Logistics outsourcing and selecting of logistics service provider of the e-commerce companies: a fuzzy TOPSIS approach

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Abstract

Logistics outsourcing has become the development trend of enterprise logistics operations. A good logistics service provider can improve the customer satisfaction, as also as reducing the cost of the whole supply chain, so it is very important to evaluate the logistics outsourcing service for the corn companies in the supply chain. This paper is an attempt to identify the main factors of selecting satisfactory logistics service provider of the electronic commerce (e-commerce) companies in China. GRA and Fuzzy TOPSIS are employed to evaluate the service of the logistics companies. The managerial implications are also discussed in the last section.

Keywords: logistics outsourcing, e-commerce, Fuzzy TOPSIS, evaluation

1 Introduction

Supply chain management involves the design and management of seamless, value-added processes across organizational boundaries to meet the real needs of the customers [1-3]. Logistics outsourcing is rapidly growing through the whole world. More than 70% of companies in Western Europe, USA and Asia Pacific have outsourcing experience in a pattern expanding from basic transportation to full logistics network control [4, 5].

In the early 1980s, logistics services in the outsourcing market were confined to the traditional activities such as transportation and warehousing. In the 1990s, a number of network players began to provide a wider geographic coverage of their transport networks, and many value adding activities such as labelling and sorting were introduced. In the late 1990s, a number of players from areas as information technology, management consultancy and financial services began working together with logistics service providers. This period saw the creation of a new service, the ‘supply chain solution’, also called ‘fourth-party logistics (4PL)’, where a logistics service provider (LSP) is hired to manage a customer’s complete logistics network [6-8].

As the development of the electronic-commerce (e-commerce), an increasingly people prefer online shopping because of the low price and convenience. Most of the logistics outsourcing performance-related studies focused on the cost saving [4, 9, 10] and traditional logistics service [11, 12], few empirical studies have reported on the selection of the logistics service provider of the e-commerce companies, which is different from the traditional logistics service in terms of the payment technology, which is the primary motivation of this research.

This paper is organized as follows. The next section introduces the related literature about logistics service provider selection. Following is a brief introduction about the fuzzy TOPSIS (Technique for Order Preference by Similarity to Ideal Solution) method used in this research. Section 4 describes an empirical analysis of logistics service provider selection of an e-commerce company Z. Finally, major issues and challenges for logistics outsourcing are identified and discussed along with the related managerial implications.

2 Literature review

There are many researches focused on the performance of the logistics service providers. Kasilingamr [13] argue that four factors for the third party logistics service supplier to choose: the perceived performance of logistics suppliers, the perception ability, the price, the strategy and external environment using the factor analysis method. Ma etc. [14] used fuzzy analytic hierarchy process (F-AHP) to choose partners. Yahya and Kingsman [15] suggest evaluation index system including quality, response delivery and performance of financial management technical ability and facilities through the investigation and AHP. Guo [16] establish an AHP judgment matrix of supplier evaluation with quality, price, technical ability and distribution reliability. Jiang and Han [17] set up evaluation index system including quality, price, delivery, service, product development and production, external environment, and other (sales and marketing staff in general) on the comprehensive analysis of the service. Ma [11] proposed 9 indexes on supplier selection standards: the product quality, the price, the post-sale service, the technical level, the geographical position, supply capacity, economic benefit, delivery and market effect. Ma et al. [11] chose

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three common indexes, such as quality, cost and delivery time, and set up a weight correlation analysis model of supplier selection and evaluation. Zhong et al. [18] suggest that the specific vendor selection indexes should consider four aspects such as technical level, management ability, and service level and management environment to make the supply chain performance maximization according to the design principle. Zhou et al. [12] set up a customer satisfaction index system from the customer's point of view to evaluate the third party logistics enterprise. It is proved that the system has the high homogeneity, the reliability and validity of the structures. Sun [19] construct a third-party logistics operation efficiency evaluation index system including four aspects, such as the input-output efficiency, the equipment utilization efficiency, quality assurance, efficiency, market competition efficiency. Hsiao et al. [20] identify and analyse the outsourcing of four levels of logistics activities: transportation (level 1), packaging (level 2), transportation management (level 3), and distribution network management (level 4). The evaluation index system of Peng [21] including logistics cost, the logistics operation efficiency, the basic qualities of service suppliers and logistics technology level has more targeted and practicability.

