SERVICE QUALITY EVALUATION OF INTERNATIONAL LOGISTICS COMPANY: AN EMPIRICAL CASE USING QFD APPROACH

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Abstract

The national logistics policy report published by Ministry of Land, Infrastructure and Tourism in 2011 proposes to establish international logistics strategy teams in 10 different regions around Japan to satisfy the increasing demand for advance transportation infrastructure and stay competitive in Asia Pacific. The globalization of world economies creates many opportunities as well as challenges for international logistics companies to gain more business chances in this changing environment. The purpose of this paper is to improve service quality of international logistics companies and explores the quality function deployment in terms of quality evaluation method. The logistics service is particularly characterized by offering a series of transport solution and including other logistics activities. The major customers of the logistics services are the industrial clients. The customer satisfaction is key managerial mission since the competitiveness is a growing issue in this industry. The quality function deployment is one of the unique procedures to expose the requirements of customer and transform them into managerial tasks by cross correlation analysis between requirements and technical measures. The empirical study is performed to investigate service quality of the logistics industry by focusing on a group of leading logistics companies.

Key Words: Quality Function Deployment, Logistics Service, Quality Management.

JEL classification numbers: L80, L90, M11, M19

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1. INTRODUCTION

The maritime transport is one of the largest service industries since around 90% of world trade is performed by seaborne transport, and the other 10% is by air or inland transport. Both Japan and Taiwan are surrounded by sea and China is also a heavily populated country with burgeoning major seaports, and international trade must be accomplished by reliable and experiential international logistics service providers (Lee, 2012). The globalization of the world economies creates many chances as well as challenges for international logistics companies to expand more business in this changing environment. More and more manufactures outsource their core logistics job to the professional logistics companies, however, a numerous of failure service cases force them to shift to better service providers with diversity of shipper's service requirement in Japan. The national logistics policy report published by Ministry of Land, Infrastructure and Tourism (2011) proposes to establish international logistics strategy teams in 10 different regions around Japan in order to satisfy the increasing demand for advance transportation infrastructure and stay competitive in Asia Pacific. In China, above a million registered logistics companies and around 90% are small or medium in size but the logistics service and infrastructure should keep pace with the consumer's demand and country's need (http://www.lloydslist.com/).

Logistics is a supply chain channel which adds the value of place and time utility. Logistics generally means a series of operational activities including inputting, packing, warehousing, information changing, transporting and physical distributing goods from point of suppliers to point of customers, and the international logistics companies can offer the firms the proper logistics solution plan and handle complicated transport task with utilizing the best transportation mode to save their logistics budget. The ISO 9001 standard stressed the importance on achieving customer satisfaction, and many studies revealed that customers will change to the service supplier whose service is perceived to have the better service quality (Hung et al., 2003). Moreover, global competition pressure forces the logistics companies to find out the way to create customer value and provide excellent service, while customer requirements are getting demanding and critical to the service providers, as a result, to satisfy the shippers' needs through hearing their voice and wants has become an important strategic and even survival issue for logistics service provider to accomplish (Mollenkopf, 2005).

To accurately express and quantify the service quality of international logistics company is difficult due to its characteristics such as intangibility, inseparability, ambiguity and heterogeneity. The perceived service quality is the interaction between service provider and customer, so the service attributes of the logistics company are practically assessed by shipper with qualitative and quantitative questionnaires.

Nevertheless, we can find many previous researches and related studies to investigate the service quality or performance of logistics industry. Mikko (2006) investigated the mode selection criteria of Finnish logistics service. According to the research, the products with high price/kg ratio, short life cycles and worldwide market, for example in the hi-tech industries, are typical relying on rapid mode transportation due to their high time utility and worthy of expensive or speedy transport. Miyashita (2006) explained the evolution and development of logistics with life cycle theory and flying geese theory. He urged the shipping industry in Japan to combine the software and hardware in both of air and shipping transportation as the combined 3PL or 3PL mega carrier because it will ensure the long term profit stability and enjoy short term low risk. Bottani (2006) explained companies may enlarge customer satisfaction and expand market shares by improving logistics performances. He applied fuzzy QFD to empirically find out the strategic management of logistics service in an Italian company operating in the mechanical industry in terms of important warehouse functions such as IT, JIT philosophy, forecasting skill, customer relationship management, order picking and warehouse lay-out optimization. Liang et al. (2008) pointed out four critical service items for an ocean freight forwarder. The four service items include operations convenience and response ability, integrated service, transportation ability, and price. Lu (2007) revealed the shippers' service attributes in logistics industry, such as documentation, storage space, transportation service, tracking system. Zhao (2007) explored the taxonomy of IT strategies utilized by 105 of 3PL companies in China with a cluster analysis survey. The study revealed the strategies can attain only IT advantages compared with their rivals but not financial or competitive advantages. Lee (2010) pointed out with the higher value of maritime logistics created, the better customer satisfaction would be attained and the key value is reflected in service effectiveness (e.g. responsiveness, flexibility and service reliability) and operational. Peter (2011) applied a two-stage DEA model to analyze the efficiency of the Brazilian 3PL for 10 years. The results of inputs and outputs analysis for each attribute are discussed to improve the scale efficiency. Chen (2012) emphasized the developing of value-added logistics activities to improve customer satisfaction. Also, the European Shipper's Council argued the port- alliance service quality of major European shipping companies and urges them to demonstrate shippers that alliance formations achieve economies of scale as well as provide better reliability and quality service. After reviewing the above journals related to measure the service quality, consulting with professor academic, experienced executive as well as shippers, we select 10 customer requirements and 11 technical measures to assess the service quality of international logistics company.

