Design of an Enhanced Logistics Service Provider Selection Model for e-Commerce Application

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***Abstract*—With the increasing popularity of online shopping, customer's purchasing habits are gradually changing in that they often prefer to buy goods online instead of visiting a physical retail store. Hence, the business-to-customer (B2C) e-commerce concept has emerged to bring convenience and flexibility to customers. By shifting the traditional business model to e-commerce, the seller, e.g. supplier or retailer, not only concentrates on directly selling goods to customers online, but also needs to manage the whole business process, including product delivery to customers within a short period of time. To focus on the core business, the logistics function in the B2C market is usually outsourced to a logistics service provider (LSP). However, sellers who are new to the e-commerce market may find it difficult to select an appropriate LSP to fulfill their needs. In this paper, an enhanced logistics service provider selection (ELSPS) model is proposed for selecting an appropriate partner for providing delivery services under the e-commerce environment. A double fuzzy analytical hierarchy processing (FAHP) approach is applied for multi-criteria decision analysis in LSP selection and follow-up action prioritization. A pilot study is conducted, and the results provide a systematic approach and guidelines for new comers to enter into the e-commerce market.**

I. Introduction

E-commerce is an online trading method through the Internet, in which consumers can purchase goods such as clothes and services from retailers over the Internet using desktop computers, laptops, tablet computers or smartphones [1]. It makes changes in the habits of consumers and operation of logistics processes. People often prefer online shopping because of the recommendation of a friend, convenience, cheaper price than shopping stores and the acceptable quality of the products [2]. Using a shopping search engine, consumers can find their target products in regard to availability and price at different e-sellers. After placing orders, they would pay for the goods or services and wait for product delivery. It may require a longer time than shopping in a physical store but online shopping is available anytime and anywhere. Such buying process becomes simple and convenient so many people now prefer to use e-commerce platforms instead of buying goods in person.

The growing trend of e-commerce has put more pressure on the parties involved in the supply chain. By shifting the traditional business model to e-commerce, e-retailers have to manage the whole business process upon receipt of an order from the Internet. Then, they need to arrange product delivery to the customer within a short period of time. However, in the e-commerce business environment, customer satisfaction not only depends on the product quality and customer service from the retailer, but also concerns the delivery performance [3]. Customers always expect to receive their products as soon as possible and, hence, the efficiency of the logistics operations becomes important [4]. To focus on the core business, the logistics operations are usually outsourced to a third-party logistics service provider (LSP). Therefore, selecting a reliable LSP is necessary to move to e-commerce business model.

Although research has been conducted to achieve the goal of LSP selection, most studies solely focused on the selection process without considering the follow-up action plan. Since different LSPs have their own operating procedures, it takes time and further action for the e-retailer to co-operate with the selected LSP. Delays in delivery and low operation efficiency will result if they cannot work well together. Therefore, this paper aims at designing an enhanced logistics service provider selection (ELSPS) model for facilitating the decision making process in LSP selection. A double fuzzy analytical hierarchy processing (FAHP) approach is applied for LSP selection and follow-up action prioritization.

This paper is organized as follows. Section 2 covers the past literature related to e-commerce, LSP selection, and multi-criteria decision making using FAHP. Section 3 presents the design of the enhanced logistics service provider selection (ELSPS) model. Section 4 presents a case study to illustrate how the proposed model works, followed by the results and discussion in Section 5. Finally, the conclusions are drawn in the Section 6.

II. Literature Review

A. Overview of B2C E-Commerce

E-commerce is defined as a business process that includes buying, selling, exchanging products, services and information conducted through the Internet [5] It breaks through a geographical borders and time constraints and can increase business opportunities globally. Fast expanding social media and the increasing use of tablet devices, smartphones and personal computers create opportunities for entrepreneurs to move from Business-to-Business (B2B) to Business-to-Customers (B2C) business model, which has enabled e-commerce to grow exponentially [6].

Since the rapid development of e-commerce worldwide, a trend for online purchasing has spread widely among different groups of people. More consumers are changing their original lifestyle from shopping in retail stores to shopping at home. An increasing number of retail store are opening B2C e-commerce platforms to attract and maintain customers. It is clear that B2C

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e-commerce has a great impact in the retail industry and the influence is going to grow in future [7].