The TOPSIS (Technique for Order Preference by Similarity to Ideal Solution) method selected for the data analysis in this research was first proposed in 1981 [22]. Many proposed numerical examples have shown that TOPSIS can avoid some weaknesses of the existing multi-attribute methods [23]. Fuzzy TOPSIS is widely employed to solve the multi-criteria evaluation problems [24-26].

In summary, the evaluation of logistics service providers both in theory and in practice has proven to be very important and quite complex, and there have been limited researches in the current literature focusing on the selection of the logistics service provider of the e-commerce companies.

3 Methodology

3.1 FUZZY SETS AND FUZZY NUMBERS

First, it is necessary to review the related Fuzzy Theory:

Definition 1: A Fuzzy set $\tilde{a}$ in a universe of discourse X is characterized by a membership function $\mu_{\tilde{a}}(x)$ which associates with each element x in X, a real number in the interval [0,1]. The function of $\mu_{\tilde{a}}(x)$ is termed the grade of membership of x in $\tilde{a}$ [27]. The present study uses triangular Fuzzy numbers. $\tilde{a}$ can be defined by a triplet (a_1, a_2, a_3). Its conceptual schema and mathematical form are shown as below:

$$\mu_{\tilde{a}}(x)\begin{cases} 0 & x \le a \\ \dfrac{x-a_1}{a_2-a_1} & a_1 < x \le a_2 \\ \dfrac{a_3-x}{a_3-a_2} & a_2 < x \le a_3 \\ 1 & x > a_3 \end{cases}.$$

Definition 2: Let $\tilde{a}=(a_1,a_2,a_3)$ and $\tilde{b}=(b_1,b_2,b_3)$ be two triangular fuzzy numbers. According to Wang [26], a distance measure function $(\tilde{a},\tilde{b})$ can be defined as below:

$$d(\tilde{a},\tilde{b})=\sqrt{\frac{1}{3}[(a_1-b_1)^2+(a_2-b_2)^2+(a_3-b_3)^2]}.$$

Definition 3: Let a triangular Fuzzy number $\tilde{a}$, then α-cut defined as below:

$$\tilde{a}_\alpha=[(a_2-a_1)\alpha+a_1, a_3-(a_3-a_2)\alpha].$$

Definition 4: Let $\tilde{a}=(a_1,a_2,a_3)$, $\tilde{b}=(b_1,b_2,b_3)$ be two triangular Fuzzy number and $\tilde{a}_\alpha$, $\tilde{b}_\alpha$ be α-cut, $\tilde{a}$ and $\tilde{b}$, then the method is defined to calculate the divided between $\tilde{a}$ and $\tilde{b}$ as follows (Kwang, 2005):

$$\frac{\tilde{a}_\alpha}{\tilde{b}_\alpha}=\left[\frac{(a_2-a_1)\alpha+a_1}{-(b_3-b_2)\alpha+b_3},\frac{-(a_3-a_2)\alpha+a_3}{(b_2-b_1)\alpha+b_1}\right].$$

When $\alpha=0$:

$$\frac{\tilde{a}_0}{\tilde{b}_0}=\left[\frac{a_1}{b_3},\frac{a_3}{b_1}\right].$$

When $\alpha=1$:

$$\frac{\tilde{a}_1}{\tilde{b}_1}=\left[\frac{(a_2-a_1)+a_1}{-(b_3-b_2)+b_3},\frac{-(a_3-a_2)+a_3}{(b_2-b_1)+b_1}\right],$$

$$\frac{\tilde{a}_1}{\tilde{b}_1}=\left[\frac{a_2}{b_2},\frac{a_2}{b_2}\right].$$

So the approximated value of $\tilde{a}/\tilde{b}$ will be:

$$\frac{\tilde{a}}{\tilde{b}}=\left[\frac{a_1}{b_3},\frac{a_2}{b_2},\frac{a_3}{b_1}\right].$$

Definition 5: Assuming that both $\tilde{a}=(a_1,a_2,a_3)$ and $\tilde{b}=(b_1,b_2,b_3)$ are real numbers, the distance measurement $d(\tilde{a},\tilde{b})$ is identical to the Euclidean distance.

