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PRIORITIZING SERVICE ATTRIBUTES FOR IMPROVEMENT USING FUZZY ZONE OF TOLERANCE

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Abstract. *The main purpose of this paper is to develop a systematic algorithm to prioritize the service attributes to be improved based on a fuzzy zone of tolerance (fuzzy ZOT). First, generalized means, a precise ZOT, and fuzzy set theory are used to construct a fuzzy ZOT and a fuzzy-based performance ratio. Then, by combining the concepts of fuzzy set theory, the fuzzy ZOT and the fuzzy-based performance ratio, an algorithm is presented for prioritizing service attributes needing improvement. Finally, an empirical study is carried out involving prioritizing service attributes that need improvement in the airline cargo business in Taiwan to demonstrate the application of the proposed algorithm. The results of this study show that active response and problem-solving in abnormal cargo situations have the highest priority for improvement. The main contribution of this paper is to develop a practical algorithm for business application to help managers understand operational service quality to improve performance and maintain high levels of customer satisfaction in a fuzzy environment.*
Keywords: Zone of tolerance, Fuzzy set theory, Fuzzy zone of tolerance, Fuzzy-based performance ratio, Service quality

1. **Introduction.** Service quality and customer satisfaction have become important issues as companies strive to differentiate their services and compete efficiently in the marketplace [20]. The zone of tolerance (ZOT) is a useful managerial and research tool for better understanding how customer perceptions of quality impact their satisfaction with the service they received [9,25].

Many precise theoretical and empirical studies of the ZOT concept have been conducted [9,18,21,25,27,33]. Parasuraman et al. proposed the "gaps model of service quality" or SERVQUAL to represent the differences between customers' expectations and actual perceptions to judge whether or not customer satisfaction is consistent [18,19]. Service quality is specified by comparing perceived service with expected service. In 1991, Parasuraman et al. suggested a two-level dynamic concept of customer service expectation [20]. They argued that customer service expectation had two levels: desired and adequate. Moreover, they considered the ZOT to be the area separating the desired service level from the adequate service level [20]. The ZOT concept can help managers develop customer loyalty [20]. Campos and Nobrega [2] performed an empirical study of fast-food customers to analyze the relationship between the importance of service-quality attributes and the ZOT between the desired and the minimum acceptable levels for customer expectations. Results of this study showed that the higher the importance of an attribute, the narrower and higher the ZOT became. Hu [8] proposed an analytical framework for prioritizing attributes through a quadrant analysis based on a precise ZOT and a normalized importance-performance analysis which took the Taipei city bus service as an example.

However, in a precise ZOT, results are presented as crisp numeric values. In real life, fuzziness and vagueness are very common in questionnaire survey responses, and good data-mining or decision-making models should tolerate vagueness and ambiguity [22,29,30]. Because respondents or decision-makers naturally provide uncertain answers rather than precise values, the transformation of qualitative preferences into crisp estimates is difficult. Hence, the precise ZOT model may not be effective. To resolve efficiently the ambiguity that frequently exists in available information and do more justice to the essential fuzziness in human judgment and preference, an algorithm has been developed for prioritizing service attributes that need improvement based on a fuzzy ZOT. The proposed algorithm can help managers to understand operational service quality as well as maintain high levels of customer satisfaction in a fuzzy environment.

This paper is organized as follows. In Section 2, certain concepts and methods used in this paper are briefly introduced. A systematic approach for prioritizing service attributes that need improvement is developed in Section 3. In Section 4, an empirical study involving prioritizing service attributes that need improvement in the airline cargo business in Taiwan is performed to evaluate the performance of the systematic algorithm. Conclusions and discussion are provided in the last section.

2. **Methodology.**

In this section, certain concepts and methods used in this paper are briefly introduced.

2.1. **Fuzzy set theory.**

Fuzzy set theory is developed to tackle the extraction of the primary possible outcome from a multiplicity of information that is expressed in vague and imprecise terms [22,29,31,32]. Fuzzy set theory characterizes vague data as possibility distributions in terms of set membership or membership function. Once determined and defined, sets of memberships in possibility distributions can be effectively used in logical or approximate reasoning.

2.2. **Triangular fuzzy numbers and algebraic operations.**

In a universe of discourse X, a fuzzy subset M of X is defined by a membership function $f_M(x)$, which maps each element x in X to a real number in the interval $[0, 1]$. The value of $f_M(x)$ represents the grade of membership of x in M.

A fuzzy number M on the real line $\Re$ [6] is a triangular fuzzy number if its membership function $f_M : \Re \to [0, 1]$ is:

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

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

The parameter a gives the maximum grade of $f_M(x)$, i.e., $f_M(a) = 1$; 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 is the degree of fuzziness of the evaluation data. In this research, triangular fuzzy numbers are used to convey the subjective evaluation of the respondents. For example, let $c = 2$, $a = 3$ and $b = 5$ be the lower bound, most probable value, and upper bound of the evaluation data for perceived service given to service attribute "on-time delivery" by a respondent. Then, the fuzzy measures of perceived service of service attribute "on-time delivery" can be denoted as $(2, 3, 5)$.

Let $M_1 = (c_1, a_1, b_1)$ and $M_2 = (c_2, a_2, b_2)$ be fuzzy numbers. According to the extension principle [31], the algebraic operations on any two fuzzy numbers M_1 and M_2 can be expressed as:

(1) Fuzzy addition, $\oplus$:
$M_1 \oplus M_2 = (c_1 + c_2, a_1 + a_2, b_1 + b_2)$,
(2) Fuzzy subtraction, $\ominus$:
$M_1 \ominus M_2 = (c_1 - b_2, a_1 - a_2, b_1 - c_2)$,
(3) Fuzzy multiplication, $\otimes$:
$k \otimes M_2 = (kc_2, ka_2, kb_2),\ k \in \Re,\ k \geq 0$,
$M_1 \otimes M_2 \cong (c_1c_2, a_1a_2, b_1b_2),\ c_1 \geq 0,\ c_2 \geq 0$,
(4) Fuzzy division, $\varnothing$:
$M_1 \varnothing M_2 \cong (c_1/b_2, a_1/a_2, b_1/c_2),\ c_1 \geq 0,\ c_2 > 0$.