2. METHODOLOGY

2.1. The quality function deployment and house of quality

Quality Function Deployment (QFD) was originally developed by Yoji Akao in 1966 and was intended to evaluate the particulars of products based on customer inputs. The most important tool of QFD is the House of Quality (HoQ) which was first applied in the Kobe Shipyard of Mitsubishi Heavy Industries for advancing a new building project of an oil tanker ship. Yoji Akao suggested the use of QFD for the shipbuilding industry and shortly its popularity was improved among several industries. The house of quality would be useful to allocate possible contribution of improvements into customer requirements, and the service provider can maximize customer satisfaction through execute the alternatives of improvement. This research investigates the international logistics companies and the customer requirements are discussed under the QFD method (Akao, 1989).

The procedure for building the house of quality for completion of the QFD can be constructed by the following steps:

A. Customer requirements (WHATs, CRs): Customer requirements information can be known throughout investigation or direct answers from customers. The weight of customer requirements is to identify with the level of importance and satisfaction of each item. The result of deployment stands for the voice of customers in this model. We can use the following formula to calculate the priorities of customer requirements after finding the means of importance and satisfaction rating of the surveys. Let $\overline{Xi}$ and $\overline{Yi}$, i =1,2,···m, symbolize the average degree of importance and satisfaction to customer requirement Ai. Because the importance degree and the priority of shipper's requirements have the direct relationship, the satisfaction degrees have the inverse relationship. We can get the priority rating vi of Ai by $vi = (5\text{-}\overline{Yi})\,\overline{Xi}$.

$$ wi = \frac{vi}{\sum_{i=1}^{n} vi,} \qquad\qquad (\text{eq. 1}) $$

According to this formula, the standard weight wi of CRs can be found.

B. Technical measures (HOWs, TMs): Technical measures are built along with a firm's service or product based the firm's resource and coordination. TMs are applicable for evaluating a firm's service or product.

C. Relationship Matrix：Combining each WHATs and HOWs, the relationship matrix shows the contribution level and relation of each technical measure to each customer requirement. Typically, symbols represent three degree of strength (low relationship, moderate relationship, strong relationship, no relationship), such as 1-4-7 or 1-5-9.

D. Correlation Matrix：Correlation matrix relationship is to measure the relationship of each technical measure and how much they influence each other. Correlations are represented with symbols that express the degree of relation between technical measures. Symbols are translated into a four-value rating scale (low relationship, moderate relationship, strong relationship, no relationship), such as 1-3-5-9 or 1-3-7-9.

E. Target values：It is essential to build the relationship between customer requirements and technical measures. The crisp numeric can present the value in precision-based QFD. In practically, the business operators often estimate them according to their practical experience, skilled knowledge and information. On the other hand, the estimation of the relation power between customer requirements and technical measures is usually demonstrated in linguistic values, e.g. 'high', 'medium' and 'low'. Through calculating weight of technical measures, we can find the target values of each TM (Liang, 2008). The classical structure of the HOQ is listed in Figure 1.

The outcome of the matrix is the ranking of TMs downward order of importance. For this purpose, both the absolute and the relative importance of each TM against customer's requirements need to be calculated. In the classical QFD applications, in order to represent the relationship between i th CR and the j th TM, the generic position Xij can be used with a numeric scale. So, the absolute importance AIj, j =1,⋯..m. The formula to find each TM is

$$\text{AI}j = \sum_{i=1}^{n} WiXij, \ j = 1, \cdots m \qquad \text{(eq. 2)}$$

Wi is the relative importance of the i th CR, Xij is the numerical value put in the point (i, j) of the matrix, j =1,⋯..m. and i =1,⋯..n the number of TMs and of CRs .

We can define the RIj through $\text{AI}j$ by using the equation as follows:

$$RIj = \frac{AIj}{\sum_{j=1}^{m} Aij,} \ j = 1, \cdots m \qquad \text{(eq. 3)}$$

We can find the TMs are ranked according to RI_j more than AI_j through literature review. So, as the higher RI_j, the TM is more important that we should include it into the product or service for the purpose of enhancing customer satisfaction and improve the service quality (Duru et al, 2011).

