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Full Length Research Paper

Critical factors influencing customer value for global shipping carrier-based logistics service providers using Fuzzy AHP approach

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The key purpose of this research is to apply Fuzzy analytic hierarchy process (AHP) approach to empirically study the critical factors influencing customer value for global shipping carrier-based logistics service providers based upon the customers' perspective. To facilitate the main issue for obtaining critical factors, the four key value metrics - service, quality, cost, and cycle time - are employed to derive those initially important factors firstly. These factors have been discussed and publicized in academic and management fields and can be summarized as four aspects and seventeen initially factors. Subsequently, the proposed Fuzzy AHP approach is used to measure relative weights for evaluating these factors. Finally, the systematic appraisal approach is to perform the empirical survey via AHP questionnaires. The results of this study show that: (1) quality is the highest aspect for customer value from the customers' perspective in Taiwan, and the time is the lowest one; and (2) the top four critical factors influencing customer value are reasonableness of price, related direct costs, safety, and customer satisfaction, respectively.

Key words: Customer value, shipping, Fuzzy analytic hierarchy process (AHP).

INTRODUCTION

The keen competitions and many changes have arisen among global shipping lines focusing on business logistics (Heaver et al., 2001; Ding, 2009a). These competitions are interrelated with the main ocean carriers, which intensely emphasize upon providing integrated logistics services to create significantly added value for their customers. The ocean carriers eventually pay attention to integrated logistical concepts involving the total solution services of logistics management. As a result, global shipping carrier- based logistics service providers (GSLPs) are emerged.

The use of third-party logistics service provided by global shipping carrier is growing rapidly. Examples of GSLPs are Maersk Logistics (Maersk Line (Denmark), rank 1 in the world in 2009); CMA-CGM Logistics (CMA-CGM Line (France), rank 3); Evergreen Logistics (Evergreen Line (Taiwan), rank 4); COSCO Logistics (COSCO Line (China), rank 8); NYK Logistics (NYK Line (Japan), rank 10). These global ocean carriers have been playing up their own brand names to strive for an effort to get customer satisfaction and customer value (CV) in the shipping market, while the shippers have been considering the brand name as an important criterion to consign for their shipments (Liang et al., 2007). All the main market players in this field generally encounter a critical issue about how to promote high CV for their customers. On the other hand, selecting those GSLPs with high CV would advance the quality of shipments for shippers in the future. Hence, the discussion of CV among different GSLPs of global shipping market has gradually been becoming an important issue.

A well-provided CV needs to be taken in terms of perspectives of customers due to promoting high CV would be beneficial to keep sustainable competitive advantage (SCA) (Heskett, 1986). Since the GSLP with high CV is beneficial for smoothing the customer behavior, assessing critical factors influencing the CV for the GSLP is becoming the basically important task for discussing the 'why' issue of giving an insight into keeping her SCA. In the light of this, this paper aims to investigate the critical factors influencing CV for the GSLPs.

Experience showed that the evaluation of critical factors, which involves a multiple criteria problem (Lin and Yahalom, 2009; Sreekumar and Mahapatra, 2009), is not an easy task. The issue of assessing critical factors faces how to evaluate the relative weights of these multiple ones, however, the Saaty's analytic hierarchy process (AHP) approach, proposed in 1980, is one of the commonly used techniques for this problem. The characteristic of multiple criteria problem, in which information is incomplete or imprecise or views that are subjective or endowed with linguistic characteristics creating a Fuzzy environment, e.g. the phrase of 'much more important than.' Thus, the use of Zadeh's Fuzzy set theory, proposed in 1965, would be more suitable in that situation. In the light of this, a fuzziness-based AHP approach is used to measure relative weights for evaluating these critical factors.

In summary, the research issues of this paper with a Fuzzy multiple criteria problem account for raising two evaluation points, which are the 'why' and 'how' questions. Regarding the former one, evaluating critical factors is decisive to insight into determining the core competence and keeping the SCA. As regards the latter one, this paper will propose the application of the Fuzzy AHP approach, which is interlinked among the AHP questionnaire. In the light of this, the key purpose of this research is to apply Fuzzy AHP approach to empirically study the critical factors influencing CV for GSLPs based upon the customers' perspective. The next section presents some theoretical concepts of the research. Consequently, an empirical survey is studied. Finally, some discussions and conclusions are made.

THEORETICAL CONCEPTS OF RESEARCH

In this section, some of the theoretical concepts used in this paper are briefly introduced. These include Fuzzy set theory and Fuzzy AHP approach.

Fuzzy set theory

The Fuzzy set theory (Zadeh, 1965) is designed to deal with the extraction of the primary possible outcome from a multiplicity of information that is expressed in vague and imprecise terms. Fuzzy set theory treats vague data as possibility distributions in terms of set memberships. Once determined and defined, the sets of memberships in possibility distributions can be effectively used in logical reasoning. Triangular Fuzzy numbers and the algebraic operations of Fuzzy numbers are two major components of this section as follows.

