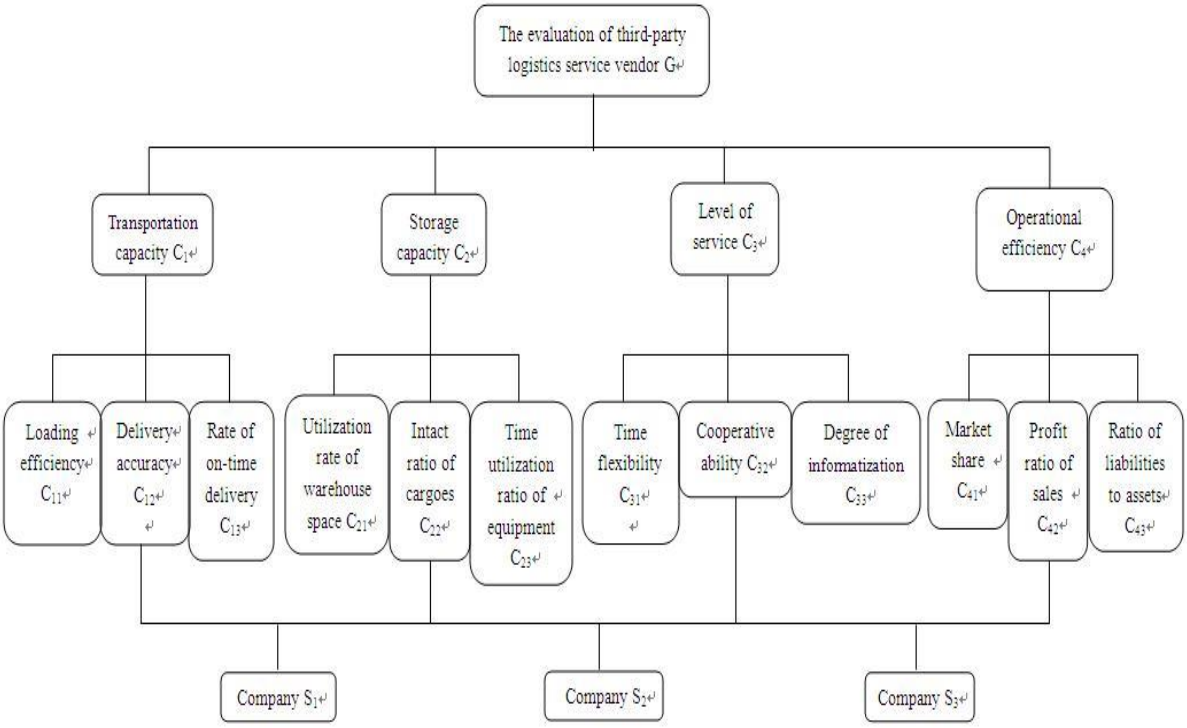

Figure 2. Structure Chart of Third Party Logistics Service Vendor Evaluation

The judgment matrix shown in the following tables can be get by calculating the indicator's score of the three vendors according to Figure 2.

Table 4. Comparison Matrix G-C

G	C_1	C_2	C_3	C_4	W_i (weight)	λ max=4.145, CI=0.048, RI=0.9, CR=0.054<0.1
C_1	1	3	1/2	4	0.322	
C_2	1/3	1	1/4	1/2	0.093	
C_3	2	4	1	3	0.448	
C_4	1/4	2	1/3	1	0.137	

Table 5. Comparison Matrix C_1

C_1	C_{11}	C_{12}	C_{13}	W_i (weight)	λ max=3.004, CI=0.0017, RI=0.58, CR=0.003<0.1
C_{11}	1	1/5	1/2	0.122	
C_{12}	5	1	3	0.648	
C_{13}	2	1/3	1	0.23	

Table 6. Comparison Matrix C_2

C_2	C_{21}	C_{22}	C_{23}	W_i (weight)	λ max=3.065, CI=0.0325, RI=0.58, CR=0.056<0.1
C_{21}	1	1/7	1/3	0.081	
C_{22}	7	1	5	0.731	
C_{23}	3	1/5	1	0.188	

Table 7. Comparison Matrix C_3

C_3	C_{31}	C_{32}	C_{33}	W_i (weight)	λ max=3.062, CI=0.031, RI=0.58, CR=0.0534<0.1
C_{31}	1	1/5	1/7	0.072	
C_{32}	5	1	1/3	0.279	
C_{33}	7	3	1	0.649	