2.2. Fuzzy analytic hierarchy process

The pair wise comparison matrix is computed with the subjective judgments of the decision makers and there might be some uncertainty associated with this judgment that is not taken into account by the analytic hierarchy process (AHP) Yang, 2004(). Therefore, Buckley 1985() proposed the evolutionary algorithm with the trapezoidal fuzzy numbers to overcome this uncertainty by using fuzzy set theory. The linguistic terms for this study are determined as in Table 1 and its fuzzy number is displayed in Figure 4. In this study, Chang's 1996() approach for FAHP is used to calculate the weight of customer satisfaction and its definition is as follows:

Definition 1: A fuzzy set Ã in a universe of discourse R is characterized by a membership function $\mu_{\tilde{A}}(x)$ which associates with each element x in R is a real number in the interval [0, 1]. The function value $\mu_{\tilde{A}}(x)$ is termed the grade of membership of x in Ã.

Definition 2: A fuzzy number is a fuzzy subset in the universe of discourse R that is both convex and normal.

Definition 3: A triangular fuzzy number denotes as Ã = (l,m,u), where l $\leq$ m $\leq$ u, has the following triangular type membership function;

$$\mu_{\tilde{A}}(x) = \begin{cases} 0, & x < l, \\ (x-l)/(m-l), & l \leq x < m, \\ 1, & x = m, \\ (u-x)/(u-m), & m < x \leq u, \\ 0, & u < x. \end{cases} \qquad \text{(eq. 4)}$$

where l and u are the lower and upper bounds of the fuzzy number Ã, respectively, and m is the midpoint as shown in Figure 2.

The Chang approach for the FAHP method is stated in as follows:

Let X= {x1, x2, x3,···, xn} be an object set and U= {u1, u2,···, um} be a goal set. The extent analysis for each goal is performed under each object. Therefore, m extent analysis values for each object are indicated with the following parameters:

$$M_{g_i}^1, M_{g_i}^2, ..., M_{g_i}^m \text{ , i=1, 2,} \cdots \text{, n,} \tag{eq. 5}$$

where all the M_g^j (j=1,2,$\cdots$,m) are TFNs.

Step 1: The value of fuzzy synthetic extent with respect to the ith object is defined as

$$S_i = \sum_{j=1}^{m} M_{g_i}^j \otimes \left[\sum_{i=1}^{n} \sum_{j=1}^{m} M_{g_i}^j \right]^{-1} \tag{eq. 6}$$

To obtain $\sum_{j=1}^{m} M_{g_i}^j$, the fuzzy addition operation of m extent analysis values for a particular matrix is performed such as:

$$\sum_{j=1}^{m} M_{g_i}^j = \left(\sum_{j=1}^{m} l_j, \sum_{j=1}^{m} m_j, \sum_{j=1}^{m} u_j \right) \tag{eq. 7}$$

And to obtain $\left[\sum_{i=1}^{n} \sum_{j=1}^{m} M_{g_i}^j \right]^{-1}$, the fuzzy addition operation of $M_{g_i}^j$ (j=1, 2,$\cdots$, m) values is performed such as:

$$\sum_{i=1}^{n} \sum_{j=1}^{m} M_{g_i}^j = \left(\sum_{i=1}^{m} l_j, \sum_{i=1}^{m} m_j, \sum_{i=1}^{m} u_j \right) \tag{eq. 8}$$

and then the inverse of the vector in Eq. (9) is computed, such as:

$$\left[\sum_{i=1}^{n} \sum_{j=1}^{m} M_{g_i}^j \right]^{-1} = \left(\frac{1}{\sum_{i=1}^{n} u_i}, \frac{1}{\sum_{i=1}^{n} m_i}, \frac{1}{\sum_{i=1}^{n} l_i} \right). \tag{eq. 9}$$

Step 2: The degree of possibility of M2= (l2, m2, u2) $\geq$ M1=(l1, m1, u1) is defined as

$$V(M_2 \geq M_1) = \sup_{y \geq x} \left\lfloor \min(\mu_{M_1}(x), \mu_{M_2}(y)) \right\rfloor$$

(eq. 10)

and can be expressed as follows:

$V (M2 \geq M1) = hgt (M1 \cap M2)$

$$= \mu_{M_2}(d) = \begin{cases} 1, & \text{if } m_2 \text{ ?} m_1 \\ 0, & \text{if } l_1 \text{ ?} u_2 \\ \dfrac{l_1 - u_2}{(m_2 - u_2) - (m_1 - l_1)}, & \text{otherwise.} \end{cases}$$

(eq. 11)

Figure 3 illustrates Eq. 11 where d is the ordinate of the highest intersection point D between μ_{M_1} and μ_{M_2}. To compare M1 and M2, we need both the values of $V (M1 \geq M2)$ and $V (M2 \geq M1)$.

Step 3: The degree possibility for a convex fuzzy number to be greater than k convex fuzzy Mi (i=1,2,···;k) numbers can be defined by

$V (M \geq M1, M2, ···; Mk) = V [(M \geq M1) and (M \geq M2) and ··· and (M \geq Mk)]$
$= \min V (M \geq Mi), i=1,2,3,···,k.$ (eq. 12)

Assume that $d'(Ai) = \min V(Si \geq Sk)$ *for k=1,2,···,n; k $\neq$ i..* Then the weight vector is given by

$W' = (d'(A1), d'(A2),···,d'(An))T$ (eq. 13)

where Ai (i=1, 2,···, n) are n elements.