Triangular Fuzzy numbers

A Fuzzy number *A* (Dubois and Prade, 1978) in real line $\Re$ is a triangular Fuzzy number, if its membership function $f_A : \Re \rightarrow [0, 1]$ is;

$$f_A(x) = \begin{cases} (x - c)/(a - c), & c \le x \le a \\ (x - b)/(a - b), & a \le x \le b \\ 0, & otherwise \end{cases} \quad (1)$$

with $-\infty < c \le a \le b < \infty$. The triangular Fuzzy number can be denoted by (c, a, b).

The parameter *a* gives the maximal grade of $f_A(x)$, that is, $f_A(a) = 1$; it is the most probable value of the evaluation data. In addition, '*c*' and '*b*' are the lower and upper bounds of the available area for the evaluation data. They are used to reflect the fuzziness of the evaluation data. The narrower the interval $[c, b]$, the lower the fuzziness of the evaluation data.

The triangular Fuzzy numbers are easy to use and easy to interpret. For example, 'a value approximately equal to 100' can be represented by $(95, 100, 106)$; and it can be represented with more leeway by $(91, 100, 112)$. In addition, the non-Fuzzy number, an exact number, '*a*' can be represented by (a, a, a). For example, 'a value of 100' can be represented by $(100, 100, 100)$.

The algebraic operations of Fuzzy numbers

The Zadeh's extension principle (1965) and the Chen's function principle (1985) are usually employed to proceed with the algebraic operations of Fuzzy numbers. The Chen's function principle is applied to arithmetical operations between Fuzzy numbers in this paper. This is because Chen's method has some merits. They are (1) function principle is easier to calculate than extension principle; (2) function principle will not change the shape of a triangular Fuzzy number after the multiplication of two triangular Fuzzy numbers, but the multiplication of two triangular Fuzzy numbers will become drum like shape Fuzzy number by using extension principle; and (3) if we have to multiply more than four triangular Fuzzy numbers, extension principle can not solve the operation, but function principle can easily find the result (Chen et al., 2007).

Let $A_1 = (c_1, a_1, b_1)$ and $A_2 = (c_2, a_2, b_2)$ be Fuzzy numbers

numbers. The algebraic operations of any two Fuzzy numbers A_1 and A_2 can be expressed as:

Fuzzy addition ⊕:

$A_1 \oplus A_2 = (c_1 + c_2, a_1 + a_2, b_1 + b_2)$, where c_1, a_1, b_1, c_2, a_2, and b_2 are any real numbers.

Fuzzy subtraction ;

$A_1 \ominus A_2 = (c_1 - b_2, a_1 - a_2, b_1 - c_2)$, where c_1, a_1, b_1, c_2, a_2, and b_2 are any real numbers.

Fuzzy multiplication ⊗;

$A_1 \otimes A_2 = (c_1c_2, a_1a_2, b_1b_2)$, where c_1, a_1, b_1, c_2, a_2, and b_2 are all nonzero positive real numbers.

Fuzzy division ∅;

(i) $(A_1)^{-1} = (c_1, a_1, b_1)^{-1} = (1/b_1, 1/a_1, 1/c_1)$, where c_1, a_1, and b_1 are all positive real numbers or all negative real numbers.

(ii) $A_1 \varnothing A_2 = (c_1/b_2,\ a_1/a_2, b_1/c_2)$, where c_1, a_1, b_1, c_2, a_2, and b_2 are all nonzero positive real numbers.

Fuzzy AHP approach

The systematic steps for evaluating relative weights using Fuzzy AHP approach (Ding, 2006; 2009c) to be taken are described thus.

Step 1: Develop a hierarchical structure

A hierarchy structure is the framework of system structure. We can skeletonize a hierarchy to evaluate research problems and benefit the context. The hierarchy structure can be constructed as Figure 1, which is covered with *k* aspects and $p + \cdots + q + \cdots + r$ factors, respectively.

Step 2: Collect pair-wise comparison matrices of decision attributes

We choose experts to collect pair-wise comparison matrices of decision attributes, which is represented the relative importance of each pair-wise attribute.

(1) Let x_{ij}^h, $h = 1, 2, \ldots, n$, be the relative importance given to aspect *i* to aspect *j* by expert *h* on the Aspects layer. Then, the pair-wise comparison matrix is defined as $[x_{ij}^h]_{k \times k}$.

(2) Let x_{uv}^h, $h = 1, 2, \ldots, n$, be the relative importance given to factor *u* to factor *v* by expert *h* on the Factors layer. Then, the pair-wise comparison matrix with respect to each aspect is defined as $[x_{uv}^h]_{p \times p}, \ldots, [x_{uv}^h]_{q \times q}, \ldots, [x_{uv}^h]_{r \times r}$.