The basic operations on Fuzzy triangular numbers are as follows [28]:

For approximation of multiplication:

$$\tilde{a}\otimes\tilde{b}=(a_1\times b_1, a_2\times b_2, a_3\times b_3).$$

For addition:

$$\tilde{a} \oplus \tilde{b} = (a_1 + b_1, a_2 + b_2, a_3 + b_3).$$

3.2 GRA (GREY RELATIONAL ANALYSIS)

Below is a briefly review of relevant definitions and the calculation procedure for the GRA approach.

GRA uses several small sub-problems to present the decision problem, and the problem is decomposed into a hierarchy with a goal at the top, criteria and sub-criteria at levels and sub-levels and decision alternatives at the bottom of the hierarchy.

The comparison matrix involves the comparison in pairs of the elements of constructed hierarchy. The aim is to set their relative priorities with respect to each of the elements at the next higher level.

$$D = \begin{array}{c} \\ C_1 \\ C_2 \\ C_3 \\ \dots \\ C_m \end{array} \begin{array}{c} \begin{array}{ccccc} C_1 & C_2 & C_3 & \dots & C_n \end{array} \\ \begin{bmatrix} x_{11} & x_{12} & x_{13} & \dots & x_{1n} \\ x_{21} & x_{22} & x_{13} & \dots & x_{2n} \\ x_{31} & x_{32} & x_{33} & \dots & x_{3n} \\ \dots & \dots & \dots & \dots & \dots \\ x_{m1} & x_{m2} & x_{m3} & \dots & x_{mn} \end{bmatrix} \end{array},$$

where x_{ij} is the degree preference of *i*-th criterion over *j*-th criterion. Before the calculation of vector of priorities, the comparison matrix has to be normalized into the range of [0,1] by the equation below:

$$r_{ij} = \frac{x_{ij}}{\sum_{i=1}^{n} x_{ij}}.$$

Step 1: The consistency ratio need to be identified to reflect the consistency of the decision maker's judgments during the evaluation phase.

$$CI = \frac{\lambda_{\max} - N}{N - 1},$$

where CI is the consistency ratio, $\lambda_{\max}$ is the principal eigenvalue of the judgement matrix and N is the order of the judgement matrix. The consistency ratio should be lower than 0.10 to accept the AHP results as consistent.

Step 2: In the next step, transform r_{ij} into the fuzzy numbers.

Step 3: Calculate the average of the elements of each rows from matrix obtained from step 4, by Definition 4.

3.3 FUZZY MEMBERSHIP FUNCTION

In the evaluating process, the weights expressed with the linguistic terms, represent the important degrees of criteria from experts via surveys on subjective assessments. These linguistic terms are categorized into very low (VL), low (L), medium (M), high (H) and very high (VH). Assume that all linguistic terms can be transferred into triangular fuzzy numbers, and these fuzzy numbers are limited in [0, 1]. As a rule of thumb, each rank is assigned an evenly spread membership function that has an interval of 0.30 or 0.25.

Based on assumptions above, a transformation table can be found as shown in Table 1. Figure 1 illustrates the Fuzzy membership function [28].

TABLE 1 Transformation for Fuzzy Membership Functions

Rank function	Sub-criteria grade	Membership
Very Low (VL)	1	(0.00,0.10,0.25)
Low (L)	2	(0.15,0.30,0.45)
Medium (M)	3	(0.35,0.50,0.65)
High (H)	4	(0.55,0.70,0.85)
Very High (VH)	5	(0.75,0.90,1.00)

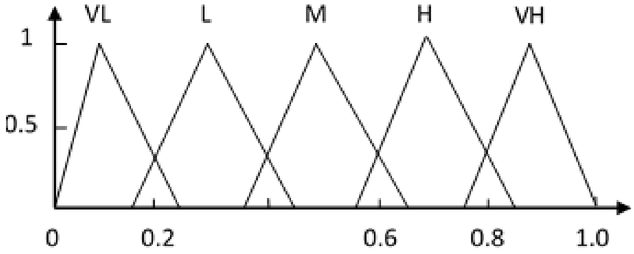

FIGURE 1 Fuzzy triangular membership functions

3.4 FUZZY TOPSIS MODEL

To describe the evaluation method clearly, the procedure of fuzzy TOPSIS is presented as below. It is formulated that a Fuzzy Multiple Criteria Decision Making (FMCDM) problem about the comparative evaluation of the websites of those laptop manufacturers. The FMCDM problem can be concisely expressed in matrix format as follows:

$$\begin{array}{c} \\ A_1 \\ A_2 \\ A_3 \\ \dots \\ A_m \end{array} \begin{array}{c} \begin{array}{ccccc} C_1 & C_2 & C_3 & \dots & C_n \end{array} \\ \begin{bmatrix} \tilde{x}_{11} & \tilde{x}_{12} & \tilde{x}_{13} & \dots & \tilde{x}_{1n} \\ \tilde{x}_{21} & \tilde{x}_{22} & \tilde{x}_{13} & \dots & \tilde{x}_{2n} \\ \tilde{x}_{31} & \tilde{x}_{32} & \tilde{x}_{33} & \dots & \tilde{x}_{3n} \\ \dots & \dots & \dots & \dots & \dots \\ \tilde{x}_{m1} & \tilde{x}_{m2} & \tilde{x}_{m3} & \dots & \tilde{x}_{mn} \end{bmatrix} \end{array}$$

$$\tilde{W} = [\tilde{w}_1, \tilde{w}_2, ..., \tilde{w}_n],$$

where x_{ij}, $i = 1, 2, ..., m$; $j = 1, 2, ..., n$ and $\tilde{w}_j$, $j = 1, 2, ..., n$ are linguistic triangular Fuzzy numbers, $\tilde{x}_{ij} = (a_{ij}, b_{ij}, c_{ij})$ and $\tilde{w}_j = (a_{j1}, b_{j2}, c_{j3})$. The normalized Fuzzy decision matrix is denoted by $\tilde{R} = [\tilde{r}_{ij}]_{m \times n}$.

The weighted Fuzzy normalized decision matrix is shown as follows:

$$V=\begin{bmatrix}\tilde{v}_{11} & \tilde{v}_{12} & \tilde{v}_{13} & \cdots & \tilde{v}_{1n}\\ \tilde{v}_{21} & \tilde{v}_{22} & \tilde{v}_{13} & \cdots & \tilde{v}_{2n}\\ \tilde{v}_{31} & \tilde{v}_{32} & \tilde{v}_{33} & \cdots & \tilde{v}_{3n}\\ \cdots & \cdots & \cdots & \cdots & \cdots\\ \tilde{v}_{n1} & \tilde{v}_{n2} & \tilde{v}_{n3} & \cdots & \tilde{v}_{nn}\end{bmatrix}=$$

$$\begin{bmatrix}\tilde{w}_1\tilde{r}_{11} & \tilde{w}_2\tilde{r}_{12} & \tilde{w}_3\tilde{r}_{13} & \cdots & \tilde{w}_n\tilde{r}_{1n}\\ \tilde{w}_1\tilde{r}_{21} & \tilde{w}_2\tilde{r}_{22} & \tilde{w}_3\tilde{r}_{13} & \cdots & \tilde{w}_n\tilde{r}_{2n}\\ \tilde{w}_1\tilde{r}_{31} & \tilde{w}_2\tilde{r}_{32} & \tilde{w}_3\tilde{r}_{33} & \cdots & \tilde{w}_n\tilde{r}_{3n}\\ \cdots & \cdots & \cdots & \cdots & \cdots\\ \tilde{w}_1\tilde{r}_{m1} & \tilde{w}_2\tilde{r}_{m2} & \tilde{w}_3\tilde{r}_{m3} & \cdots & \tilde{w}_n\tilde{r}_{mn}\end{bmatrix}.$$

Given the above Fuzzy theory, the proposed Fuzzy TOPSIS procedure is then defined as follows:

Step 1:

Choose the $x_{ij},\ i=1,2,...,m;\ j=1,2,...,n$ for alternatives with respect to criteria and $\tilde{w}_j,\ j=1,2,...,n$ for the weight of the criteria.

Step 2: Construct the weighted normalized Fuzzy decision matrix V.