Step 4: Via normalization, the normalized weight vectors are

$W= (d(A1), d(A2),···,d(An))T,$ (eq. 14)

where W is a non-fuzzy number.

2.2.1 The consistency calculation for the FAHP method

The consistency calculation for pair wise matrices plays a significant role for the FAHP method and Duru et al. (2012) proposed the centric consistency index (CCI) which is based on the geometric consistency index (GCI) Aguarón and Moreno-Jiménez, 2003Crawford and Williams, 1985(;) is applied to compute the consistency of each matrix. The calculation of CCI is as follows:

Let $A = (aL_{ij}, aM_{ij}, aU_{ij})n \times n$ be a fuzzy judgment matrix, and let $w = [(w_{L1}, w_{M1}, w_{U1}), (w_{L2}, w_{M2}, w_{U2}), \cdots, (w_{Ln}, w_{Mn}, w_{Un})]^T$ be the priority vector derived from A using the RGMM. The centric consistency index (CCI) is computed by

$$CCI(A) = \frac{2}{(n-1)(n-2)} \sum_{i<j} (\log(\frac{a_{Lij} + a_{Mij} + a_{Uij}}{3}) - \log(\frac{w_{Li} + w_{Mi} + w_{Ui}}{3})$$
$$+ \log(\frac{w_{Lj} + w_{Mj} + w_{Uj}}{3}))^2 \qquad \text{(eq. 15)}$$

where n is the number of elements. When CCI(A)=0, we consider A fully consistent. The thresholds of GCI are used for the CCI and its scale is $\overline{GCI}$=0.31 for n=3; $\overline{GCI}$=0.35 for n=4 and $\overline{GCI}$=0.37 for n>4 (Aguarón et al, 2003).

2.2.2 The prioritization of decision maker

In the existing literature, the prioritization of each decision maker is assumed same; however, their experience and knowledge are different than each other. Duru et al. (2012) suggest that the reverse of each decision maker's consistency can be used for the weight of each matrix. The algorithm of proposed method is as follows:

Let D = {d1, d2,···, dm}be the set of decision makers, and λk = {λ1, λ2,···, λm} be the weight of decision makers. The weight of decision makers (λk) is the normalized Ik for the group of experts which is calculated as follows:

$$I_k = \frac{1}{CCI_k} \qquad \text{(eq. 16)}$$

where Ik is the inverse of the CCI,

$$\lambda_k = \frac{I_k}{\sum_{k=1}^{m} I_k} \qquad \text{(eq. 17)}$$

where $\lambda k > 0$, k = 1,2,$\cdots$,m, and $\sum_{k=1}^{m} \lambda_k = 1$.

All individual matrices can be aggregated by using the aggregation of individual judgment (AIJ) or the aggregation of individual priorities (AIP) Cao et al., 2008Forman and Peniwati, 1998Ramanathan and Ganesh, 1994(; ;). In this study, AIP is applied for the calculation of aggregation matrix because the prioritization of each decision makers is assumed different than each other and its formulation is as follows;

Let A (k) = $(a_{ij}^{(k)})_{n \times n}$ be the judgment matrix provided by the decision maker dk. $w_i^{(k)}$ is the priority vector of criteria for each decision maker calculated by

$$w_i^{(k)} = \frac{\left(\prod_{j=1}^{n} a_{ij} \right)^{1/n}}{\sum_{i=1}^{n} \left(\prod_{j=1}^{n} a_{ij} \right)^{1/n}} \qquad \text{(eq. 18)}$$

The aggregation of individual priorities is defined by

$$w_i^{(w)} = \frac{\prod_{k=1}^{m} (w_i^{(k)})^{\lambda_k}}{\sum_{i=1}^{n} \prod_{k=1}^{m} (w_i^{(k)})^{\lambda_k}} \qquad \text{(eq. 19)}$$

where $w_i^{(w)}$ is the aggregated weight vector.

3. THE EMPIRICAL STUDY ON LOGISTICS COMPANIES IN ASIAN REGION

The leading logistics companies of Asian region are investigated for service quality assessment and a series of technical measures are used to convey customer requirements. A group of leading logistics companies (LLC) is compared according to technical measures and customer requirements. These companies are selected from East Asian countries such as Japan, China, South Korea and Taiwan and the name of the companies is kept confidential (alphabetical labels are used). The expert participants are professors, practitioners and experiential experts from East Asian countries. The surveys were collected by telephone, email, facsimile and personal visits.

The expert consultation is performed in two steps. In the first step, a preliminary survey is prepared to define customer needs and technical measures in a small group.

Then, the fundamental survey is performed to collect responses for an assessment in the second step. The initial expert group considers items existing in the literature and also suggests possible novel contributions to them. At this stage, a number of customer requirements are preferred as presented in Table 2.

Several technical measures are selected to transform customer requirements to measurable and tangible indicators. Table 3 presents these technical measures for quality assessment of logistics companies. The technical measures disclose the size of logistics companies by evaluating the assets (fleet size, distribution centres, CRM centre etc.) and also expose the availability of professional organizational segments and systems. Although some of the technical measures are directly tangible items, some of them are indirectly tangible by binary selection of existence (1/0).