Step 3: Transform relative importance into triangular Fuzzy number

The generalized means is a typical representation of many well-known averaging operations (Klir and Yuan, 1985), e.g., min, max, geometric mean, arithmetic mean, harmonic mean, etc. The min and max are the lower bound and upper bound of generalized means, respectively. Besides, the geometric mean is more effective in representing the multiple decision makers' consensus opinions (Saaty, 1980). To aggregate all information generated by different averaging operations, we use the grade of membership to demonstrate their strength after considering all approaches. For the above-mentioned reasons, the triangular Fuzzy numbers characterized by using the min, max and geometric mean operations is used to convey the opinions of all experts.

Let $x_{ij}^h \in \{\frac{1}{9}, \frac{1}{8}, \ldots, \frac{1}{2}, 1\} \cup \{1, 2, \ldots, 8, 9\}$, $h = 1, 2, \ldots, n$, $\forall i, j = 1, 2, \ldots, k$, be the relative importance given to aspect *i* to aspect *j* by expert *h* on the Aspects layer. After integrating the opinions of all *n* experts, the triangular Fuzzy numbers can be denoted by $\tilde{B}_{ij}^A = (c_{ij}, a_{ij}, b_{ij})$, where $c_{ij} = \min\{x_{ij}^1, x_{ij}^2, \ldots, x_{ij}^n\}$, $a_{ij} = \left(\prod_{h=1}^{n} x_{ij}^h\right)^{1/n}$, $b_{ij} = \max\{x_{ij}^1, x_{ij}^2, \ldots, x_{ij}^n\}$.

By the same concept, we can integrate the opinions of all *n* experts on the Factors layer, that is the triangular Fuzzy numbers can be denoted by $\tilde{B}_{uv}^F = (c_{uv}, a_{uv}, b_{uv})$, $\forall u, v = 1, \ldots, p; \ldots; \forall u, v = 1, \ldots, q; \ldots; \forall u, v = 1, \ldots, r$, where $c_{uv} = \min\{x_{uv}^1, x_{uv}^2, \ldots, x_{uv}^n\}$, $a_{uv} = \left(\prod_{h=1}^{n} x_{uv}^h\right)^{1/n}$, $b_{uv} = \max\{x_{uv}^1, x_{uv}^2, \ldots, x_{uv}^n\}$.

Step 4: Build Fuzzy positive reciprocal matrices

We use the integrated triangular Fuzzy numbers to build Fuzzy positive reciprocal matrices. For the Aspects layer, the Fuzzy positive reciprocal matrix can be denoted by

$$B_k^A = [\tilde{B}_{ij}^A]_{k \times k} = \begin{bmatrix} \tilde{1} & \tilde{B}_{12}^A & \cdots & \tilde{B}_{1k}^A \\ 1/\tilde{B}_{12}^A & \tilde{1} & \cdots & \tilde{B}_{2k}^A \\ \vdots & \vdots & \ddots & \vdots \\ 1/\tilde{B}_{1k}^A & 1/\tilde{B}_{2k}^A & \cdots & \tilde{1} \end{bmatrix},$$ where

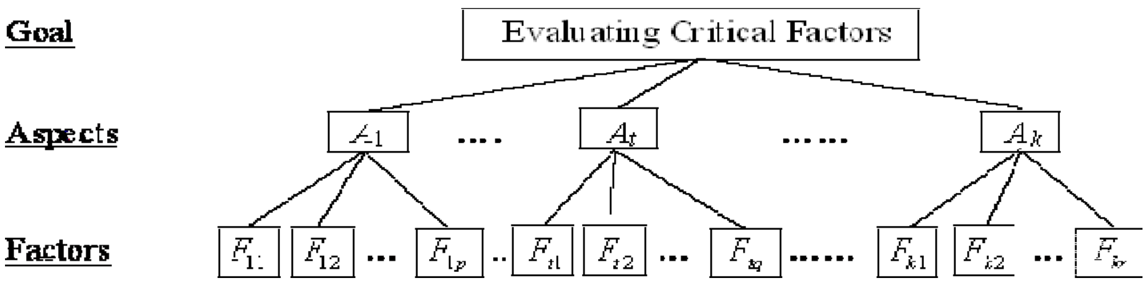

Figure 1. Hierarchy structure.