Step 3: Identify positive ideal (A^+) and negative ideal (A^-) solutions:

$$A^+=\left\{\tilde{v}_1^+,\tilde{v}_2^+,...,\tilde{v}_n^+\right\}$$
$$=\left\{(\max_i \tilde{v}_{ij}\,\middle|\, i=1,2,...,m),\ j=1,2,...,n\right\},$$

$$A^-=\left\{\tilde{v}_1^-,\tilde{v}_2^-,...,\tilde{v}_n^-\right\}$$
$$=\left\{(\min_i \tilde{v}_{ij}\,\middle|\, i=1,2,...,m),\ j=1,2,...,n\right\}.$$

Considering that the elements $\tilde{v}_{ij}$ are normalized positive triangular fuzzy numbers and their ranges belong to the closed interval [0,1], the positive ideal and negative ideal solutions can be defined as $\tilde{v}_j^+=(1,1,1)$ and

$$\tilde{v}_j^-=(0,0,0),\ j=1,2,...,n. \tag{29}$$

Step 4: Calculate separation measures. The distance of each alternative from A^+ and A^- can be identified as follows:

$$d_i^+=\frac{1}{n}\sum_{j=1}^{n} d(\tilde{v}_{ij},\tilde{v}_j^+), i=1,2,...,m,$$

$$d_i^-=\frac{1}{n}\sum_{j=1}^{n} d(\tilde{v}_{ij},\tilde{v}_j^-), i=1,2,...,m.$$

Step 5: Calculate the similarities to ideal solution:

$$CC_i=\frac{d_i^-}{d_i^+ + d_i^-}.$$

Step 6: Rank preference order. Rank alternatives according to CC_i in descending order [28].

4 Solutions from GRA and TOPSIS analysis

The evaluation criteria in terms of logistics service providers of the e-commerce companies are show in Figure 2, and payment technology is added to the evaluation system identified by Peng [21], since this paper is focused on the evaluation of e-commerce companies' logistics service providers.

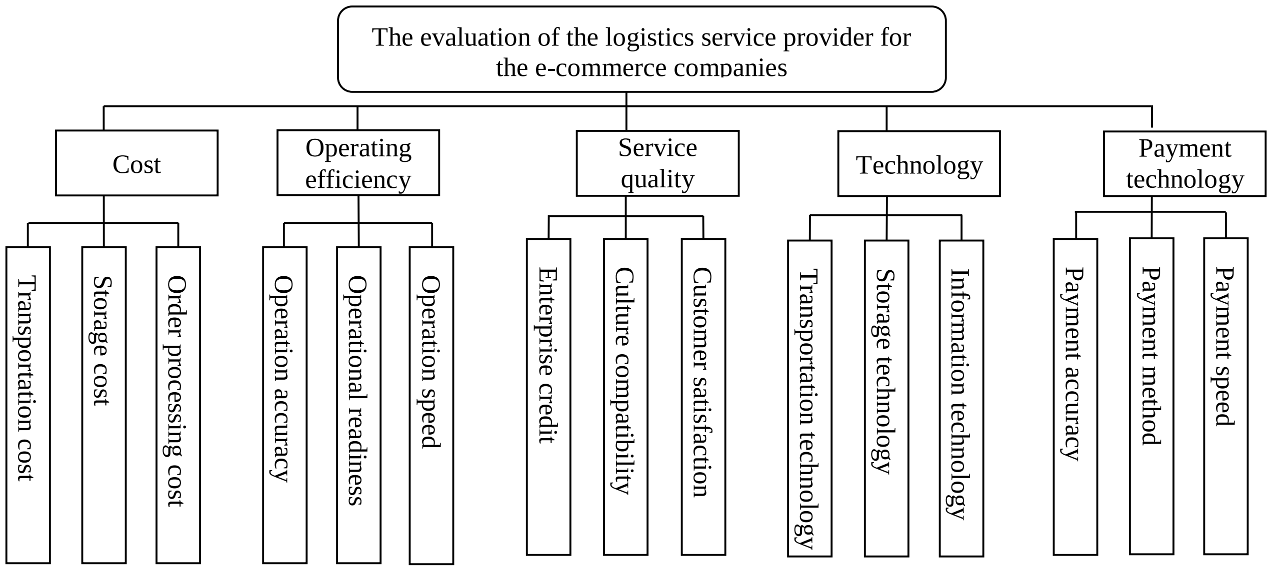

FIGURE 2 The evaluation of the logistics service provider for the e-commerce companies

Fuzzy TOPSIS, as a quantitative tool, is employed in this research. These specific measures are listed and named in Figure 2. The decision problem consists of three levels: at the highest level, the objective of the problem is situated while in the second level, the criteria are listed, and in the third level, the sub-criteria are listed.