2.3. **Ranking of triangular fuzzy numbers.** Many fuzzy ranking methods have been proposed [3-5,10]. Because the graded mean integration representation method not only alleviates some drawbacks of the existing method, but also possesses the advantages of easy implementation and problem-solving power, it will be used here to find the ranks of triangular fuzzy numbers [5].

Let $M_i = (c_i, a_i, b_i)$, $i = 1, 2, \ldots, n$, be n triangular fuzzy numbers. Based on the graded mean integration representation method, the ranking value $R(M_i)$ of M_i is defined as: $R(M_i) = (c_i + 4a_i + b_i)/6$.

Let $R(M_i)$ and $R(M_j)$ be the ranking values of triangular fuzzy numbers M_i and M_j respectively. The following relations can then be defined:

$$\begin{aligned} M_i > M_j \quad &\Leftrightarrow \quad R(M_i) > R(M_j), \\ M_i = M_j \quad &\Leftrightarrow \quad R(M_i) = R(M_j) \text{ and} \\ M_i < M_j \quad &\Leftrightarrow \quad R(M_i) < R(M_j). \end{aligned}$$

2.4. **Fuzzy zone of tolerance.** With a precise ZOT, customers' perceptions of services can be categorized into three levels: *adequate service*, *desired service* and *perceived service*. The relationships among these three levels are shown in Figure 1 [19]. The *adequate service* level reflects the minimum performance level expected by customers with a variety of individual and situational factors taken into consideration [20]. A precise ZOT is the area separating the *desired service* level from the *adequate service level*. The concepts of *adequate service*, *desired service* and a precise ZOT are useful for helping managers build customer loyalty through service. Based on these concepts, a company can operate at a competitive disadvantage, a competitive advantage or a customer-loyalty level of service. If customer perceptions of service performance fall below the *adequate service* level, the customer is dissatisfied, and the company is at a competitive disadvantage. If a company is performing in the precise ZOT, the customer is satisfied, and the company has a competitive advantage. On the other hand, if a company's service performance exceeds the *desired service* level, the customer is delighted, and the company enjoys high customer loyalty. To develop true customer loyalty, a company has to deliver service, not only at the *adequate service* level, but also at the *desired service* level.

Because customer attitudes inherently provide highly uncertain answers rather than precise values, the transformation of qualitative preferences to point estimates is difficult. To characterize effectively customers' perceptions of satisfaction and the importance of

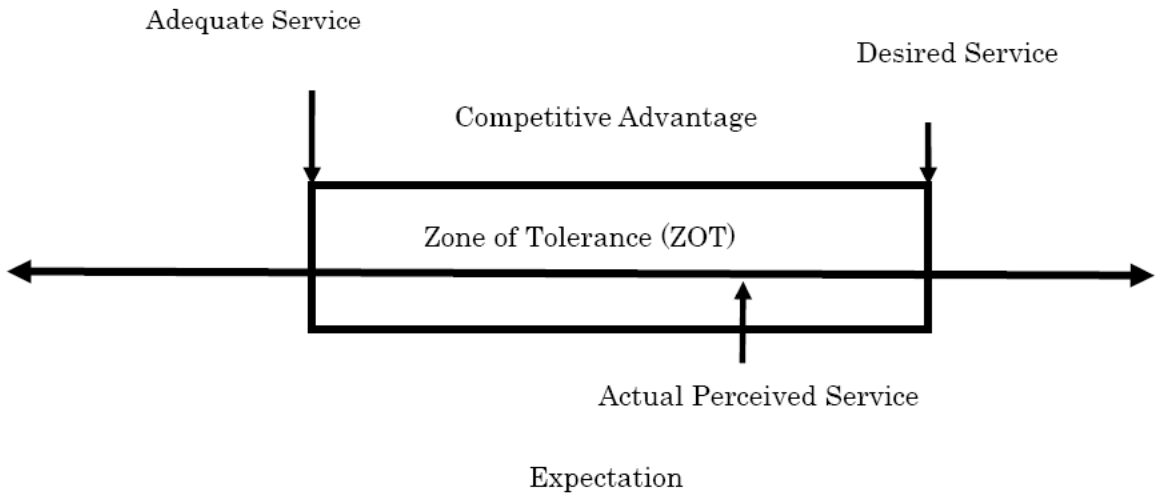

FIGURE 1. The results of customer perceptions of service performance

service attributes, fuzzy perception levels representing *adequate service*, *perceived service* and *desired service*, as well as a fuzzy ZOT (FZOT) are proposed here.

Generalized means are a typical representation of many well-known averaging operations, e.g., min, max, geometric mean, arithmetic mean and harmonic mean [11]. The min and max are the lower bound and the upper bound respectively of the generalized means. Moreover, the geometric mean is more effective in representing the consensus opinions of multiple decision makers [24]. To aggregate all information generated by these different averaging operations, after considering all approaches, the grade of membership was chosen to indicate the strength of consumers' perceptions of service [12]. For reasons mentioned earlier, triangular fuzzy numbers characterized using the min, max, and geometric mean operations were used to convey the degrees of satisfaction of all respondents.

