A Fuzzy SERVAQUL Model for Evaluating Service Quality of Service Industry

Chien-Chang Chou
Department of Shipping Technology
National Kaohsiung Marine University
Kaohsiung, Taiwan
chiench1@ms58.hinet.net

***Abstract*—The evaluation of service quality is an important issue in the service industry. The aim of this paper is to construct a fuzzy SERVQUAL method for evaluating the service quality of service industry. This assessment model is tested by a numerical example. The results show that this assessment model proposed in this paper seems to be promising.**

***Keywords*—fuzzy set theory, service quailty, evaluation, service industry, SERVQUAL method**

I. INTRODUCTION

In recent years, the service industry has been experiencing great competition due to the increasing of customer's awareness of service quality. In today's highly competitive environment, service companies attempt to introduce more promotional incentives. However, the marginal benefits of these marketing strategies gradually reduce because most of service companies applied the same marketing strategies. Thus some of service companies now tend to focus on the commitment of improving customer service quality. Thus understanding, maintaining and improving the service quality are the main concerns of service companies today.

In the past, although many researchers evaluated the service quality using the SERVQUAL questionnaire, few of these researchers applied the fuzzy sets method to evaluate the service quality. Service quality can be regarded as a composite of various attributes. It is not only consists of tangible attributes, but also intangible and subjective attributes such as safety, comfort and satisfaction, which are difficult to measure accurately. Different customers usually have wide range of perceptions toward quality service, depending on their preference structures. To measure the service quality, conventional measurement tools are devised on cardinal or ordinal scales. Most of the criticism about scale based on measurement is that scores do not necessarily represent user preference. This is because respondents have to internally convert preference to scores and the conversion may introduce distortion of the preference being captured. Thus the fuzzy set theory is an appropriate method to measure consumer's perception and evaluate the service quality. The aim of this paper is to construct the fuzzy SERVQUAL method for evaluating and understanding service quality. This assessment model is tested by a numerical example.

II. LITERRATURE REVIEW

Understanding exactly what customers expect and want is the most crucial step in defining and delivering the high-quality service [15, 16]. As in other sectors, the problem in the service sector is whether management can correctly perceive what customers want and expect. Expectations serve as a major determinant of a consumer's service quality evaluation and satisfaction[13]. At this point, the "voice of the customer" should be taken into the design process using advanced techniques, such as the experimental design, quality function development and value engineering. After delivering services, service providers should monitor how well the customers' expectations have been met. For this task, the SERVQUAL method proposed by Parasuraman et al. [14] is one of the best evaluation methods for assessing the expectations and perceptions.

SERVQUAL method has five dimensions to measure service quality, including the tangibles, reliability, responsiveness, assurance and empathy [16]. Customers evaluate the service quality by determining whether there is any gap between their expectations and perceptions. SERVQUAL is based on the idea that quality is a subjective customer evaluation, as service is not a physical item, but an experience [10, 14].

III. FUZZY SET THEORY

Since human judgments preference are often vague and can not estimate his preference with an exact numerical value. A more realistic way may be to use linguistic terms to describe the desired value and important weight of criteria, e.g. "very low", "low", "fair", "high", "very high", etc [2, 11]. Due to this type of existing fuzziness in the process, fuzzy set theory is an appropriate method for dealing with uncertainty and the subjective evaluation data can be more adequately expressed in fuzzy linguistic variables [5, 12, 17].