According to Zhu and Kraemer [8], process of a B2C e-commerce trading process can be divided into two major dimensions, i.e. "front-end" and "back-end". "Front-end" represents all the customers-related activities, with order receiving, sales and marketing; "Back-end" refers to activities to fulfil customer satisfaction, such as shipments of ordered goods, management and movement of ordered goods [9]. Concerning the requirement of fast and accurate delivery to meet tight delivery schedules in B2C e-commerce, there are major challenges posed on logistics processes in e-commerce shipments. They include increased daily order volumes, the change of order size from large to small, and a small parcel shipments to consumers in a limited time frame [10]. Compared to traditional logistics in the retail industry, e-commerce logistics consists of logistics process automation, information integration and management services to the different parties in the supply chain [11].

B. LSP Selection

Under the e-commerce environment, third-party logistics service providers (LSPs) play an increasingly important role in handling e-commerce logistics. Defined as an outsource logistics service provider with a role of integrating different supply chain elements to a customer, LSPs provide supporting activities to e-commerce, including management of goods and last-mile delivery to end-customers [12]. In general, LSPs assist e-commerce businesses in achieving flexibility and reducing investment by monitoring the distribution process of goods, monetary and manpower consumption in inventory management and transportation. Hence, to meet the customer requirements and ensure that goods can be delivered on time, selecting a reliable LSPs is crucial in the "back-end" processing of an e-commerce transaction.

According to Aguezzoul [13], cost, relationship, services, and quality are four major criteria that are commonly considered in LSP selection. Rodrigue [14] suggested that speed of delivery, accuracy, real-time tracking, and the distribution network become customers' needs on e-commerce logistics nowadays, rather than only the delivery status, as in the past. Jharkharia and Shankar [15] identified four criteria, long-term relationships, operational performance, financial performance, and risk management when outsourcing logistics functions to LSPs. On the other hand, product damage occurs frequently during the delivery process in e-commerce orders. Hence, LSPs who can minimize product quality risks during delivery would be an advantage in handling e-commerce orders [16]. Furthermore, LSPs are not only required to deliver products, but also need to manage the delivery process in a transparent and low cost manner, with a high quality of value-added services. To increase compatibility, LSPs are expected to adopt different technologies to handle e-commerce orders, such as radio frequency identification (RFID), Internet of things (IoT) and mobile applications so as to achieve real-time tracking and increase visibility [17][18]. Without a systematic approach in decision making, the increasing demands of customers make it challenging to select a reliable LSP in fulfilling e-commerce orders.

C. Multi-Criteria Decision Making using FAHP

Multi-criteria decision making (MCDM) provides a systematic decision making approach to identify the best alternative by evaluating multiple attributes. It is commonly used in supplier evaluation and selection [19][20] and the selection of outsourcing alternatives [21]. The analytic hierarchy process (AHP) is commonly used for tackling multi-attribute decision problems in real situations, as it is a useful, practical and simple method in decision making. Although AHP is easy to use, it cannot effectively take into account vague values and uncertainties in assessing the performance of an LSP. Sometimes the criteria are subjective and qualitative in nature, and it is very difficult for the decision maker to directly compare two attributes with distinct and exact numerical values. According to Balezentis and Zeng [22], MCDM often involves uncertainty which can be tackled by employing fuzzy set theory. In order to deal with the fuzziness of data in decision making, the fuzzy analytic hierarchy process (FAHP) approach is commonly used. It is a fuzzy extension of AHP which allows linguistic inputs to be used in the pair-wise comparison of AHP [23]. Fuzzy AHP inherits the advantages in making efficient and valuable decisions when multi-criteria exist, especially when the criteria are qualitative and difficult to quantify. Ho et al. [24] integrated quality function deployment and fuzzy AHP for outsourcing logistics operations to LSPs. Govindan and Murugesan [25] proposed a fuzzy AHP based model to select a third-party LSP for reverse logistics based on organizational performance criteria, user satisfaction and IT applications. It was found that the use of FAHP in multi-criteria decision making is promising in LSP selection. However, although numerous research studies have been done on selecting LSPs using the AHP/FAHP approach, the formulation of a follow-up action plan after LSP selection is always neglected. Formulation of follow-up action plan is important because companies have to ensure that the selected LSP can work well and effectively following the current process [26].