Let a_{1ij}, a_{2ij} and a_{3ij}, $i = 1, 2, \ldots, n$; $j = 1, 2, \ldots, m$, be the lower bound, most probable value and upper bound of the evaluation data for *adequate service* given to service attribute i by respondent j. Based on the concepts of generalized means and geometric mean, the fuzzy measure of *adequate service* attribute i can be obtained as:

$$A_i = (a_{1i}, a_{2i}, a_{3i}),$$

where $a_{1i} = \min_j\{a_{1ij}\}$, $a_{2i} = \left(\prod_{j=1}^{m} a_{2ij}\right)^{1/m}$, $a_{3i} = \max_j\{a_{3ij}\}$.

Let p_{1ij}, p_{2ij} and p_{3ij}, $i = 1, 2, \ldots, n$; $j = 1, 2, \ldots, m$, be the lower bound, most probable value and upper bound of the evaluation data for *perceived service* given to service attribute i by respondent j. The fuzzy measure of *perceived service* attribute i can be defined as:

$$P_i = (p_{1i}, p_{2i}, p_{3i}),$$

where $p_{1i} = \min_j\{p_{1ij}\}$, $p_{2i} = \left(\prod_{j=1}^{m} p_{2ij}\right)^{1/m}$, $p_{3i} = \max_j\{p_{3ij}\}$.

Similarly, let d_{1ij}, d_{2ij} and d_{3ij}, $i = 1, 2, \ldots, n$; $j = 1, 2, \ldots, m$, be the lower bound, most probable value and upper bound of the evaluation data for *desired service* given to service attribute i by respondent j. The fuzzy measure of *desired service* attribute i can be defined as:

$$D_i = (d_{1i}, d_{2i}, d_{3i}),$$

where $d_{1i} = \min_j\{d_{1ij}\}$, $d_{2i} = \left(\prod_{j=1}^{m} d_{2ij}\right)^{1/m}$, $d_{3i} = \max_j\{d_{3ij}\}$.

Finally, let the FZOT be defined as a fuzzy area separating the fuzzy measure of *desired service* from the fuzzy measure of *adequate service.*

3. Algorithm for Prioritizing Service Attributes for Improvement Using FZOT.

To resolve efficiently the ambiguity that frequently exists in available information and to do more justice to the essential fuzziness in human judgment and preference as well as to represent consensus opinions of multiple subjects, a systematic algorithm has been developed for prioritizing service attributes that need improvement, combining the concepts of fuzzy set theory, generalized means and fuzzy ZOT.

3.1. Notation. The notations used in the proposed systematic algorithm can be explained as follows:

A_i : fuzzy measure of *adequate service* of service attribute i.
P_i : fuzzy measure of *perceived service* of service attribute i.
D_i : fuzzy measure of *desired service* of service attribute i.
T_i : fuzzy importance level of service attribute i.
NT_i: normalization of T_i.
$FZOT_i$: fuzzy zone of tolerance of service attribute i.
$R(FZOT_i)$: ranking value of $FZOT_i$.
$SA_i = P_i \ominus A_i$
$R(SA_i)$: ranking value of SA_i.
$R(NT_i)$: ranking value of NT_i.

3.2. Fuzzy-based performance ratio of service quality based on customer expectation. The precise performance ratio [8,26] is a valid evaluation index in customer satisfaction studies for determining how much an organization has progressed on a certain service attribute in a precise decision environment. To evaluate service performance more efficiently and accurately by combining the concepts of the precise performance ratio and the FZOT, a fuzzy-based performance ratio is proposed to measure performance on a service attribute.

Let the fuzzy-based performance ratio $RSFZ_i$ on service attribute i be defined as:

$$RSFZ_i = R(SA_i)/R(FZOT_i),$$

where $SA_i = P_i \ominus A_i$, $FZOT_i = D_i \ominus A_i$. $R(SA_i)$ and $R(FZOT_i)$ are the ranking values of SA_i and $FZOT_i$ respectively.

In a real service scenario, *adequate service* and *desired service* are always identified as the minimum and maximum goals. Based on this concept, the service attribute with a smaller value of the fuzzy-based performance ratio has worse performance and should be improved with a higher priority.

More specifically, the meanings of the different interval values of a fuzzy-based performance ratio can be explained as follows:

(1) If $RSFZ_i > 1$ (i.e., $SA_i > FZOT_i$), the performance on service attribute i is higher than the *desired service* level. This means that service attribute i does not need to be improved at the moment.
(2) If $0 \le RSFZ_i \le 1$ (i.e., $(0,0,0) \le SA_i \le FZOT_i$), the performance on service attribute i is equal to or better than *adequate service* but never greater than *desired service.*

(3) If $RSFZ_i < 0$ (i.e., $SA_i < (0,0,0)$), the performance on service attribute i is lower than the *adequate service* level and must be improved immediately.

3.3. **Analysis based on normalized fuzzy importance and fuzzy-based performance.** According to the meanings of the different interval values of the fuzzy-based performance ratio, identifying the improvement priorities for these service attributes which satisfy the fuzzy-based performance ratio for satisfied customers should be greater than or equal to 0 but never greater than 1, is an important issue for enhancing service performance. To address this problem efficiently, an analysis based on normalized fuzzy importance (NFI) and fuzzy-based performance (FP) is presented.

The normalized fuzzy importance of T_i can be defined as:

$$NT_i = (T_i \ominus L) \varnothing (U \ominus L). \tag{1}$$

where L and U are the minimum and maximum values of the scale points for evaluating the importance of a service attribute or the degree of satisfaction of the customer with respect to the service attribute.

Because attitudes to each of these service attributes in this study were assessed using a seven-point scale anchored by the satisfaction (or importance) levels "1 = lowest satisfaction (or importance)" to "7 = highest satisfaction (or importance)", L and U are defined as $L = (1,1,1)$ and $U = (7,7,7)$.