$\tilde{B}^A_{ij} \otimes \tilde{B}^A_{ji} = 1, \ \forall i, j = 1, 2, \ldots, k.$

By the same concept, we use the integrated triangular Fuzzy numbers to build the Fuzzy pair-wise comparison matrices for the Factors layer, it can be denoted by

$$\tilde{B}^F_p = [\tilde{b}^F_{uv}]_{p\times p} = \begin{bmatrix} \tilde{1} & \tilde{b}^F_{12} & \cdots & \tilde{b}^F_{1p} \\ 1/\tilde{b}^F_{12} & \tilde{1} & \cdots & \tilde{b}^F_{2p} \\ \vdots & \vdots & & \vdots \\ 1/\tilde{b}^F_{1p} & 1/\tilde{b}^F_{2p} & \cdots & \tilde{1} \end{bmatrix},$$

where $\tilde{b}^F_{uv} \otimes \tilde{b}^F_{vu} = 1, \ \forall u, v = 1, 2, \ldots, p.$

$$\tilde{B}^F_q = [\tilde{b}^F_{uv}]_{q\times q} = \begin{bmatrix} \tilde{1} & \tilde{b}^F_{12} & \cdots & \tilde{b}^F_{1q} \\ 1/\tilde{b}^F_{12} & \tilde{1} & \cdots & \tilde{b}^F_{2q} \\ \vdots & \vdots & & \vdots \\ 1/\tilde{b}^F_{1q} & 1/\tilde{b}^F_{2q} & \cdots & \tilde{1} \end{bmatrix},$$

where $\tilde{b}^F_{uv} \otimes \tilde{b}^F_{vu} = 1, \ \forall u, v = 1, 2, \ldots, q.$

and

$$\tilde{B}^F_r = [\tilde{b}^F_{uv}]_{r\times r} = \begin{bmatrix} \tilde{1} & \tilde{b}^F_{12} & \cdots & \tilde{b}^F_{1r} \\ 1/\tilde{b}^F_{12} & \tilde{1} & \cdots & \tilde{b}^F_{2r} \\ \vdots & \vdots & & \vdots \\ 1/\tilde{b}^F_{1r} & 1/\tilde{b}^F_{2r} & \cdots & \tilde{1} \end{bmatrix},$$

where $\tilde{b}^F_{uv} \otimes \tilde{b}^F_{vu} = 1, \ \forall u, v = 1, 2, \ldots, r.$

Step 5: Calculate the Fuzzy weights of the Fuzzy positive reciprocal matrices

Let $\tilde{Z}^A_i = (\tilde{b}^A_{i1} \otimes \tilde{b}^A_{i2} \otimes \cdots \otimes \tilde{b}^A_{ik})^{1/k}, \ \forall i = 1, 2, \ldots, k,$ be the geometric mean of triangular Fuzzy number of i^{th} aspect on the Aspects layer. Then, the Fuzzy weight of i^{th} aspect can be denoted by $\tilde{W}^A_i = \tilde{Z}^A_i \otimes (\tilde{Z}^A_1 \oplus \tilde{Z}^A_2 \oplus \cdots \oplus \tilde{Z}^A_k)^{-1}$. For being convenient, the Fuzzy weight is denoted by $\tilde{W}^A_i = (w^A_{ic}, w^A_{ia}, w^A_{ib})$. By the same concept, let $\tilde{Z}^F_u = (\tilde{b}^F_{u1} \otimes \tilde{b}^F_{u2} \otimes \cdots \otimes \tilde{b}^F_{up})^{1/p}, \ \forall u = 1, 2, \ldots, p,$ be the geometric mean of triangular Fuzzy number of u^{th} factor on the Factors layer. Then, the Fuzzy weight of u^{th} factor can be denoted by $\tilde{W}^F_u = \tilde{Z}^F_u \otimes (\tilde{Z}^F_1 \oplus \tilde{Z}^F_2 \oplus \cdots \oplus \tilde{Z}^F_p)^{-1}$, where the Fuzzy weight is denoted by $\tilde{W}^F_u = (w^F_{uc}, w^F_{ua}, w^F_{ub})$. The Fuzzy weights of $[(p + \cdots + q + \cdots + r) - p]$ factors can be obtained by the above-mentioned method. For saving space, the equations of Fuzzy weights are omitted to reason by analogy on the Factors layer.

Step 6: Defuzzify the Fuzzy weights to crisp weights

For solving the problem of defuzzification powerfully, the graded mean integration representation (GMIR) method, proposed by Chen and Hsieh in 2000, is used to defuzzify the Fuzzy weights. Let $\tilde{W}^A_i = (w^A_{ic}, w^A_{ia}, w^A_{ib})$, $\forall i = 1, 2, \ldots, k,$ be k Fuzzy weights. By the powerful method, the GMIR of $\tilde{W}^A_i$ can be denoted by $W^A_i = \dfrac{w^A_{ic} + 4w^A_{ia} + w^A_{ib}}{6}, \ \forall i = 1, 2, \ldots, k$.

For saving space, the defuzzifications of Fuzzy weights are omitted to reason by analogy on the Factors layer.

Step 7: Standardize the crisp weights

For being convenient to compare the relative importance between each layer, these crisp weights are standardized and denoted by $SW^A_i = W^A_i \Big/ \sum_{i=1}^{k} W^A_i$.