To fulfill this research gap, an enhanced logistics service provider selection (ELSPS) model integrating two stages of the FAHP process is designed. Firstly, it facilitates the multi-criteria decision making process in LSP selection under the B2C e-commerce environment. Secondly, it allows the formulation of a corresponding follow-up action plan which provides further guidelines to enable the e-retailer to work smoothly with the selected LSP.

III. Design of the Enhanced Logistics Service Provider Selection (ELSPS) Model

In this section, the design of the enhanced logistics service provider selection (ELSPS) model is presented. It is divided into two modules: data collection and decision support. Fig. 1 shows the design of the ELSPS model.

A. Data Collection Module

Diffing from traditional retail practice, a customers can now place orders online and the retailer then arranges to deliver the goods to customers through an LSP. Therefore, a reliable LSP is important in maintaining good service quality. In this module, data or information that are useful in LSP selection are collected.

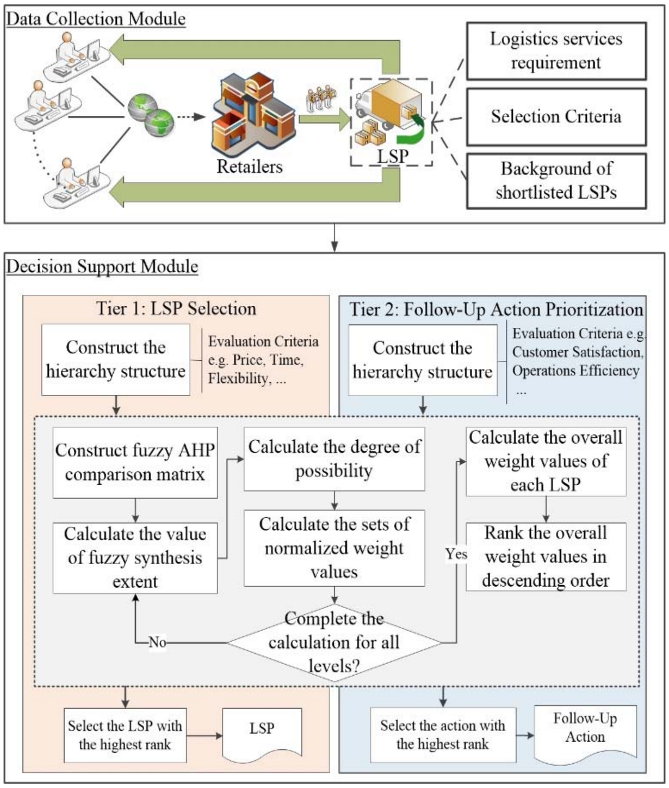

Fig. 1. Design of the ELSPS model

They include the logistics service requirements and selection criteria specified by the retailer, as well as the background of shortlisted LSPs for reference. This information is collected through interviews and LSP websites.

B. Decision Support Module

This module is divided into two tiers: LSP selection and follow-up action prioritization. An extent analysis method on FAHP is applied to determine the weight values of the criteria and alternatives in multi-criteria analysis [27]. Firstly, the best LSP alternative is determined based on the criteria of LSP performance and the service requirement, such as price, time and quality. After the best LSP is selected, the FAHP steps are repeated to prioritize the corresponding follow-up action so as to achieve the business goal. In summary, FAHP has the following six steps:

Step 1: Construct the hierarchy structure of the fuzzy AHP

Decision makers should first identify the alternatives to be classified and determine the key criteria which should be considered so as to evaluate the alternatives. A hierarchy structure consisting of criteria, sub-criteria and alternatives is then constructed to achieve the defined goal.