Let t_{1ij}, t_{2ij} and t_{3ij}, $i = 1,2,\ldots,n$; $j = 1,2,\ldots,m$, be the lower bound, most probable value, and upper bound of the evaluation data for importance level given to service attribute i by respondent j. Then, fuzzy importance level of service attribute $i\,(T_i)$ and the normalized fuzzy importance of T_i can be obtained as:

$$T_i = (t_{1i}, t_{2i}, t_{3i}) \text{ and } NT_i = ((t_{1i}-1)/6, (t_{2i}-1)/6, (t_{3i}-1)/6),$$

where $t_{1i} = \min_j \{t_{1ij}\}$, $t_{2i} = \left(\prod_{j=1}^{m} t_{2ij}\right)^{1/m}$, $t_{3i} = \max_j \{t_{3ij}\}$.

The analysis based on NFI and FP is constructed based on an importance-performance map in a two-dimensional space with the ranking value of normalized fuzzy importance ($R(NT_i)$) on the Y-axis and the fuzzy-based performance ratio ($RSFZ_i$) on the X-axis. Because both $R(NT_i)$ and $RSFZ_i$ vary between 0 and 1, the importance-performance map can be divided into four quadrants by the midpoint 0.5.

The four-quadrant matrix can help identify the areas needing improvement and possible actions to minimize the gap between importance and performance. The 45-degree line (called the *ideal line*) from point $(0,0)$ to point $(1,1)$ is the ideal positions for an attribute. In other words, the degree of importance of a service attribute on the 45-degree line is equal to its level of performance. Because the degree of importance of a service attribute on the left side of the 45-degree line is greater than its performance, it follows that these attributes on the left side of the 45-degree line need to be improved. In addition, the difference $S_i = RSFZ_i - R(NT_i)$ can be used to characterize the degree of urgency of improving a particular service attribute i. A service attribute with a lower S_i value has a higher priority for improvement, whereas an attribute with a higher S_i has a lower priority.

3.4. **Procedure for prioritizing service attributes for improvement.** A systematic algorithm for prioritizing service attributes that need to be improved is presented in this section. The steps to be taken are described below.

Step 1: Calculate the fuzzy measure of *adequate service* (A_i), the fuzzy measure of *perceived service* (P_i), the fuzzy measure of *desired service* (D_i) and the fuzzy importance level (T_i) with respect to service attribute i.
Step 2: Calculate $SA_i = P_i \ominus A_i$ and the fuzzy zone of tolerance ($FZOT_i$) with respect to service attribute i.
Step 3: Calculate the fuzzy-based performance ratio ($RSFZ_i = R(SA_i)/R(FZOT_i)$) with respect to service attribute i.
  Case 3-1: If $RSFZ_i > 1$, then assign attribute i to set K (a service attribute set associated with customer loyalty), go to Step 6.
  Case 3-2: If $RSFZ_i < 0$, then assign attribute i to set H (a service attribute set associated with competitive disadvantage), go to Step 6.
  Case 3-3: If $0 \leq RSFZ_i \leq 1$, then go to Step 4.
Step 4: Perform the analysis based on NFI and FP.
  Step 4-1: Normalize the fuzzy importance of T_i with respect to service attribute i. The normalized fuzzy importance (NT_i) of T_i can be calculated using Equation (1).
  Step 4-2: Calculate the graded mean integration representation of the normalized fuzzy importance ($R(NT_i)$) with respect to service attribute i.
  Step 4-3: Calculate $S_i = RSFZ_i - R(NT_i)$.
    Case 4-3-1: If $S_i \geq 0$, then assign attribute i to set W_1 (a service attribute set associated with competitive advantage such that the service performance of attribute i is greater than or equal to its importance level).
    Case 4-3-2: If $S_i < 0$, then assign attribute i to set W_2 (a service attribute set associated with competitive advantage such that the service performance of attribute i is less than its importance level).
Step 5: Repeat Steps 1 to 4 until all service attributes have been processed.
Step 6: Rank the priorities of all service attributes.
  Case 6-1: In set K, all attributes have exceptional strength and should continue to be maintained at their current levels.
  Case 6-2: In set H, all service attributes must be improved as soon as possible; the smaller the value of $RSFZ_i$ for attribute i, the higher should be its priority for improvement.
  Case 6-3: In set W_1, to build customer loyalty, enhancing some or all of the service attributes in set K should be considered.
  Case 6-4: In set W_2, all service attributes need to be improved; the smaller the value of S_i, the higher should be the priority for improving attribute i.

4. **Empirical Study.** Taiwan is a trade-oriented island country, and the government has an export-oriented policy. To maintain vitality and growth in international trade, efficient air transportation is very important. Goods from the domestic high-tech industry must be transported from enterprises to overseas markets using air transportation. Connecting high-tech enterprises with international airlines, with air freight forwarders as intermediaries, is a must. Air freight forwarders play an important role in assisting enterprises with logistics and supply chain management. They are niche customers of an international airline's cargo business.

In this section, an empirical study of prioritizing service attributes needing improvement for the airline cargo business in Taiwan is described to demonstrate the application of the proposed algorithm.

4.1. **Service attributes.** Brooks [1] proposed an approach to the evaluation of line shipping using 15 service attributes which affect the selection model of shippers: tracing capability of the carrier, frequency of sailings, directness of sailings, on-time pickup and delivery, cost of service, sales representative service, fast claims response, past loss and damage experience, proximity of carrier's office, informational nature of advertising, carrier's reputation for reliability, transit time, cooperation between personnel, carrier flexibility and appropriateness of the carrier.

An APL (American President Line) report [23] described a set of service attributes from a shipper's perspective: on-time delivery, total responsiveness to shippers' demands, freight cost, pickup and delivery service, transit time, area of service, accuracy of documents, equipment availability, well-implemented service control, process for freight indemnification and shipment tracing.