Step 8: Calculate the integrated weights for each layer

Let SW^A_i and SW_{u^F} be the standardized crisp weights on the aspects and factors layers, respectively. Then,

(1) The integrated weights of each aspect on the aspects layer is $IW_i^{\,A} = SW_i^{\,A}$, $\forall i = 1, 2, , k$.

(2) The integrated weights of each factor on the factors layer is

$$IW_u^{\,F} = SW_i^{\,A} \times SW_u^{\,F} \text{ , } \forall i = 1, 2,, k \text{ ;}$$
$$\forall u = 1, \quad , p; \quad ; \forall u = 1, \quad , q; \quad ;$$
$$\forall u = 1, \quad , r \text{ .}$$

EMPIRICAL STUDY

In this section, an empirical study of obtaining critical factors related with CV for GSLPs is carried out to demonstrate the computational process as described above. The process of the algorithm is empirically implemented, step by step, as follows.

Adoption of the initially important factors

In a multiple criteria evaluation problem, numerous criteria/attributes (in this paper we call aspects) and sub-criteria (in this paper we call factors) needed to be considered. In this paper, the criteria are cited from using Johansson et al.'s (1993) four key value metrics, which are service (S), quality (Q), cost (C), and cycle time (T), to show the CV. Johansson et al. indicated the value equation is $V = \frac{S \times Q}{C \times T}$.

According to their viewpoints, any company should concentrate on improving the product quality and/or service, and at the same time reducing the cycle time and cost to the customer. Therefore, based on the four key value criteria mentioned above, the sub-criteria are firstly derived from academic, business and management publications, official Taiwanese sources, a detailed literature review (Christopher, 1998; Ding, 2009b; Johansson et al., 1993; Lagoudis et al., 2006; Liang et al., 2007; Lu, 1997, 2000, 2003, 2007; Meyronin, 2004; Selviaridis et al., 2008; Stock and Lambert, 2001; Yilmaz and Bititci, 2006), and comprehensive interviews conducted by the author with main shippers of GSLPs. Hence, using the concept of inductive method, four aspects in the Aspects hierarchy and seventeen initially important factors in the Factors hierarchy are suggested, and their codes are shown in parentheses. They are categorized and subsequently explained as follows:

Service (A_1)

Better service will get more margin and greater market share. Experience shows superior service deriving high customer satisfaction. Five initially important factors are summed to measure this aspect:

Providing diversity of value-added services (F_{11}): Creating significantly added value for customers and providing different services for different customers are critical issues in logistics industry. It may be a business strategy or tactic to provide diversity services for serving a heterogeneous customer base.

Availability (F_{12}): Each element of the logistics services will benefit from the widespread adoption of any service availability via phone call, e-mail, web, and internet etc. Immediately availability of services will provide customers with gaining their needs and understanding.

Reliability (F_{13}): It means the ability of a logistics service system to perform its functions in routine circumstances, as well as hostile or unexpected circumstances. The reliability in GSLPs especially emerged from the precise degree in the functions of storage, distribution, delivery, and consignment.

Providing adequacy of physical facilities and equipment (F_{14}): Adequate physical facilities and equipment, e.g. handling equipment, storage areas, and containers and chassis etc., plays an important role in complex market designed to meet rigorous market demands.

Increasing marketing channel and network (F_{15}): The numbers of service node and channel, and marketing network can provide more convenient service for customers. Also, serving heterogeneous customers to provide customerized services making it more flexible to customers.

Quality (A_2)

Consumers may focus on the specification quality of a product, and they will compare with competitors in the marketplace. The conformance quality provided by the GSLPs might be accepted by customers. The degree to which product should produce correctly, it means the movements of goods can arrive safely, economically, and quickly from one location to another in this industry. Five initially important factors are summed to measure this aspect;

Improving customer satisfaction (F_{21}): Experience show customer satisfaction is the most important factor influencing customer quality to achieve customer retention and customer loyalty. Satisfying customer needs is a great vital for obtaining customer acquisition to eventually gain profitability.

Safety (F_{22}): It is the state of being safe when logistics activities are processed in the logistics center or warehouse. Controlling the safety means high quality and low risk in handling shipments.

Accuracy and precision of shipments (F_{23}): Accuracy is the degree of veracity while precision is the degree of reproducibility. Both of them are important. Providing right accuracy and precision of shipments makes customer quality in high level to carry out.

Skills and knowledge of operating personnel (F_{24}): All involved activities that make for the functionality to work well need good human resources to have an effective organization. All personnel with superior skills and knowledge will make the logistics operations more facile.