Step 2: Construct fuzzy AHP comparison matrix

Decision makers are required to compare a particular level to evaluate the relative importance of one element with another on a pair-wise basis. Comparison results are expressed in linguistics terms, which can be transferred into fuzzy numbers. Table I shows the fuzzy linguistic variable set and fuzzy scale. There are five linguistic variables V_i: Equally important (V_1), Moderately important (V_2), More important (V_3), Strongly important (V_4), and Extremely important (V_5). Each linguistic variable V_i is denoted with triangular fuzzy numbers (l_i, m_i, u_i), where l_i is the lower bound, m_i is the most promising value and u_i is the upper bound. By collecting the opinions of decision makers, a $(n \times n)$ fuzzy comparison matrix $A = (\widetilde{a_{ij}})_{n\times n}$ is constructed to summarize the results of the pair-wise comparison, where $\widetilde{a_{ij}} = (l_{ij},\ m_{ij},\ u_{ij})$ represents the relative importance of i^{th} element over j^{th} element. Table II shows the generic form of a pair-wise comparison matrix with n criteria.

Step 3: Calculate the value of fuzzy synthesis extent

Then, the value of fuzzy synthesis extent with respect to the i^{th} element in the k^{th} level of hierarchy, S_i^k, is calculated using (1).

$$S_i^k = \sum_{j=1}^{n} \widetilde{a_{ij}^k} \times \left(\sum_{i=1}^{n}\sum_{j=1}^{n} \widetilde{a_{ij}^k}\right)^{-1}, i = 1,2,\ldots,n \qquad (1)$$

Step 4: Calculate the degree of possibility

The degree of possibility of $S_i = (l_i,\ m_i,\ u_i) \geq S_j = (l_j,\ m_j,\ u_j)$ is calculated using (2). By selecting the minimum value of the degree of possibility of each element, C_i, the weighting of the element, C_i, can be calculated using (3).

$$P(S_i \geq S_j) = \begin{cases} 1 & m_i \geq m_j \\ \frac{l_j - u_i}{(m_i-u_i)-(m_j-l_{j2})} & m_i \leq m_j, u_i \geq l_j \\ 0 & Otherwise \end{cases}, i \neq j \qquad (2)$$

$$d(C_i) = min P(S_i \geq S_j) \quad \forall j, i \neq j \qquad (3)$$

Step 5: Calculate the sets of the normalized weight values

By using (4), the weight values of each element in the k^{th} level of the hierarchy can be obtained. Steps 3 and 5 are repeated until the weight values of all k^{th} levels of the hierarchy are determined.

$$w(C_i^k) = d(C_i^k) \times \left(\sum_{i=1}^{n} d(C_i^k)^{-1}\right) \qquad (4)$$

TABLE I. FUZZY LINGUISTIC VARIABLE SET AND FUZZY SCALE

Linguistic Variable	Symbol	Triangular Fuzzy Number
Equally important	V_1	1,1,1
Moderately important	V_2	1,2,3
More important	V_3	2,3,4
Strongly important	V_4	3,4,5
Extremely important	V_5	4,5,6

TABLE II. PAIR-WISE COMPARISON MATRIX WITH N CRITERIA

	C_1	C_2	…	C_n
C_1	(1,1,1)	(l_{12}, m_{12}, u_{12})	…	(l_{1n}, m_{1n}, u_{1n})
C_2	(l_{12}^{-1}, m_{12}^{-1}, u_{12}^{-1})	(1,1,1)	…	(l_{2n}, m_{2n}, u_{2n})
⋮	⋮	⋮	⋱	⋮
C_n	(l_{1n}^{-1}, m_{1n}^{-1}, u_{1n}^{-1})	(l_{2n}^{-1}, m_{2n}^{-1}, u_{2n}^{-1})	…	(1,1,1)

Step 6: Calculate the overall weight values of each LSP

The weight values of each element are ranked in descending order and the alternative with the highest weight is chosen as the best solution.

IV. CASE STUDY

This section covers the case company background and the implementation steps of ELSPS model in the company.

A. *Company Background*

ABC Company Ltd. is a company which mainly designs, produces and sells consumer electronics to their customers. Their products include audio players, headphones and high quality speakers. They set up their own retail shops to sell their products, however, with the rapid growth of Internet users, it was found that some target customers tend to buy consumer electronics product online instead of visiting a retail shop. In 2017, the sales volume of the company dropped by 8% compared to 2016. Therefore, the company tried to expend its business in the e-commerce market. The sales channel was diversified so that customers can just visit their website or other e-commerce platforms to place an order. However, the company is new to the e-commerce market, and they do not have their own transportation team to deliver the goods to customers. Hence, a pilot study was conducted in this case company to select an appropriate LSP for their business. There were two decision makers involved in the process of logistics service provider selection, both senior managers in the operations department of the company. With the need to deliver e-commerce orders to customers, they were responsible for undertaking this project in identifying a suitable logistics service provider.