Lillie and Sparks [14] presented 18 criteria for selecting a carrier, which can be used to explore the buying behavior of air freight forwarders. The ten most important criteria were consistent performance, shipment transit time, ability to trace goods, damage/loss experience, frequency of departure, rates offered, direct flights, understanding of shippers' needs, integration of services and ease of contact.

Gooley [7] pointed out that high service quality, quick transit, on-time delivery, electronic information capabilities, a sales-oriented attitude, freight tracing and document handling are the service components that a shipper expects from a carrier.

Lu [15] used 33 service attributes to explore logistical services in Taiwanese maritime shipping companies. Among the criteria mentioned were prompt response to shippers' complaints, short transit time, accurate documentation (e.g., bills of lading), ability to provide customs clearance service, good reputation, prompt response to quotes, pricing flexibility to meet competitors' rates, courtesy of sales representatives and the ability of sales representatives to handle problems.

Lu [16] examined the previous literature and conducted personal interviews with 10 shipping executives. Thirty service attributes were selected for use in a questionnaire. The five most important carrier service attributes according to the shippers' perspective were availability of cargo space, low rate of damage or loss, accurate documentation, reliability of advertised sailing schedules and courtesy in response to inquiries.

Liang et al. [13] proposed 24 service attributes to characterize shippers' service needs: professional knowledge and service attitude of staff, prompt response to claims, consulting services, willingness to negotiate, computer EDI capabilities, cargo tracing ability, ability to handle emergencies, simple and prompt document processing, safekeeping services, ability of sales representatives to handle problems, door-to-door service, simple consignment procedures for shipment, intermodal service, diversified service, business reputation, maintenance of communication with customers, reasonable agent fees, on-time delivery, complete shipping routes, short transit time, safe delivery, sufficient shipping space, reasonable damage indemnification, reasonable operations fees and reasonable transportation price.

Yang et al. [28] presented 26 logistical service attributes which were used to examine the level of satisfaction with container shipping services in Taiwan. The service attributes considered included quality of data transmission, cargo safety, availability of cargo space, responsiveness to unforeseen events during cargo transit, ability to provide customized service, prompt response to claims, ability to handle special cargo and ability to provide customs clearance service.

4.2. **Questionnaire design.** The content validity of the questionnaire used in this paper was ensured by a comprehensive review of the literature and by interviews with practitioners. The set of indicators used in the questionnaire was based on previous studies, interviews with practitioners and scholars, and discussions with a number of executives and experts in air freight forwarding companies. After a review of previous literature [1,7,13,15,16,23,28], an initial questionnaire was developed. This questionnaire was used in one-on-one interviews with three professional experts, three professional academics and four air freight forwarders. The interviews resulted in minor modifications to the wording and the examples provided for certain measurement items, which were finally accepted as possessing content validity. The pilot test of the questionnaire was mailed to a group of first-line employees in air freight forwarding companies. The refined measurement items were included in the final survey questionnaire administered to the target respondents.

Finally, thirty service attributes were chosen for the final questionnaire survey: (C_1) reasonability of tariff and pricing; (C_2) flexibility of tariffs and pricing; (C_3) cash allowance and volume discount on tariffs and pricing; (C_4) better credit terms; (C_5) speed of customs clearance; (C_6) security of delivery service; (C_7) special cargo-handling facilities and equipment; (C_8) online booking service; (C_9) low rate of damage and loss; (C_{10}) attitude towards and sincerity in complaint handling; (C_{11}) availability of air-freight space; (C_{12}) simple processes for cargo booking and goods retrieval; (C_{13}) low frequency of cargo returned or sent to the wrong destination; (C_{14}) ability to accept emergency cargo bookings; (C_{15}) accurate bookings and documentation; (C_{16}) convenient, accurate, and real-time online cargo tracing and tracking; (C_{17}) convenience of pickup and delivery times; (C_{18}) low transit time; (C_{19}) on-time delivery; (C_{20}) coverage area of transport service; (C_{21}) fast response to customers' requirements; (C_{22}) flexibility in meeting customers' requirements; (C_{23}) professional knowledge of employees; (C_{24}) ability of employees to respond immediately; (C_{25}) passion and courtesy of employees; (C_{26}) active response and problem-solving in abnormal cargo situations; (C_{27}) proactive notification of cargo arrival; (C_{28}) one-stop shopping (door-to-door service); (C_{29}) reputation and image of airlines and (C_{30}) consistency of service quality.

The questionnaire consisted of two parts: background information on the air freight forwarder, and information about the importance and level of satisfaction associated with the service attributes, based on the questionnaire responses. In this study, the importance and satisfaction analysis was used to try to improve service quality for the air cargo business. Attitudes to each of the variables in this study were assessed using a seven-point scale anchored by the satisfaction (or importance) levels "1 = lowest satisfaction (or importance)" to "7 = highest satisfaction (or importance)".

4.3. **Questionnaire survey.** The sample was selected from the 2009 issue of the business directory, *Members of the Association of Airfreight Forwarding and Logistics in Taiwan.* The survey was carried out from January to April 2009. In an initial mailing and follow-up mailing, 372 questionnaires were sent out. Ninety-two responses were received, of which 12 were invalid and 80 were usable. The overall effective response rate was 21.51%.

4.4. **Reliability and validity tests.** Values of Cronbach's α were statistically determined to provide a summary measure of the intercorrelations that existed among a set of questionnaire items. The Cronbach's α of all 30 service attributes with respect to importance levels, adequate service levels, perceived service levels and desired service levels were 0.981, 0.986, 0.986 and 0.981 respectively. This means that this questionnaire achieved a satisfactory level of reliability for research purposes [17].

The content of the questionnaire was established through literature review and interviews with professional experts, professional academics and air freight forwarders. In addition, a pretest was carried out. Therefore, the content validity of this questionnaire can be considered as very good.