Capability of total quality service and integrated process management (F_{25}): Does the service quality deliver the value to customers? Capabilities of total quality service provided by GSLPs will meet the customers' satisfaction. Developing a customer service network is very important. Of course, providing total quality service usually needs the supports from top managing layer. Subsequently, all shipments in warehouse to process logistics activities smoothly rely on having possession of capability of integrated process management. It makes logistics operations more fluent. Therefore, these two capabilities are possessed by the GSLPs; the customer quality will be satisfied later.

Cost (A_3)

In accounting, costs are the monetary value of expenditures for supplies, services, labor, products, equipment and other items purchased for use by a business. In economics, cost often means opportunity cost. Whatever in which fields, reducing cost is usually a common opinion and idea due to a firm can make a cheaper price. Hence, diminishing total logistics costs to customers can raise the value and benefits for customer. Three initially important factors are summed to measure this aspect:

Providing reasonableness of price (F_{31}): Usually, the price includes a mark up for profit over the cost of the services. Price comparison between competitors is often affected by the customer in terms of evaluating the selection of GSLPs. Even price was uppermost as a critical impress on the purchasing decision; how-ever price now is not a single most important variable of decision.

Reducing related operating costs of shipments (direct costs) (F_{32}): These kinds of costs are usually appeared on the core operational activities, e.g. marketing, warehousing and distribution. Operating costs are parts of variable costs, in which they are mostly concentrated by customers. Selecting the best GSLP will compare with the lower related operating costs of shipments among these competitors. Hence, reducing these kinds of costs can attract customers to buy her services.

Reducing related overhead, charges and fees (indirect costs) (F_{33}): Buyers prefer to pay money when they used related services, not pay overhead, surcharges and fees without using services, especially, which customers believe they do not use these services. All in one price is willing to customers. Too much related overhead, charges and fees are negative for evaluating the selection of GSLPs.

***Time* (A_4)**

'Time is money' is especially in evidence in today's globally competitive environment. Consumers in this field are increasingly sensitive on time aspect, while time or speed is deemed as a source of differentiation for firms. The 'cost of time' is referred to a major influence of selecting GSLPs where the impor-tance of timing is foremost. Time-based competition has become an argument of main stream among the growth of time-sensitive logistics market. Four initially important factors are summed to measure this aspect thus:

Reducing lead time of core logistics services (F_{41}): Reducing the lead time can be achieved by shortening the logistics operation time (that is the time taken to complete the main core operational services from marketing, warehousing to distribution).

Implementing integrated logistics information system (F_{42}): The applications highlight on aiding a number of information technology (IT) and information system (IS), e.g. radio frequency identification (RFID), electronic data interchange (EDI), decision support system (DSS), and artificial intelligence (AI). The more automated the information system, the less opportunity on human error, and eventually reducing the operating time.

Reducing the non-value-adding time (F_{43}): To make significantly improving, understanding the total activities of logistics processes is required. Eliminating out the non-value-adding activities and reducing the time spent on these useless and inefficient ones become apparent.

Quick responsiveness (F_{44}): The responsiveness of service should have a standard to show the service is available any time per day; it is possible that on occasion it may be unavailable for very short time periods to permit maintenance or other development activity to take place. A quick and efficient responsiveness system service will reduce the complaint to arise.

Questionnaire and data collection

In this section, four aspects and seventeen initially important factors, as mentioned above, were used to design the Saaty's AHP questionnaire (Saaty, 1980), and to collect pair- wise comparison matrices of each layer to represent the relative importance. We used the top 200 exporters and importers in Taiwan as the population, recorded in the 'Directory of Excellent Exporters and Importers in 2008, Taiwan (ROC)' (Ministry of Economic Affairs (Taiwan), 2009). The questionnaire was filled in by the export/import department of each company on September to November in 2009. In addition, the surveys were completed through e-mails, phone calls, and in-person interviews conducted by the author. A total of 64 valid questionnaires were collected from the 200 respondents, or which represents about 32% of the total ones. A large proportion of responses, working 15-20 years, participated in this survey.

EMPIRICAL RESULTS

In our case, with four aspects and seventeen factors, there are five (1+4) pair-wise comparison matrices to collect. The author uses the four aspects (A_1 – A_4) of the 64 valid questionnaires as an example for illustrating the computational process of the Fuzzy AHP approach (Ding, 2006; 2009c). As regards to the others 4 pair-wise comparison matrices, these are omitted by reasoning by analogy. The computing process and empirical results are shown as follows.

Step 1: Build Fuzzy positive reciprocal matrix

The author used the data of the relative importance of 64 valid questionnaires to collect pair-wise comparison matrix and then transformed these data into triangular Fuzzy numbers using the geometric mean approach. We use the integrated triangular Fuzzy numbers to build Fuzzy positive reciprocal matrix. The result of the Fuzzy positive reciprocal matrix for the Aspects layer (A_1 – A_4) is shown as Table 1.