B. *Implementation of the ELSPS Model*

The implementation of the ELSPS model is divided into two parts, which are LSP selection and follow-up action prioritization. Each part consists of six steps, as discussed in Section III.

1) *LSP selection*

LSP selection is to identify the most appropriate LSP to perform the delivery function in handling E-commerce orders. Fig. 2 shows the 3-level hierarchy for LSP selection. Firstly, four potential LSPs, which have different characteristics and service standards, are identified. With the goal of selecting an appropriate LSP, five criteria are identified. They are price (C1), time (C2), IT capability (C3), flexibility (C4), and, reliability (C5). Each criteria is further divided into various sub-criteria for evaluation.

Price (C1) refers to the fee for an LSP to perform door-to-door delivery tasks. It consists of two sub-criteria: the service fee (SC11) and extra charge for urgent orders (SC12). The service fee is standard delivery service. If there is any urgent orders that need to be done within a short period of time, e.g. 2-4 hours, an extra service fee is charged. It may affect the choice of an LSP, with a high service fee and extra charge for urgent orders.

Time (C2) refers to the time interval between placing the order and delivery to the destination. It includes transportation time (SC21) and order processing time (SC22). Transportation time is the time required for delivering the item to the destination, and order processing time is the time required for processing after an order is placed.

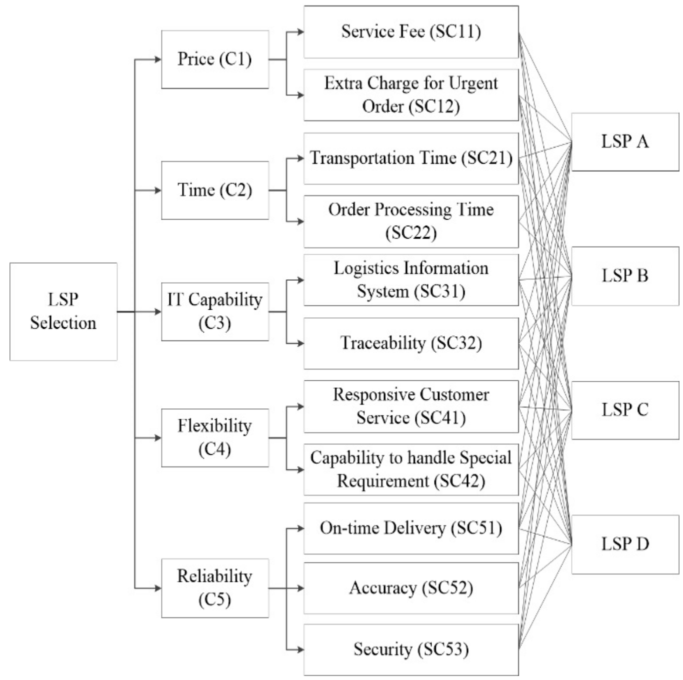

Fig. 2. 3-level hierarchy for LSP selection

IT capability (C3) refers to the availability of using information technology in managing the delivery operations. This criteria becomes increasingly important due to the rapid development of IT in recent years. The use of a logistics information system (SC31) is crucial to manage the transaction order efficiently, while traceability (SC32) provides a value-added service to allow tracking of the real-time delivery status.

Flexibility (C4) refers to the ability of an LSP to respond to change effectively. Responsive customer service (SC41) and capability of handling special requirements (SC42) are the sub-criteria of flexibility. If there is any unexpected incident that may cause a delay in delivery, responsive customer service can provide timely action and a flexible solution to complete the service. On the other hand, the capability to handle special requirements is also important for flexibility in service.

Reliability (C5) refers to the ability to deliver the item to the right destination, with good quality. It can be further divided into on-time delivery (SC51), accuracy (SC52) and security (SC53). On-time delivery makes sure that the order can be delivered on or before the target schedule. Accuracy ensures that the right item is delivered to the right location. Security ensures that the item is delivered safely and in its original form, without being stolen or damaged during transportation.