4.5. **Results.** From Step 1 of the proposed algorithm, values for the fuzzy measures of *adequate service*, *perceived service* and *desired service*, as well as the fuzzy importance level with respect to service attribute i can be obtained. The results are shown in Table 1.

Table 1. The fuzzy measures of adequate service, fuzzy measures of perceived service, fuzzy measures of desired service and fuzzy importance levels of all service attributes

Service attributes	Fuzzy measures of of adequate service $A_i = (a_{1i}, a_{2i}, a_{3i})$			Fuzzy measures of perceived service $P_i = (p_{1i}, p_{2i}, p_{3i})$			Fuzzy measures of desired service $D_i = (d_{1i}, d_{2i}, d_{3i})$			Fuzzy importance levels $T_i = (t_{1i}, t_{2i}, t_{3i})$		
i	a_{1i}	a_{2i}	a_{3i}	p_{1i}	p_{2i}	p_{3i}	d_{1i}	d_{2i}	d_{3i}	t_{1i}	t_{2i}	t_{3i}
C_1	2	4.1127	7	2	4.5510	7	3	5.0863	7	1	5.3364	7
C_2	1	4.0568	7	2	4.4051	7	2	4.9901	7	3	5.3959	7
C_3	2	4.0717	7	2	4.4277	7	1	4.9776	7	3	5.3850	7
C_4	2	4.0511	7	2	4.3358	7	1	4.8867	7	1	4.9145	7
C_5	1	4.1919	7	2	4.5067	7	3	5.0987	7	3	5.4711	7
C_6	2	4.2825	7	3	4.6210	7	3	5.1826	7	3	5.4278	7
C_7	2	4.2113	7	3	4.5267	7	2	4.9372	7	3	5.4473	7
C_8	2	4.1853	7	2	4.4062	7	2	4.7266	7	2	4.9500	7
C_9	1	4.3272	7	2	4.6334	7	2	5.1852	7	3	5.4981	7
C_{10}	1	4.2968	7	2	4.5951	7	1	5.0811	7	3	5.5212	7
C_{11}	2	4.1849	7	2	4.6377	7	3	5.1010	7	3	5.4330	7
C_{12}	2	4.2663	7	3	4.6523	7	3	5.0424	7	3	5.3324	7
C_{13}	1	4.1931	7	2	4.5237	7	1	5.1145	7	1	5.1016	7
C_{14}	2	4.3799	7	2	4.6046	7	3	5.1952	7	3	5.4634	7
C_{15}	1	4.2639	7	2	4.6290	7	3	5.2015	7	3	5.4590	7
C_{16}	1	4.3206	7	2	4.6841	7	3	5.1728	7	3	5.3698	7
C_{17}	2	4.2742	7	2	4.5665	7	3	5.1681	7	3	5.3523	7
C_{18}	1	4.1443	7	2	4.5765	7	3	5.1762	7	3	5.3684	7
C_{19}	2	4.2230	7	3	4.7231	7	2	5.2596	7	3	5.5922	7
C_{20}	1	4.1252	7	2	4.4726	7	2	4.8808	7	3	5.1434	7
C_{21}	2	4.2591	7	2	4.5164	7	2	5.0693	7	3	5.5243	7
C_{22}	1	4.1601	7	2	4.4410	7	2	5.1111	7	2	5.2463	7
C_{23}	1	4.2120	7	2	4.4789	7	3	5.2139	7	3	5.4429	7
C_{24}	2	4.2296	7	2	4.5809	7	3	5.2913	7	3	5.4231	7
C_{25}	1	4.2623	7	2	4.5635	7	3	5.2649	7	3	5.4245	7
C_{26}	1	4.1950	7	1	4.3601	7	3	5.2831	7	3	5.6323	7
C_{27}	1	3.9706	7	1	4.1928	7	1	5.0342	7	2	5.3094	7
C_{28}	1	4.0724	7	1	4.1724	7	1	5.0215	7	3	5.3164	7
C_{29}	2	4.1923	7	2	4.4953	7	4	5.1126	7	3	5.2253	7
C_{30}	2	4.1633	7	2	4.5058	7	3	5.1212	7	3	5.3342	7

Comparing the ranking values (shown in Table 2) to the fuzzy importance level and the fuzzy measure of *perceived service*, it is apparent that for each service attribute, the fuzzy measure of *perceived service* is less than the fuzzy importance level. This means that the service attribute is important in the perception of air freight forwarders, but the actual customer experience is unsatisfactory. The air cargo business needs to try to reduce this gap.

TABLE 2. The SA_i, $FZOT_i$, ranking values of P_i, T_i, SA_i, $FZOT_i$ and $RSFZ_i$ of all service attributes