Table 8 Comparison Matrix C_4

C_4	C_{41}	C_{42}	C_{43}	W_i (weight)	λ max=3.032, CI=0.018, RI=0.58, CR=0.0311<0.1
C_{41}	1	6	7	0.758	
C_{42}	1/6	1	2	0.151	
C_{43}	1/7	1/2	1	0.091	

The datum from the above five tables are all satisfied the consistency check. Thus, the weights from each indicator to total goal can be calculated and shown as the following table:

Table 9. Weights from Each Index to Total Goal

Criterion level 1	W_i	Criterion level 2	W_i
Transportation capability C_1	0.032	Loading efficiency C_{11}	0.122
		Delivery accuracy C_{12}	0.648
		Rate of on-time delivery C_{13}	0.23
Storage capacity C_2	0.093	Utilization rate of warehouse space C_{21}	0.081
		Intact ratio of cargoes C_{22}	0.731
		Time utilization ratio of equipment C_{23}	0.188
Level of service C_3	0.448	Time flexibility C_{31}	0.072
		Cooperative ability C_{32}	0.279
		Degree of informatization C_{33}	0.649
Operational efficiency C_4	0.137	Market share C_{41}	0.758
		Profit ratio of sales C_{42}	0.151
		Ratio of liabilities to assets C_{43}	0.091

5.3. Evaluation and Selection of Service Vendor Based on Fuzzy Comprehensive Method

In the decision-making process, fuzzy comprehensive method always brings about a certain amount of subjective nature. Thus, two kinds of evaluation methods are combined together in this paper to overcome the drawback. First, calculate the weights of each indicator and check consistency by using analytic hierarchy process. Then, proceed further comprehensive evaluation for the three service vendors by using fuzzy comprehensive method. The specific steps are as follows:

1. Determination of comprehensive evaluation index of logistics service vendor.

First-grade evaluation index:

$U = \{u_1, u_2, u_3, u_4\}$ = {transportation capability, storage capacity, level of service and operational efficiency}

Secondary evaluation index:

$u_1 = \{u_{11}, u_{12}, u_{13}\}$ = {loading efficiency, delivery accuracy and rate of on-time delivery}

$u_2 = \{u_{21}, u_{22}, u_{23}\}$ = {utilization rate of warehouse space, intact ratio of cargoes and time utilization ratio of equipment}

$u_3 = \{u_{31}, u_{32}, u_{33}\}$ = {time flexibility, cooperative ability and degree of informatization}

$u_4 = \{u_{41}, u_{42}, u_{43}\}$ = {market share, profit ratio of sales and ratio of liabilities to assets}

2. Determination of the evaluation set.

$V= \{v_1, v_2, v_3, v_4\}$ = {very satisfied, satisfied, basically satisfied, in general, dissatisfied},

The corresponding score set F= {100, 80, 60, 40, 20}

3. The single factor judgment for the second stage factor set.

Some main leaders and relevant experts are selected as jury via Delphi method to do the single factor evaluation for the three alternative vendors. The datum of each vendor are organized and displayed as the table below:

Table 10. Single Factor Evaluation for Logistics Service Vendor S_1

First-grade evaluation factor	Weight A	Secondary evaluation factor	Weight A_i	Evaluation set					B
				V_1	V_2	V_3	V_4	V_5	$A_i \cdot R_i$
Transportation capability u_1	0.032	Loading efficiency	0.122	0.1	0.4	0.3	0.2	0	{0.23,0.648,0.23, 0.122,0.23}
		Delivery accuracy	0.648	0.1	0.7	0.2	0	0	
		Rate of on-time delivery	0.23	0.4	0	0.3	0	0.3	
Storage capacity u_2	0.093	Utilization rate of warehouse space	0.081	0.2	0.4	0.3	0	0.1	{0.081, 0.188,0.731,0.188,0.081}
		Intact ratio of cargoes	0.731	0	0.1	0.8	0.1	0	
		Time utilization ratio of equipment	0.188	0	0.2	0.5	0.3	0	
Level of service u_3	0.448	Time flexibility	0.072	0.1	0.2	0.2	0.4	0.1	{0.072, 0.279,0.649,0.279,0.072}
		Cooperative ability	0.279	0	0.3	0.3	0.4	0	
		Degree of informatization	0.649	0	0.2	0.7	0.1	0	
Operational efficiency u_4	0.137	Market share	0.758	0.1	0	0.8	0	0.1	{0.151, 0.091,0.758,0.091,0.151}
		Profit ratio of sales	0.151	0.4	0	0.4	0	0.2	
		Ratio of liabilities to assets	0.091	0	0.3	0.2	0.3	0.2	