The fuzzy-AHP process is applied to define the priority weights of the customer requirements. An expert group from manufacturing industry is asked to complete a pair wise comparison survey and the time spent for the business is also noted for the prioritization process. Table 4 presents the aggregated fuzzy judgment matrix for the customer requirements. CCI is 0.01 which is far less than the critical value of 0.37. The "speedy delivery and quality" is the major requirement of the customers with relative weight of 0.26. Since the purpose of transport is the transhipment of product in good manner, safety of cargo condition is crucial. Then, the second important variable is "cheaper service" with relative weight of 0.23. The time spent for transport and the business reputation are following indicators among others.

The relationship matrix is the key part of HoQ in QFD assessment. A group of contributors including scholars from shipping research is asked to define correlation degree of each customer requirements with the technical measures. For this purpose, a three-level scale is used which consists of strong relationship ("■" corresponding to 9) , medium relationship ("▲" corresponding to 5), low relationship ("●" corresponding to 1) and no relationship ("nil" corresponding to 0).

Table 5 shows the final content of the matrix in two parts including the priorities of the customer requirements, the correlation matrix among the technical measures, the direction of improvement and the comparative analysis among the international logistics companies. The relative weights of the technical measures are also indicated in Table 6.

According to the number of indications through a single row of customer requirements, "Good business reputation" is found the most dependent factor by the technical content (11 of 11 items). The "Speedy delivery and quality" (9 of 11), "Cheaper service" (8 of 11), "Excellent problem solving ability" (8 of 11) and "Strong logistics and intermodal solution" (8 of 11) are also substantially oriented by the technical measures.

The relative weights of the technical measures are calculated by using eq. 2 & 3.

The particulars of operation and business developing are found the most significant improvement for the customer satisfaction. The existence of ISO 9001, particulars of customer relationship management (CRM) and supply chain integrations are considered as important indicators for the enhancement of customer satisfaction. In the right side of Table 5, the comparison of the LLC is indicated according to the customer requirements by using ranking orders. For this step of the analysis, authors endeavoured to collect responses from business practitioners of the logistics and freight forwarding industry of different countries to ensure objectivity and quality of the results.

The comparative analysis indicates that LLC C has superiority in general and LLC A and LLC D have a strong competition for the customer satisfaction. According to the logistics fees, LLC B and LLC A have the leading status among the industry. Since the cheaper service is the second important requirement, price advantage is an important parameter. LSC B is not in superior position in the remaining assessment, but its outstanding price advantage is preferable by many medium to small size industries. On the other hand, the logistic framework of the LLC C maintains several superior facilities and sophisticated business solutions which contribute to the cumulative satisfaction of the customers.

The top of the HoQ table indicates the correlation matrix of technical measures as shown in Table 6. For this reason, a four-level scale is used which consists of strong positive correlation ("++"), positive correlation ("+"), negative correlation ("-"), strong negative correlation ("--") and no correlation ("nil"). The correlation matrix is particularly useful for developing corrective actions and policies. While an industry attempts to implement a number of tasks for the improvement of the customer satisfaction according to the QFD assessment, it should be taken into consideration that the technical measures may interact and positively or negatively influence each other. Therefore, one improvement may cause unexpected loss of quality on another aspect. Although, these indications are based on a limited number of expert considerations, the implications may exist on the practical use of the results.

4. DISCUSION ON SERVICE QUALITY IMPROVEMENT IN LSCs

According to the research literature, a group of improvements are found critical to ensure business sustainability and increasing competitiveness in the logistics business market. A numerous of failure cases of logistics service providers lose their customers because they do not provide the right service or appropriate solutions to attain customer satisfaction in each details of service items. First of all, the customer of

international logistics service tends to purchase a complete transport solution and expect long term relationship commitment rather one time transaction or short term cooperation. Customer cares about the transport reliability and service quality more than alliance service or other advertisement slogan stressed by logistics companies (Lee, 2011). LLCs with the strong customer relationship management have critical foremost position. In case of multimodal solution issue, customer requirement may be somehow different in terms of cost saving, delivery speed or other individual requirement. The ability of customized and individual service becomes an important task to handle according to the shipper's special requirement (Yoshida et al. 2005).

5. CONCLUSION

This paper investigated the service quality of international logistics companies in the Asian market and the QFD method is implemented to conduct the assessment of the services and facilities for customer satisfaction. The present study indicated the foremost requirements of the customers while transferring this information to practical improvements on technical content.

First, since the operation and business developing are found the most significant improvement for the customer satisfaction, enlarging the overall service coverage and analyzing cost performance of specific logistics functions such as order processing, transportation, warehousing will contribute to the diversified service options and decreasing the total operating cost. In February 2012, the Maersk Line CEO Thomas Knudsen identifies relative high operational cost as one of Singapore's logistics weakness compared with China, though they have high quality of labour, property and supportive government towards businesses. High operational cost may spoil the profit and competitive advantage, so it is necessary for logistics companies to analyze the costly areas such as fuel or labour to have a big savings to increase total revenue.