Service attributes	$SA_i = (s_{1i}, s_{2i}, s_{3i})$			$FZOT_i = (f_{1i}, f_{2i}, f_{3i})$			The ranking values of P_i	The ranking values of T_i	The ranking values of SA_i (1)	The ranking values of $FZOT_i$ (2)	The fuzzy-based performance ratio $RSFZ_i$ (3)=(1)/(2)
i	s_{1i}	s_{2i}	s_{3i}	f_{1i}	f_{2i}	f_{3i}	$R(P_i)$	$R(T_i)$	$R(SA_i)$	$R(FZOT_i)$	$RSFZ_i$
C_1	–5	0.4383	5	–4	0.9735	5	4.5340	4.8909	0.2922	0.8157	0.3582
C_2	–5	0.3483	6	–5	0.9332	6	4.4367	5.2640	0.3988	0.7888	0.5056
C_3	–5	0.3560	5	–6	0.9059	5	4.4518	5.2567	0.2373	0.4373	0.5427
C_4	–5	0.2847	5	–6	0.8356	5	4.3905	4.6097	0.1898	0.3904	0.4862
C_5	–5	0.3148	6	–4	0.9068	6	4.5045	5.3141	0.3766	0.9379	0.4015
C_6	–4	0.3385	5	–4	0.9001	5	4.7474	5.2852	0.3923	0.7667	0.5117
C_7	–4	0.3154	5	–5	0.7259	5	4.6844	5.2982	0.3769	0.4839	0.7789
C_8	–5	0.2209	5	–5	0.5413	5	4.4375	4.8000	0.1473	0.3609	0.4081
C_9	–5	0.3062	6	–5	0.8580	6	4.5889	5.3320	0.3708	0.7387	0.5020
C_{10}	–5	0.2983	6	–6	0.7843	6	4.5634	5.3475	0.3656	0.5229	0.6991
C_{11}	–5	0.4528	5	–4	0.9161	5	4.5918	5.2886	0.3019	0.7774	0.3883
C_{12}	–4	0.3860	5	–4	0.7761	5	4.7682	5.2216	0.4240	0.6841	0.6198
C_{13}	–5	0.3305	6	–6	0.9214	6	4.5158	4.7344	0.3870	0.6143	0.6301
C_{14}	–5	0.2247	5	–4	0.8153	5	4.5698	5.3089	0.1498	0.7102	0.2109
C_{15}	–5	0.3651	6	–4	0.9376	6	4.5860	5.3060	0.4101	0.9584	0.4279
C_{16}	–5	0.3635	6	–4	0.8522	6	4.6227	5.2465	0.4090	0.9015	0.4537
C_{17}	–5	0.2923	5	–4	0.8939	5	4.5443	5.2349	0.1949	0.7626	0.2555
C_{18}	–5	0.4322	6	–4	1.0319	6	4.5510	5.2456	0.4548	1.0213	0.4453
C_{19}	–4	0.5000	5	–5	1.0366	5	4.8154	5.3948	0.5000	0.6910	0.7236
C_{20}	–5	0.3474	6	–5	0.7555	6	4.4817	5.0956	0.3982	0.6704	0.5941
C_{21}	–5	0.2573	5	–5	0.8102	5	4.5109	5.3495	0.1715	0.5402	0.3176
C_{22}	–5	0.2808	6	–5	0.9510	6	4.4607	4.9975	0.3539	0.8006	0.4420
C_{23}	–5	0.2669	6	–4	1.0018	6	4.4859	5.2953	0.3446	1.0012	0.3442
C_{24}	–5	0.3513	5	–4	1.0617	5	4.5539	5.2821	0.2342	0.8745	0.2678
C_{25}	–5	0.3012	6	–4	1.0026	6	4.5423	5.2830	0.3674	1.0017	0.3668
C_{26}	–6	0.1650	6	–4	1.0880	6	4.2400	5.4216	0.1100	1.0587	0.1039
C_{27}	–6	0.2222	6	–6	1.0635	6	4.1285	5.0396	0.1481	0.7090	0.2089
C_{28}	–6	0.1000	6	–6	0.9491	6	4.1149	5.2109	0.0667	0.6327	0.1053
C_{29}	–5	0.3030	5	–3	0.9203	5	4.4969	5.1502	0.2020	0.9469	0.2133
C_{30}	–5	0.3425	5	–4	0.9579	5	4.5039	5.2228	0.2283	0.8053	0.2835

Based on these ranking values of he fuzzy importance level and the fuzzy measure of *perceived service* depicted in Table 2, the most important service attribute is active response and problem-solving in abnormal cargo situations, followed by on-time delivery, fast response to customers' requirements, attitude towards and sincerity in complaint handling, and low rates of damage and loss. Meanwhile, the five best satisfied attributes of air freight forwarders' service are on-time delivery; simple processes for cargo booking and goods retrieval; security of delivery service; special cargo-handling facilities and equipment; and convenient, accurate, and real-time online cargo tracing and tracking.

Based on Steps 2 and 3, the fuzzy difference (SA_i), fuzzy ZOT ($FZOT_i$) and fuzzy-based performance ratio $RSFZ_i$ with respect to all services can be determined. The results are shown in Table 2. Because the ranks $RSFZ_i$ of all service attributes are between 0 and 1, the service performance on all attributes is higher than the *adequate service* level, but still lower than the *desired service* level. In other words, none of the service attributes is exceptionally strong and needs only to be maintained, and none needs to be improved immediately.

Using Step 4 of the algorithm, values of NT_i, $R(NT_i)$, S_i, and the priority of improvement for each service attribute can be obtained. The results are summarized in Table 3.

TABLE 3. The normalization of fuzzy importance NT_i, the ranking values of NT_i, S_i and priority to be improved of all service attributes