Step 2: Calculate the Fuzzy weights of Fuzzy positive reciprocal matrix

Using the Step 5 of Fuzzy AHP approach, the geometric mean of triangular Fuzzy number ($\tilde{Z}_i^{A}$) and the Fuzzy weights ($\tilde{W}_i^{A}$) of four aspects can be shown as Table 2.

Step 3: Defuzzify the Fuzzy weights and normalize the crisp weights

Using the Step 6 of Fuzzy AHP approach, the Fuzzy weights can be defuzzified by the GMIR method to obtain the crisp weights (W_i^{A}). Then using the Step 7 of Fuzzy AHP approach, we can obtain the standardized weights (SW_i^{A}). The results are shown in Table 3.

Table 1. The Fuzzy positive reciprocal matrix of four aspects.

	A_1	A_2	A_3	A_4
A_1	(1, 1, 1)	(0.3333, 0.886, 2)	(0.5, 1.079, 2)	(1, 1.577, 4)
A_2	(0.5, 1.1287, 3)	(1, 1, 1)	(0.5, 1.148, 2)	(0.5, 1.957, 4)
A_3	(0.5, 0.9268, 2)	(0.5, 0.8711, 2)	(1, 1, 1)	(0.125, 1.103, 2)
A_4	(0.25, 0.6341, 1)	(0.25, 0.5110, 2)	(0.5, 0.9066, 8)	(1, 1, 1)

Table 2. The geometric mean of triangular Fuzzy number and the Fuzzy weights.

	$\tilde{Z}_i^A$	$\tilde{W}_i^A$
$i = 1$	(0.6389, 1.1081, 2)	(0.0809, 0.2718, 0.9641)
$i = 2$	(0.5946, 1.2619, 2.2134)	(0.0753, 0.3095, 1.0670)
$i = 3$	(0.4205, 0.9714, 1.6818)	(0.0533, 0.2382, 0.8107)
$i = 4$	(0.4205, 0.7362, 2)	(0.0533, 0.1806, 0.9641)

Table 3. The defuzzified and standardized weights of four aspects.

	A_1	A_2	A_3	A_4
W_i^A	0.3553	0.3967	0.3028	0.2899
SW_i^A	0.2642	0.2950	0.2252	0.2156

Table 4. The standardized weights and integrated weights for the proposed hierarchy.

Aspects	Standardized / integrated weights (*X*)	Factors	Standardized weights (*Y*)	Integrated weights (*Z*)=(*X*)*(*Y*)
		F_{11}	0.2514 (1)	0.0664 (5)
		F_{12}	0.2312 (3)	0.0611 (9)
A_1	0.2642 (2)	F_{13}	0.2324 (2)	0.0614 (8)
		F_{14}	0.1469 (4)	0.0388 (15)
		F_{15}	0.1381 (5)	0.0365 (17)
		F_{21}	0.2414 (2)	0.0712 (4)
		F_{22}	0.2689 (1)	0.0793 (3)
A_2	0.2950 (1)	F_{23}	0.1287 (5)	0.0380 (16)
		F_{24}	0.1494 (4)	0.0441 (13)
		F_{25}	0.2116 (3)	0.0624 (7)
		F_{31}	0.4582 (1)	0.1032 (1)
A_3	0.2252 (3)	F_{32}	0.3679 (2)	0.0828 (2)
		F_{33}	0.1739 (3)	0.0392 (14)
		F_{41}	0.3066 (1)	0.0661 (6)
		F_{42}	0.2264 (3)	0.0488 (11)
A_4	0.2156 (4)	F_{43}	0.2103 (4)	0.0453 (12)
		F_{44}	0.2567 (2)	0.0554 (10)

Remark: Numbers in parentheses are ranks.

Step 4: Calculate the integrated weights

For saving space, the author used the same computational process of Fuzzy AHP approach for each factor to obtain the standardized weights. And then, the results of the integrated weights can be shown as Table 4.

DISCUSSIONS AND CONCLUDING REMARKS

This paper aims to investigate the critical factors influencing CV for GSLPs using Fuzzy AHP approach. To facilitate the main issue for obtaining critical factors, the four key value metrics, proposed by Johansson et al. are employed to derive those initially important factors firstly. These initially important factors have been discussed and publicized in academic and management fields and can be summarized as four aspects and seventeen initially important factors. Subsequently, the next issue faced how to evaluate the relative weights of multiple criteria problem. The proposed Fuzzy AHP approach is used to measure relative weights for evaluating these critical factors. Finally, the systematic appraisal approach is to perform the empirical survey via AHP questionnaires.