Pairwise comparisons are then conducted based on the fuzzy linguistic variables defined in Table I. Since a 3-level hierarchy is constructed, pairwise comparisons are conducted for (i) criteria with respect to the goal, i.e. LSP Selection, (ii) sub-criteria with respect to the corresponding criteria, and, (iii) alternatives with respect to the sub-criteria. Since there are two decision makers involved in the selection process, each of them is required to conduct their own sets of pairwise comparisons. Then, the average value of their feedback is taken as the input to construct the fuzzy comparison matrix. Table III shows the fuzzy comparison matrix for criteria with respect to LSP selection. The fuzzy values in the table show the importance of each criteria compared to the other criteria. Through applying the extent analysis method on FAHP, the normalized weight values of the 3-level comparison are obtained, as shown in Table IV. In addition, the weights of each criteria and sub-criteria are calculated to determine the most important criteria in this case. By aggregating the calculation results, the overall weight values of each LSP are shown in Table V. It is found that LSP2 was the highest value among the four alternatives. Therefore, it is suggested that the case company should work with LSP2 in offering the delivery service to customers.

2) Follow-up action prioritization

In the previous part, LSP2 is selected as most appropriate in providing the delivery service. Since different LSPs have their own practice and service details, the retailer should also determine the corresponding follow-up action in order to work with the selected LSP effectively and maintain the service quality. Hence, as shown in Fig. 3, a 2-level hierarchy is constructed after interviews with the managers of the case company for follow-up action prioritization. Four criteria are defined according to the business goal of the company. These are customer satisfaction (C1), operations efficiency (C2), data accuracy (C3), and, profit (C4). Customer satisfaction (C1) refers to the degree of satisfaction to be achieved, measured by the number of complaints received regarding delays in delivery. Operations efficiency (C2) refers to the capability of delivering the goods to its customers in a cost-effective and timely manner. It measures whether the services can be completed within a specified period of time. Data accuracy (C3) refers to the correctness of the order data between the LSP and retailer. If good communication through the logistics information system is established, the data accuracy should be high, also providing accurate information to the customer. Profit (C4) refers to the amount earned by the retailer when an order is completed. If the price of the LSP in delivering an urgent order is high, then the profit that can be earned by the retailer become smaller.

TABLE III. FUZZY COMPARISON MATRIX FOR CRITERIA WITH RESPECT TO LSP SELECTION

	C1	C2	C3	C4	C5
C1	(1,1,1)	(0.3,0.5,1)	(0.3,0.5,1)	(1,2,3)	(0.25,0.3,0.5)
C2	(1,2,3)	(1,1,1)	(0.3,0.5,1)	(3,4,5)	(0.25,0.3,0.5)
C3	(1,2,3)	(1,2,3)	(1,1,1)	(1,2,3)	(1,2,3)
C4	(0.3,0.5,1)	(0.2,0.25,0.3)	(0.3,0.5,1)	(1,1,1)	(1,2,3)
C5	(2,3,4)	(2,3,4)	(0.3,0.5,1)	(0.3,0.5,1)	(1,1,1)

TABLE IV. NORMALIZED WEIGHT VALUES OF 3 LEVELS COMPARISON

Criteria with respect to Goal	Sub-criteria with respect to Criteria	Criteria Weighting	Alternatives with respect to Sub-criteria
C1: 0.145	SC11: 0.308	0.044	(0.05,0.54,0.14,0.27)
	SC12: 0.692	0.100	(0.25,0.22,0.26,0.27)
C2: 0.230	SC21: 0.692	0.159	(0.25,0.27,0.26,0.22)
	SC22: 0.308	0.071	(0.21,0.30,0.27,0.22)
C3: 0.251	SC31: 0.308	0.077	(0.19,0.29,0.27,0.25)
	SC32: 0.692	0.174	(0.05,0.38,0.41,0.27)
C4: 0.141	SC41: 0.692	0.098	(0.10,0.43,0.25,0.22)
	SC42: 0.308	0.043	(0.26,0.26,0.28,0.20)
C5: 0.233	SC51: 0.298	0.070	(0.15,0.31,0.33,0.21)
	SC52: 0.317	0.074	(0.30,0.33,0.27,0.10)
	SC53: 0.385	0.090	(0.17,0.35,0.35,0.13)