$$R_{A1} = \begin{bmatrix} 1.0000 & 0.2904 & 0.2693 \\ 0.2894 & 1.0000 & 1.0000 \\ 0.2811 & 1.0000 & 1.0000 \end{bmatrix},$$

$$R_{A2} = \begin{bmatrix} 1.0000 & 0.5727 & 0.5727 \\ 0.5504 & 1.0000 & 1.0000 \\ 0.5727 & 1.0000 & 1.0000 \end{bmatrix},$$

$$R_{A3} = \begin{bmatrix} 1.0000 & 0.0990 & 1.0000 \\ 0.0990 & 1.0000 & 0.0921 \\ 1.0000 & 0.0986 & 1.0000 \end{bmatrix},$$

$$R_{A4} = \begin{bmatrix} 1.0000 & 0.2220 & 0.2008 \\ 0.2564 & 1.0000 & 0.5624 \\ 0.2559 & 0.5667 & 1.0000 \end{bmatrix},$$

$$R_{A5} = \begin{bmatrix} 1.0000 & 0.1741 & 0.3672 \\ 0.1925 & 1.0000 & 0.1541 \\ 0.4012 & 0.1650 & 1.0000 \end{bmatrix}.$$

According to the above matrices and the definition described earlier, the measures can be grouped into several clusters on the three aspects by threshold value r = 0.60. The final criteria are shown in Table 2. The weights of the criteria are driven from five experts as shown in Table 3. In the next step, the rates are asked to evaluate the four logistics outsourcing companies, and considering the limit of the page, part of the results are shown in Table 4.

TABLE 2 The evaluation criteria of the logistics service provider for the e-commerce companies

Goal	Aspects	Criteria
The logistics service provider evaluation for the e-commerce companies	C_1 Cost	SC_1 Transportation cost SC_2 Storage cost
	C_2 Operating efficiency	SC_3 Operation accuracy SC_4 Operational readiness
	C_3 Service quality	SC_5 Enterprise credit SC_6 Culture compatibility
	C_4 Technology level	SC_7 Transportation technology SC_8 Storage technology SC_9 Information technology
	C_5 Payment technology	SC_{10} Payment accuracy SC_{11} Payment method SC_{12} Payment speed

TABLE 3 The linguistic weights given by five experts

	Sub- Criteria	E1	E2	E3	E4	E5
cost	SC_1	VH	VH	H	VH	H
	SC_2	H	M	M	H	M
Operating efficiency	SC_3	H	M	H	H	VH
	SC_4	H	M	L	M	H
Service quality	SC_5	H	H	VH	H	H
	SC_6	M	L	L	L	VL
Technology level	SC_7	M	M	L	M	L
	SC_8	L	M	H	M	L
	SC_9	H	M	H	M	H
Payment technology	SC_{10}	H	M	H	L	M
	SC_{11}	H	M	H	H	H
	SC_{12}	M	L	L	VL	L

TABLE 4 Part of the evaluation results using Fuzzy linguistic variables

	Cost		Operating efficiency		Service quality		Technology level		
	Transport cost	*Storage cost*	*Operation accuracy*	*Operationa l readiness*	*Enterprise credit*	*Culture compatibility*	*Transport tech.*	*Storage tech.*	*Information tech.*
A1	VH	M	H	M	M	L	M	M	L
A2	H	H	H	H	H	M	H	M	H
A3	VH	H	H	VH	H	M	H	H	H
A4	H	M	M	M	M	L	M	M	M

Then the normalized decision matrix is then derived from the original data as follows:

The larger, the better type [28]:

$$r_{ij} = \frac{\left[x_{ij} - \min\left\{x_{ij}\right\}\right]}{\left[\max\left\{x_{ij}\right\} - \min\left\{x_{ij}\right\}\right]}.$$

The smaller, the better type:

$$r_{ij} = \frac{\left[\max\left\{x_{ij}\right\} - x_{ij}\right]}{\left[\max\left\{x_{ij}\right\} - \min\left\{x_{ij}\right\}\right]}.$$

The Fuzzy linguistic variable is then transformed into a Fuzzy triangular membership function as shown in Table 5, and then the resulting Fuzzy weighted decision matrix can be derived based on Table 5 and the weights identified before. As discussed in 3.3, the positive ideal and negative ideal solutions can be defined as $\tilde{v}_j^+ = (1,1,1)$ and $\tilde{v}_j^- = (0,0,0)$, $j = 1,2,...,n.$ The distance of each alternative from A^+ and A^-, as well as the similarities to an ideal solution, is obtained in Table 6.