The results of empirical study in Table 4 are shown as follows:

1) Quality (A_2), ranking 1, is the most important aspect influencing the CV from the customers' perspective in Taiwan. Service (A_1) and Cost (A_3) are ranked in the second and third places. Time (A_4) is the lowest ranked. It is worthy to note that the aforementioned four aspects, quality, service, cost, and time, are very close with the values of importance weights of 0.2950, 0.2642, 0.2252, and 0.2156, respectively. This indicated that quality, service, cost, and time, are almost equally important in this study. Nevertheless, these values of importance weights could be widely different among various industries.

2) For service aspect (A_1), providing diversity of value-added services (F_{11}) is the critical attribute. For quality aspect (A_2), safety (F_{22}) is the critical attribute. For cost aspect (A_3), providing reasonableness of price (F_{31}) is the critical attribute. For time aspect (C_4), reducing lead time of core logistics services (F_{41}) is the critical attribute.

3) The top four critical factors are providing reasonableness of price (F_{31}); reducing related operating costs of shipments (direct costs) (F_{32}); safety (F_{22}); and improving customer satisfaction (F_{21}). The weights of these four critical factors are all above 7%, and the sum of four weights is 33.60% (about 1/3). However, if we consider that the weights are all above 6%, and the sum of the night weights is 65.39% (about 2/3), then we must add the other five quasi-critical factors, that is providing diversity of value-added services (F_{11}); reducing lead time of core logistics services (F_{41}); capability of total quality service and integrated process management (F_{25}); reliability (F_{13}); availability (F_{12}). At thesame time, the lowest weights of four factors are, below 4% (the sum of four weights is 15.25%), increasing marketing channel and network (F_{15}); accuracy and precision of shipments (F_{23}); providing adequacy of physical facilities and equipment (F_{14}); and reducing related overhead, charges and fees (indirect costs) (F_{33}).

Overall speaking, the quality dimension is paid close attention on CV by Taiwanese customers. Even though enhancing quality would be costliness and time-spending, however, quality created on CV for customers might be worthy to keep up the competitive advantage. It is worthy to note that safety and improving customer satisfaction are most contributed to quality aspect.

Safety - top one performance for measuring the quality aspect and the 3rd critical factor influencing CV for GSLPs - is pursued to make a controlling on minimum loss and damage of shipments for both customers and GSLPs. Customers care the overall safety levels on different handling process activities; on the other hand, service providers should meet this need to provide good safety levels. It is suggested that safety supervision and management system should be made and developed for analyzing the data of accident, framing safety index, inducing high/low risks on accident, and finally improving the future safety levels.

With regard to customer satisfaction - second contributor on measuring the quality aspect and the 4th critical factor influencing CV for GSLPs - it is a significant performance criterion to be understood the importance in what should be measured in the logistics activities to drive profitability for service providers. The GSLPs should inspect that the customer retention and loyalty are great vital for customer satisfaction to create customer profitability. Therefore, with reviews of indicators on customer satisfaction should be developed to observe the financial and non-financial performance for the GSLPs.

Although the cost dimension is ranked in the third place, however, the other two critical factors - providing reasonableness of price, and reducing related operating costs of shipments (direct costs) - influencing CV for GSLPs are ranked 1st and 2nd in this aspect. It has an evident impact on the pricing strategy to make a good margin of profit. Customers care the price provided by GSLPs can be reasonable since the wool still comes from the sheep's back. Related additional direct costs and inefficiencies resulted in core operational activities will cause upward pressure on the pricing. In the competitive market, price will be made based on the degree of competition, while providing reasonable price and reducing direct costs can raise competitive advantage and can reduce the business pressure among competitors.

With regard to two quasi-critical factors as well as critical contributors for service and time dimensions are needed to describe. These two quasi-critical factors - providing diversity of value-added services, and reducing lead time of core logistics services - are ranked 5th, and 6th for quasi-critical factors influencing CV for GSLPs.

Although they are not designated as critical factors, however, they are almost equal and are really close to the 4th critical factor - improving customer satisfaction.

In this field, the provision of an integrated logistics services increases the value added to the shipments. It is believed that the diversity with value-added business provided by GSLPs can allow customers to serve better services. This rouses heterogeneous customers to prefer using such kinds of services. Therefore, providing diversity of value-added services can help the business enhance performance of profitability.

As for reducing lead time of core logistics services, the key point is to identify the core activities of services, e.g. marketing, warehousing, and distribution. The shortening of the core logistics operation time makes a great contribution on reducing lead time. All operation process, schedule, and sequence made by different departments are needed accurately to operate and follow; so that the shipments can be smoothly continued and then the core logistics activities in each stage of different departments cannot be delayed.

Besides, the other important factors without detailed descriptions should be worthy to note with a lot of attention in the future. It is just because these factors are hinted at initially important factors. Furthermore, this paper with its methodologies developed can be employed as a practical tool for various business applications. Also, an alternatives layer can be added to Figure 1 as a complete hierarchy in the future research, so that we can compare the decision value (performance value) to evaluate the attractiveness of alternatives.

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