Second, the implement of ISO 9001will ensure the standard operation procedure and capable staff to handle every detail of logistics activity to earn the mutual trust with customers and build stronger business reputation. It is necessary for logistics companies to have more quality certificates to show their services are equal to international standard.

Third, as to the success of CRM, the logistics company should concentrate on the requirements of individual customer and conduct one-to-one marketing to their special needs. Recently, SBS Group CEO Steve Walker stresses the importance for shipper to have strong relationships and long term cooperation commitment with more than one reliable logistics or shipping service providers in 2012. Therefore, the strengthen

functions of CRM will help logistics companies to hear the voice of their customers and build long-term cooperation agreement and commitment with their shippers to gain sustainable competitive advantage in the shipping market. Surprisingly, although the current green logistics and environmental issue catches the attention around the world, the relative weight remains the lowest and has very little contribution to customer satisfaction in this empirical study (Chang, 2006).

Finally, improving supply chain integration will directly affect the efficiency and cost of the logistics systems. The IMC Pan Asia Management's general manager of shipping and logistics reveals that China's immature internal logistics infrastructure invalidate its 60% market share of the iron ore market as world's largest iron importer. He stresses that China needs all the facilities including hardware, software, integrated supply chain systems and government policies to accommodate the increase imported iron ore. For that reason, logistics companies should provide a overall seamless supply chain systems to minimize the transit time and improve customer satisfaction. Though providing quality service is sometimes costly to many logistics companies, the further research to find out the customer's requirement is still necessary to the sustainable business and win-win relationship with customers (http://www.fairplay.co.uk). The relationship between service quality and performance can be explored for future research issue.

Table 1.

Transformation for TFNs Membership Functions.

Fuzzy number	Linguistic scales Reciprocal	Membership function
$\tilde{A}_1$ (1,1,1)	Equally important	(1,1,1)
$\tilde{A}_2$ (1/5,1/3,1)	Moderately important	(1,3,5)
$\tilde{A}_3$ (1/7,1/5,1/3)	More important	(3,5,7)
$\tilde{A}_4$ (1/9,1/7,1/5)	Strongly important	(5,7,9)
$\tilde{A}_5$ (1/9,1/9,1/7)	Extremely important	(7,9,9)

Table 2.

Customer Requirements in the Empirical Work.

Customer requirements	Symbol	Description
1. Cheaper service	CS	Price of service
2. Speedy delivery and quality and cargo condition	SDQ	Time spent for delivery
3. Global service local service network	GS	Worldwide service and
4. Efficient operation and customized ability customer and staff	EOC	Interaction between
5. Strong logistics and intermodal solution modes of service	SL	Ability to offer different
6. Good business reputation of the company	GBR	Public image and records
7. Well information providing dynamic market situation	WI	Instant information
8. Professional sales and staff of company staff	PSS	Profession and expertise
9. Excellent problem solving ability to provide solution	EPS	Experiential and capable

10. Sufficient slot supply shipment	SSS	Enough capacity to large

Table 3.

Technical Measures in the Empirical Work.

1. Operation and business developing
2. IT and technical support
3. Existence of ISO 9001 (1/0)
4. Global network (1/0)
5. Customer relationship management
6. Human resource management
7. Performance assessment system (1/0)
8. Multimodal options
9. Strategic alliance and partnership (1/0)
10. Supply chain integration
11. Legal regulation and green logistics

Table 4.
The Aggregated Fuzzy Judgment Matrix for Customer's Satisfaction.