TABLE 5 Part of the Fuzzy decision matrix

	A1	A2	A3	A4
Transportation cost	(0.75,0.90,1.00)	(0.55,0.70,0.85)	(0.75,0.90,1.00)	(0.55,0.70,0.85)
Storage cost	(0.35,0.50,0.65)	(0.55,0.70,0.85)	(0.55,0.70,0.85)	(0.35,0.50,0.65)
Operation accuracy	(0.55,0.70,0.85)	(0.55,0.70,0.85)	(0.55,0.70,0.85)	(0.35,0.50,0.65)
Operational readiness	(0.35,0.50,0.65)	(0.55,0.70,0.85)	(0.75,0.90,1.00)	(0.35,0.50,0.65)
Enterprise credit	(0.35,0.50,0.65)	(0.55,0.70,0.85)	(0.55,0.70,0.85)	(0.35,0.50,0.65)
Culture compatibility	(0.15,0.30,0.45)	(0.35,0.50,0.65)	(0.35,0.50,0.65)	(0.15,0.30,0.45)
Transportation technology	(0.35,0.50,0.65)	(0.55,0.70,0.85)	(0.55,0.70,0.85)	(0.35,0.50,0.65)
Storage technology	(0.35,0.50,0.65)	(0.35,0.50,0.65)	(0.55,0.70,0.85)	(0.35,0.50,0.65)
Information technology	(0.15,0.30,0.45)	(0.55,0.70,0.85)	(0.55,0.70,0.85)	(0.35,0.50,0.65)
Payment accuracy	(0.35,0.50,0.65)	(0.55,0.70,0.85)	(0.55,0.70,0.85)	(0.35,0.50,0.65)
Payment method	(0.00,0.10,0.25)	(0.55,0.70,0.85)	(0.55,0.70,0.85)	(0.15,0.30,0.45)
Payment speed	(0.35,0.50,0.65)	(0.35,0.50,0.65)	(0.55,0.70,0.85)	(0.35,0.50,0.65)

TABLE 6 The distance of each alternative from A^+ and A^-

No.	d_i^+	d_i^-	CC_i
A_1	0.129	0.024	0.157
A_2	0.034	0.119	0.780
A_3	0.000	0.153	1.000
A_{17}	0.132	0.021	0.139

In order to see the result more clearly, the resulting Fuzzy TOPSIS analysis is shown in Figure 3.

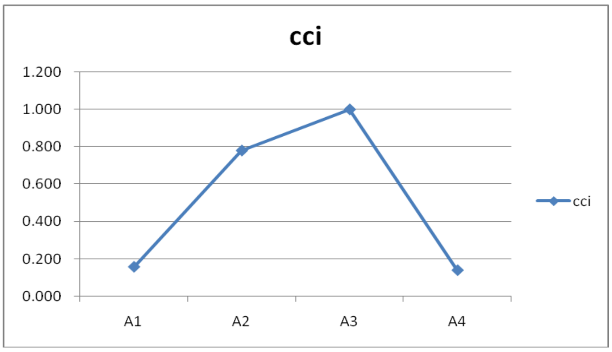

FIGURE 3 Summary of the evaluation of the four logistics outsourcing companies

It is can be seen from the Figure 3 that the third logistics outsourcing company is the best among the four companies to be identified as the logistics service provider.

5 Conclusions and suggestions for future research

This study is an attempt to identify the main factors of selecting satisfactory logistics service provider of the electronic commerce (e-commerce) companies in China. GRA and Fuzzy TOPSIS are employed to evaluate the service of the logistics companies. According to the criteria weights derived from this section earlier, the relative top three important measures to evaluate a logistics outsourcing company are (1) SC_1 Transportation cost, and its weight = (0.67, 0.82, 0.94); (2) SC_5 Enterprise credit, and its weight = (0.59, 0.74, 0.88); and (3) SC_3 Operation accuracy, and its weight = (0.55,0.70,0.84). As such, when the corn company of the supply chain selects the logistics outsourcing companies, it should choose the logistics service company, which is low in transportation coast and has good enterprise credit and high operation accuracy.

Based on the results of this research, our recommendations for improving logistics service in terms of enhancing their effectiveness are: (1) selecting the high operation efficiency logistics company; (2) combing logistics service and payment service; and (3) strengthen the evaluation of the logistics outsourcing company.

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