TABLE V. OVERALL WEIGHT VALUES OF EACH LSP

Sub-criteria	LSP1	LSP2	LSP3	LSP4
SC11	0.002	0.024	0.006	0.012
CS12	0.025	0.022	0.026	0.027
CS21	0.040	0.043	0.041	0.035
CS22	0.015	0.021	0.019	0.015
CS31	0.014	0.022	0.021	0.019
CS32	0.008	0.066	0.071	0.029
CS41	0.010	0.042	0.024	0.021
CS42	0.011	0.011	0.012	0.009
CS51	0.010	0.021	0.023	0.015
CS52	0.022	0.024	0.020	0.007
CS53	0.016	0.031	0.031	0.012
Sum	0.174	**0.329**	0.294	0.203

In addition, three follow-up actions are defined. They are process review & improvement (A1), training (A2), and, system upgrade (A3). Process review & improvement (A1) is needed to evaluate whether there is any problem in the existing processes and whether improvement is needed. Training (A2) is required as it is a new practice for the staff to place delivery orders with the selected LSP. They may not be familiar with the operation procedure, leading to mistakes and low working efficiency. System upgrade (A3) refers to an upgrade of the computer software to cope with the selected LSP. If a logistics information system is available that can allow real time tracking of goods, the case company should ensure that the computer is equipped with compatible software.

Based on the defined criteria and alternatives, pairwise comparisons are conducted to evaluate their importance. Table VI shows the fuzzy comparison matrix for criteria with respect to the goal, i.e. follow-up action prioritization. Taking customer satisfaction (C1) and operations efficiency (C2) for example, it is suggested that customer satisfaction (C1) is more important than operations efficiency (C2) when determining the follow-up action for LSP2. By aggregating the calculation results, the overall weight values of each follow-up action is shown in Table VII. It is found that process review & improvement (A1) has the highest value among the three alternatives. Therefore, it is suggested that the case company should review its existing

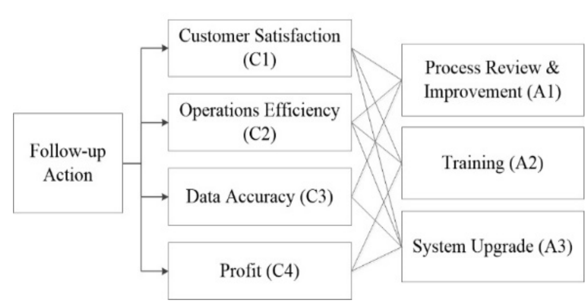

Fig. 3. 2-level hierarchy for follow-up action prioritization

processes and make necessary improvements in order to work smoothly with LSP2 so as to maintain its service quality.

V. Results and Discussion

After conducting FAHP analysis, it is found that LSP2 should be selected from the four potential LSPs, while process review & improvement should be performed as the follow-up action so as to work smoothly with the selected LSP. Since the operations of traditional retail activities and e-commerce business are different, the existing process has to be reviewed to identify the areas for improvement. Apart from the selection result, the result of criteria weights is also presented in order to discuss which criteria are important in LSP selection and follow-up action prioritization.

Fig. 4 shows the weights of the 11 sub-criteria in LSP selection. It is found that traceability (SC32) is the most important criteria when selecting an LSP, and accounts for 17.4% of the total weight. The second important criteria is transportation time (SC21), which also accounts for 15.9% of the total weight. These two criteria contribute to more 33% of the total weight, which implies that the case company should focus on traceability and transportation time in e-commerce applications. Compared to the traditional retail industry that sells products in a retail shop, traceability becomes increasingly important. It is because, unlike previous practice where customer can directly buy and take away the goods from the retail shop, customers have to wait for the retailer to process the order online and arrange delivery to customers. The lead time becomes longer and therefore good traceability allows customers to know the real-time status of their goods up to delivery. On the other hand, short transportation time is also an important concern when selecting an LSP. Customers always want to receive their goods within a short period of time, therefore, an LSP who can deliver the goods to a destination quickly has an advantage over other LSPs.

Comparison of the criteria weighting in follow-up action prioritization is shown in Fig. 5. It shows that four criteria have similar weights, accounting for 20% to 30% of the total weights. It implies that four criteria have similar importance in selection. Among the four criteria, operations efficiency (C2) contributes to the highest weight, which is 27.5%. It is because, in the e-commerce business environment, the retailer who can handle the order and deliver the goods to customers within a short period of time would be the order winner.