	CS	SDQ	GS	EOC	SL	GBR	WI	PSS	EPS	SSS	Weight
CS	(1,1,1)	(1.92,2.33,2.66)	(1.62,2.03,2.36)	(1.77,2.69,3.41)	(0.89,1.40,1.88)	(0.99,1.50,1.98)	(1.67,2.57,3.29)	(2.10,2.49,2.66)	(0.94,1.14,1.48)	(2.5,3.01,3.67)	(0.23)
SDQ	(0.38,0.43,0.52)	(1,1,1)	(1.86,2.22,2.52)	(2.03,2.94,3.65)	(1.19,1.61,2.06)	(1.67,2.57,3.29)	(1.54,2.54,3.29)	(2.10,2.49,2.66)	(1.25,1.86,2.28)	(2.03,2.81,3.49)	(0.26)
GS	(0.42,0.49,0.62)	(0.40,0.45,0.54)	(1,1,1)	(1,1.21,1.32)	(0.85,0.99,1.12)	(0.81,1.03,1.48)	(1,1.25,1.38)	(0.76,1.38,2.13)	(0.41,0.58,0.78)	(0.85,1.27,1.62)	(0.06)
EOC	(0.29,0.37,0.56)	(0.27,0.34,0.49)	(0.76,0.83,1)	(1,1,1)	(0.68,0.71,0.76)	(0.81,1.03,1.48)	(0.76,1.38,2.13)	(1.01,1.58,2.33)	(0.41,0.58,0.78)	(0.59,0.81,1.03)	(0.05)
SL	(0.53,0.71,1.12)	(0.49,0.62,0.84)	(0.89,1.01,1.17)	(1.32,1.40,1.47)	(1,1,1)	(0.89,1.01,1.17)	(0.97,1.49,2.22)	(0.97,1.49,2.22)	(0.59,0.65,0.75)	(0.82,1.28,1.73)	(0.09)
GBR	(0.51,0.67,1.01)	(0.30,0.39,0.60)	(0.68,0.97,1.23)	(0.68,0.97,1.23)	(0.85,0.99,1.12)	(1,1,1)	(0.73,1.02,1.68)	(0.73,1.02,1.68)	(0.72,0.80,1)	(1.34,1.92,2.33)	(0.07)
WI	(0.30,0.39,0.60)	(0.30,0.39,0.65)	(0.72,0.80,1)	(0.47,0.72,1.32)	(0.45,0.67,1.03)	(0.59,0.98,1.37)	(1,1,1)	(1,1,1)	(0.30,0.39,0.65)	(1,1.51,1.83)	(0.01)
PSS	(0.38,0.40,0.48)	(0.38,0.40,0.48)	(0.47,0.72,1.32)	(0.43,0.63,0.99)	(0.45,0.67,1.03)	(0.59,0.98,1.37)	(1,1,1)	(1,1,1)	(0.31,0.39,0.62)	(0.73,1.02,1.68)	(0.02)
EPS	(0.68,0.87,1.06)	(0.44,0.54,0.80)	(1.28,1.73,2.46)	(1.28,1.73,2.46)	(1.34,1.54,1.68)	(1,1.25,1.38)	(1.54,2.54,3.29)	(1.62,2.54,3.26)	(1,1,1)	(1.62,2.54,3.26)	(0.19)
SSS	(0.27,0.33,0.45)	(0.29,0.36,0.49)	(0.62,0.79,1.17)	(0.97,1.23,1.68)	(0.58,0.78,1.22)	(0.43,0.52,0.75)	(0.55,0.66,1)	(0.73,1.02,1.68)	(0.31,0.39,0.62)	(1,1,1)	(0.02)

CCI = 0.04

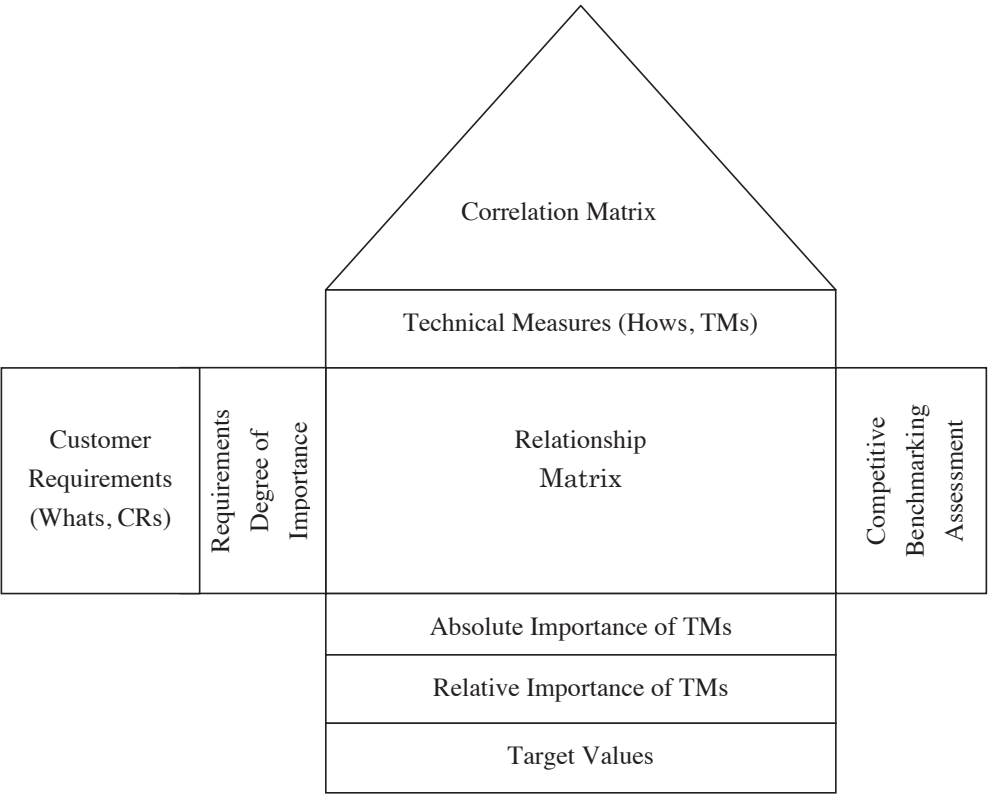**Table 5.** House of Quality Matrix for Customer's Requirements

HoQ of Customer Satisfaction

Maximize (▲), Minimize (▼) and Target (x)