4. Comprehensive evaluation of the first-grade factor set: U = {u_1, u_2, u_3, u_4}
Weights of the first-grade factor set: A= (0.032 0.093 0.448 0.137)
A total evaluation matrix can be obtained from above tables:

$$R = \begin{bmatrix} 0.23 & 0.648 & 0.23 & 0.122 & 0.23 \\ 0.081 & 0.188 & 0.731 & 0.188 & 0.081 \\ 0.072 & 0.279 & 0.649 & 0.279 & 0.072 \\ 0.151 & 0.091 & 0.758 & 0.091 & 0.151 \end{bmatrix}$$

Calculating by model operator to get comprehensive evaluation:

$$B_{S_1} = A \square R = (0.032 \quad 0.093 \quad 0.448 \quad 0.137) \begin{bmatrix} 0.23 & 0.648 & 0.23 & 0.122 & 0.23 \\ 0.081 & 0.188 & 0.731 & 0.188 & 0.081 \\ 0.072 & 0.279 & 0.649 & 0.279 & 0.072 \\ 0.151 & 0.091 & 0.758 & 0.091 & 0.151 \end{bmatrix}$$

$$= (0.068 \quad 0.176 \quad 0.47 \quad 0.15) \quad (4)$$

Error! Reference source not found. Normalization processing for above result:

$$B_{S_1}' = (0.069 \quad 0.179 \quad 0.49 \quad 0.193 \quad 0.069)$$

Multiply B_i' by fuzzy evaluation vector F to get the evaluation results:

$$S_1 = B_{s_1}' \cdot F^T = 59.72 \quad (5)$$

Similarly, the other two vendors' results can be obtained:

$$B_{S_2}' = (0.286 \quad 0.327 \quad 0.273 \quad 0.073 \quad 0.041) \qquad S_2 = B_{s_2}' \cdot F^T = 74.88 \qquad (6)$$

$$B_{S_3}' = (0.168 \quad 0.346 \quad 0.31 \quad 0.095 \quad 0.081) \qquad S_3 = B_{s_3}' \cdot F^T = 68.5 \qquad (7)$$

According to above calculation results, the comprehensive evaluation of the three service vendors are shown in the following table:

Table 11. Service Vendor Evaluation Form

	Well satisfied	satisfied	Basically satisfied	In general	dissatisfied	comprehensiveness
S_1	0.069	0.179	0.49	0.193	0.069	59.72
S_2	0.286	0.327	0.273	0.073	0.041	74.88
S_3	0.168	0.346	0.31	0.095	0.081	68.5

The final composite score of the three vendors can be revealed from the above table, which respectively are 59.72, 74.88 and 68.5. The score of vendor S_2 is highest. Thus, the enterprise should choose S_2 as a third party logistics service vendor. In addition, the results showed that the index system has been effective and efficient in solving the evaluation and selection of third-party logistics service vendor.

6. Conclusions

By referring the domestic and foreign literature and taking the problem of existing indicators into account, the paper proposed the comprehensive evaluation index system which is suitable for most businesses, especially the warehousing service enterprises. In addition, in the processing of specific analysis of vendors, the paper combined the analytic hierarchy process with fuzzy comprehensive evaluation method to deal with weights of indicators, which can well realize a combination of qualitative and quantitative and make the calculation process more reasonable and scientific. Finally, the paper took a Shanghai foreign trade warehousing enterprises as an example to verify a certain degree of practicality of the index system and the evaluation methods. Meanwhile, by setting the algorithm to calculate the final results, the whole procedure can play a role in solving practical problems.

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Authors

Wei-Yan is a PhD, Professor, and Ph.D. Supervisor. Research Fields include logistics and supply chain management, knowledge engineering and expert system. (E-mail)weiyan@shmtu.edu.cn