TABLE VI. Fuzzy Comparison Matrix for Criteria with respect to Follow-up Action Prioritization

	C1	C2	C3	C4
C1	(1.1.1)	(2,3,4)	(0.33,0.5,1)	(0.2,0.25,0.33)
C2	(0.25,0.33,0.5)	(1,1,1)	(2,3,4)	(1,2,3)
C3	(1,2,3)	(0.25,0.33,0.5)	(1,1,1)	(1,2,3)
C4	(3,4,5)	(0.33,0.5,1)	(0.33,0.5,1)	(1,1,1)

TABLE VII. Overall Weight Values of Each Follow-up Action

	Criteria Weighting	Alternatives with respect to Criteria	A1	A2	A3
C1	0.217	(0.55,0.31,0.14)	0.119	0.068	0.030
C2	0.275	(0.33,0.43,0.24)	0.090	0.120	0.066
C3	0.243	(0.74,0.26,0)	0.179	0.064	0.000
C4	0.265	(0.16,0.51,0.34)	0.041	0.134	0.089
		Sum	**0.429**	0.385	0.186

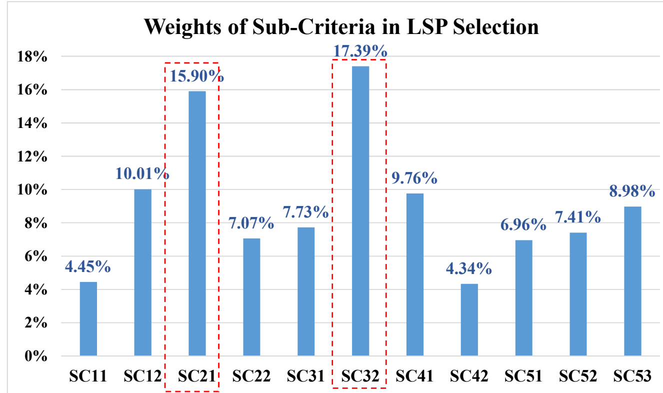

Fig. 4. Weights of Sub-Criteria in LSP Selection

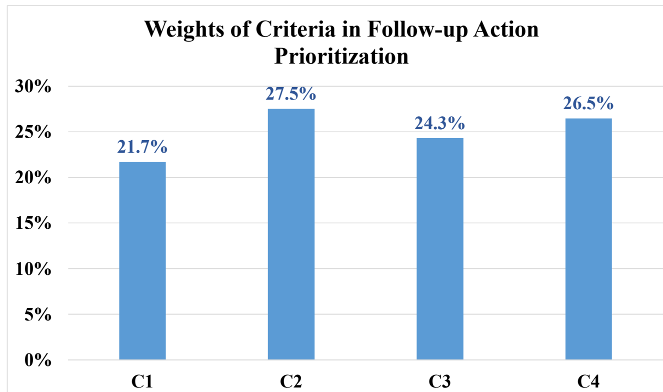

Fig. 5. Weights of Criteria in Follow-up Action Prioritization

VI. Conclusions

Due to the change in buying behavior of consumers, e-commerce business has emerged to provide another channel for shopping online. In an e-commerce business, orders are first received through the online platform, then the goods are delivered to customers. Instead of visiting physical retail shops, the emergence of e-commerce provides convenience to customers. In this case, good logistics arrangements are crucial to ensure that the right goods can be delivered to customers in the right place and with good quality. Therefore, selecting a suitable LSP to provide logistics service is important. Although numerous research have been done to select LSP using the AHP/FAHP approach, the selection of follow-up action after LSP selection is always neglected. This paper presents the enhanced logistics service provider selection (ELSPS) model to fill the research gap. A double FAHP based on an extended analysis method is used to determine the weights of the criteria. A case study is conducted to illustrate the procedure of using the proposed FAHP approach. The results provide a systematic approach and guidelines for new comers to enter into the e-commerce market. The ELSPS model not only provides a practical solution for LSP selection, but also allows formulating corresponding follow-up action so as to work smoothly with the selected LSP.

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