Row No.	Max. value in row	Relative weight	Direction of improvement	Operation and business developing ▲	IT and technical support ▲	Existence of ISO 9001 (1/0) x	Global network(1/0) ▲	Customer relationship management x	Particulars of Human resource management ▼	Performance assessment system (1/0) x	Multimodal options x	Strategic alliance and partnership(1/0) x	Supply chain integration x	Legal regulation and green logistics ▼	LSC A - Taiwan	LSC B - China	LSC C - Japan	LSC D - South Korea
1	5	0.23	Cheaper service	▲*	■	●	●	●		●	●	▲	●		3	1	4	2
2	9	0.26	Speedy delivery and quality	▲	●	▲	▲	▲		▲	▲	●	■		2	3	1	2
3	9	0.06	Global service	●		●	■	▲		▲	■	■	●		2	3	1	3
4	9	0.05	Efficient operation and customized ability	■		▲				●				●	2	2	1	1
5	9	0.09	Strong logistics and intermodal solution	▲	■	●	●	●	▲	▲	■	■	■	●	2	4	1	3
6	9	0.07	Good business reputation	▲	●	■	■	●	▲	●	●	▲	●	■	2	3	1	3
7	9	0.01	Well information providing	●	■	■	●	■	▲	●	●				2	3	2	1
8	9	0.02	Professional sales and staff	●	■	■		■	■	●				●	3	4	2	1
9	9	0.19	Excellent problem solving ability	▲	■	■	●	■	■	▲		■	●		3	2	1	2
10	9	0.02	Sufficient slot supply	●	●	●	●				●		▲		3	1	4	2
			Max. value in column	9	9	9	9	9	9	5	9	9	9	9				
			Sum product	4.76	2.78	4.56	3.01	4.28	2.54	3.38	2.98	3.29	3.85	0.7				
			Relative weight	0.13	0.08	0.13	0.08	0.12	0.07	0.09	0.08	0.09	0.11	0.02				
			Rank	1	9	2	7	3	10	5	8	6	4	11				

*"▲", Strong relationship (9), "■", Moderate relationship (5), "●" Low relationship (1) and "Ø" No relationship.

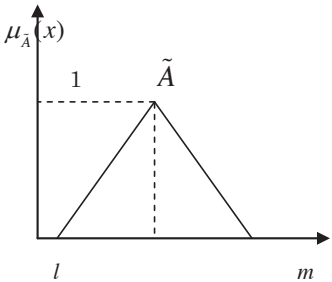**Table 6.** Correlation between Technical Measures

Correlation of Technical Measures	Operation and business developing	IT and technical support	Existence of ISO 9001 (1/0)	Global network (1/0)	Customer relationship management	Human resource management	Performance assessment system (1/0)	Multimodal options	Strategic alliance and partnership (1/0)	Supply chain integration	Legal regulation and green logistics
Operation and business developing											
IT and technical support	+										
Existence of ISO 9001 (1/0)	+	‡									
Global network (1/0)	+		+								
Customer relationship management		+	+								
Human resource management			+	-							
Performance assessment system (1/0)	+		-			‡					
Multimodal solution	‡	+	+	‡	+						
Strategic alliance and partnership (1/0)	‡	+	+	‡	+	-	-	+			
Supply chain integration	+	+			+	-		‡	‡		
Legal regulation and green logistics	+	‡	‡						-		

Legend

Symbol	
‡	Strong positive correlation
+	Positive correlation
	No correlation
-	Negative correlation
=	Strong negative correlation

Figure 1.
House of Quality

Correlation Matrix

Technical Measures (Hows, TMs)

Customer Requirements (Whats, CRs)

Requirements Degree of Importance

Relationship Matrix

Competitive Benchmarking Assessment

Absolute Importance of TMs

Relative Importance of TMs

Target Values

Figure 2.
A Triangular Fuzzy Number Ã

$\mu_{\tilde{A}}(x)$

1

$\tilde{A}$

l

m

Figure 3.

The Intersection between M1 and M2
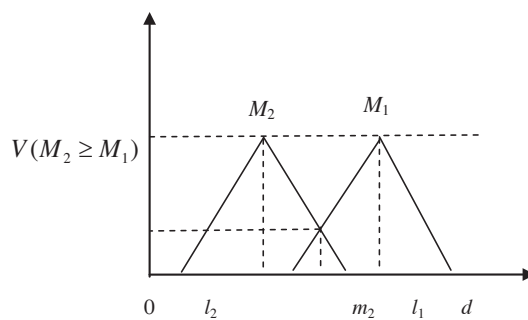
Figure 4.

Fuzzy Number of Linguistic Variable Set
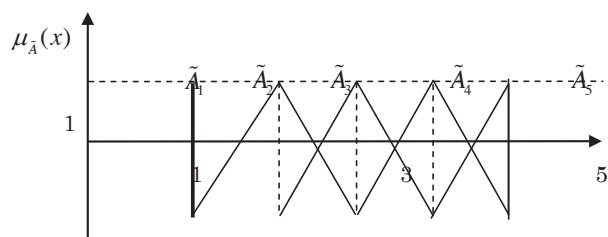
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