Service attributes	Normalization of fuzzy importance T_i $NT_i = (nt_{1i}, nt_{2i}, nt_{3i})$			The ranking values of NT_i (4)	$S_i = (3) - (4)$	Priority to be improved
i	nt_{1i}	nt_{2i}	nt_{3i}	$R(NT_i)$	S_i	
C_1	0	0.7227	1	0.6485	–0.2903	14
C_2	0.3333	0.7327	1	0.7107	–0.2051	20
C_3	0.3333	0.7308	1	0.7094	–0.1667	21
C_4	0	0.6524	1	0.6016	–0.1154	22
C_5	0.3333	0.7452	1	0.7190	–0.3175	13
C_6	0.3333	0.7380	1	0.7142	0.0000	28
C_7	0.3333	0.7412	1	0.7164	0.0000	28
C_8	0.1667	0.6583	1	0.6333	0.0000	28
C_9	0.3333	0.7491	1	0.7220	–0.2200	19
C_{10}	0.3333	0.7535	1	0.7246	–0.0255	25
C_{11}	0.3333	0.7388	1	0.7148	–0.3265	12
C_{12}	0.3333	0.7221	1	0.7036	–0.0838	24
C_{13}	0	0.6836	1	0.6224	0.0077	30
C_{14}	0.3333	0.7439	1	0.7182	–0.5073	3
C_{15}	0.3333	0.7432	1	0.7177	–0.2898	15
C_{16}	0.3333	0.7283	1	0.7078	–0.2541	17
C_{17}	0.3333	0.7254	1	0.7058	–0.4503	6
C_{18}	0.3333	0.7281	1	0.7076	–0.2623	16
C_{19}	0.3333	0.7654	1	0.7325	–0.0089	26
C_{20}	0.3333	0.6906	1	0.6826	–0.0885	23
C_{21}	0.3333	0.7541	1	0.7249	–0.4073	9
C_{22}	0.1667	0.7077	1	0.6663	–0.2443	18
C_{23}	0.3333	0.7405	1	0.7159	–0.3717	10
C_{24}	0.3333	0.7372	1	0.7137	–0.4459	7
C_{25}	0.3333	0.7374	1	0.7138	–0.3470	11
C_{26}	0.3333	0.7721	1	0.7369	–0.6330	1
C_{27}	0.1667	0.7182	1	0.6733	–0.4644	5
C_{28}	0.3333	0.7194	1	0.7018	–0.5965	2
C_{29}	0.3333	0.7042	1	0.6917	–0.4784	4
C_{30}	0.3333	0.7224	1	0.7038	–0.4203	8

Based on the priorities for improvement shown in Table 3, it is obvious that the three highest-priority service attributes for improvement are C_{26}, C_{28} and C_{14}. "(C_{26}) active response and problem-solving in abnormal cargo situations" has the highest priority for improvement. In second place is "(C_{28}) one-stop shopping (door-to-door service)". In third place is "(C_{14}) ability to accept emergency cargo bookings". These results may suggest to airline cargo business managers that they need not only to satisfy their customers' demand for seamless transportation, but also to enhance their ability to respond to customers during the cargo transit process. In addition, service attributes "(C_{29}) reputation and image of airlines" and "(C_{27}) proactive notification of cargo arrival" also had high priorities. Therefore, the issues of enhancing the company's reputation and image as well as providing proactive notification of cargo arrival also need attention.

5. **Conclusions and Discussion.** Service quality and customer satisfaction have become important issues as companies have dedicated themselves to providing differentiated services and competing efficiently in the marketplace. The precise ZOT is a useful managerial and research tool for obtaining a better understanding of customer perceptions of quality and their impact on customers' satisfaction with service [9]. In a precise (conventional) ZOT, customer satisfaction is expressed as a crisp value. However, assessments of importance and satisfaction levels on service attributes have always been made subjectively by customers based on their preferences, available information and experience. Customers naturally provide uncertain answers rather than precise values. The transformation of qualitative preferences to crisp estimates is difficult. For this reason, the precise ZOT model may not be effective.

In addition, to enhance service quality efficiently, business managers must be able to identify the priority of service attributes needing improvement on the basis of customers' expectations, especially under the constraint of limited resources.

To resolve efficiently the ambiguity that often exists in available information and to do more justice to the essential fuzziness in human judgment and preference as well as to represent the consensus opinions of multiple subjects, this paper has presented a systematic approach for prioritizing service attributes that need improvement, combining the concepts of fuzzy set theory, generalized means and precise ZOT. The proposed algorithm offers much important management information in a fuzzy decision-making environment. If a company's service offerings are at a level that provides competitive advantage, customers will be satisfied. However, such a level of service is enough only to maintain competitive advantage. More useful and more accurate information about service attributes needing improvement can be obtained by means of the proposed algorithm. Attributes classified at a lower level will put the company at a competitive disadvantage. Service attributes at a level that encourages customer loyalty remind the manager of the possibility of developing a long-term competitive advantage.

To enhance service quality efficiently, managers of an international airline's cargo business must know how to identify the priority of service attributes needing improvement based on customers' expectations, especially under the constraint of limited resources. To address this problem and to demonstrate the calculation process of the proposed algorithm, an international airline's cargo business in Taiwan was taken as an example. According to the results of this study, service attribute "(C_{13}) low frequency of cargo returned or sent to the wrong destination" is above the ideal line. Meanwhile, "(C_6) security of delivery service", "(C_7) special cargo-handling facilities and equipment" and "(C_8) online booking service" are at the ideal position. All other service attributes need to be improved. "(C_{26}) active response and problem-solving in abnormal cargo situations" has the highest priority for improvement. These results serve to remind the managers of the airline's cargo business that devoting their energies to enhancing their ability to respond to problems during the cargo transit process is their most important priority at the present stage.

The proposed algorithm has been developed to help managers to understand the quality of service in their operations with the aim of improving performance and maintaining high levels of customer satisfaction. The proposed algorithm has the following merits: (1) generalized means and triangular fuzzy numbers are combined to represent the air freight forwarders' fuzzy perception levels with regard to all service attributes; (2) by using the proposed algorithm, the fuzzy importance of each service attribute and the fuzzy-based performance ratio can be taken into account in the evaluation process to ensure a solid and accurate link between customer satisfaction and service quality. A comparison with the precise ZOT shows that the proposed algorithm tends to be more effective in developing an understanding of how customer perceptions of quality impact their satisfaction with service; (3) by using the proposed algorithm, managers can easily obtain priority information without mapping scatter plots or considering the scale of the two axes or the location of the center line, as in traditional or fuzzy importance and performance analyses; (4) the proposed approach not only overcomes the limitations of crisp values, but also facilitates computer-based implementation as a decision-support system for prioritizing the service attributes to be improved in a fuzzy environment.

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