A. The Basic Concept of Fuzzy Number

First we introduce briefly the concept of fuzzy number. Let $A=(c, a, b, d)$ be a trapezoidal fuzzy number. Suppose the membership function of A is $f_A(x)$.

$$f_A(x)=\begin{cases}\dfrac{(x-c)}{(a-c)}, & c\le x\le a,\\ 1, & a\le x\le b,\\ \dfrac{(x-d)}{(b-d)}, & b\le x\le d,\\ 0, & \text{otherwise.}\end{cases}$$

$$L_A(x)=\frac{(x-c)}{(a-c)},\quad c\le x\le a,\qquad L^{-1}{}_A(h)=c+(a-c)h,\quad 0\le h\le 1.$$

$$R_A(x)=\frac{(x-d)}{(b-d)},\quad b\le x\le d,\qquad R^{-1}{}_A(h)=d+(b-d)h,\quad 0\le h\le 1.$$

$L_A(x)$ and $R_A(x)$ are the function L and the function R of the trapezoidal fuzzy number A, respectively. $L^{-1}{}_A(h)$ and $R^{-1}{}_A(h)$ are the inverse functions of the function $L_A(x)$and function $R_A(x)$ at h-level, respectively.

Chen and Hsieh [4] proposed the graded mean integration representation method for presenting the representation of one fuzzy number, based on the integral value of graded mean h-level of fuzzy number. Here we describe the meaning as follows. Let the graded mean h-level value of fuzzy number A is $h(L^{-1}{}_A(h)+ R^{-1}{}_A(h))/2$. Then the graded mean integration representation of A is $P(A)$.

$$P(A)=\int_0^1 \frac{h(L^{-1}(h)+R^{-1}(h))}{2}\,dh\Big/\int_0^1 h\,dh$$
$$=\int_0^1 \frac{h(c+(a-c)h+d+(b-d)h)}{2}\,dh\Big/\int_0^1 h\,dh$$
$$=\frac{1}{6}(c+2a+2b+d)$$

Triangular fuzzy number $Y=(c, a, b)$ is a special case of generalized trapezoidal fuzzy number. The graded mean integration representation of triangular fuzzy number Y becomes

$$P(Y)=\frac{1}{6}(c+4a+b) \tag{1}$$

Customer's subjective satisfaction can be expressed in linguistic variables in the context of this study. For example, the customer's subjective perception is "fair". The linguistic variable "fair can be expressed in a triangular fuzzy number.

$Y=(c, a, b)=(2, 3, 4)$. By formula (1), $P(Y)=\frac{1}{6}(2+12+4)=3$.

B. The Basic Arithmetic Operation on Fuzzy Numbers

The basic fuzzy arithmetic operations on fuzzy numbers have been proposed in previous literature [1, 3, 6, 7, 8, 9]. The basic arithmetic operations on fuzzy numbers are introduced as follows. Suppose $A_1=(c_1, a_1, b_1)$ and $A_2=(c_2, a_2, b_2)$ are two triangular fuzzy number.

- The addition operation on A_1 and A_2

$$A_1 \oplus A_2=(c_1+c_2, a_1+a_2, b_1+b_2) \tag{2}$$

where $c_1, c_2, a_1, a_2, b_1, b_2$ are real numbers.

The above addition operation on fuzzy numbers will be applied to evaluate the service quality in this study. For example, the subjective expectation from the customer 1 is "fair". The linguistic variable "fair" can be expressed in a triangular fuzzy number $A_1=(2, 3, 4)$. And the subjective expectation from the customer 2 is "high". The linguistic variable "high" can be expressed in a triangular fuzzy number $A_2=(3, 4, 5)$.

By above formula (2), we can obtain easily the total subjective expectation from the customer 1 and customer 2.

$$A_1 \oplus A_2=(2+3, 3+4, 4+5)=(5, 7, 9)$$

- The subtraction operation on A_1 and A_2

$$A_1 \ominus A_2=(c_1-b_2, a_1-a_2, b_1-c_2) \tag{3}$$

For example, the customer's subjective perception is "fair". The linguistic variable "fair" can be expressed in a triangular fuzzy number $A_1=(2, 3, 4)$. On the other hand, the customer's subjective expectation is "high". The "high" linguistic variable can be expressed in a triangular fuzzy number $A_2=(3, 4, 5)$. The service quality gap between the expectation and perception from the customer is $A_1 \ominus A_2$.

By formula (3), we can obtain

$$A_1 \ominus A_2=(2-5, 3-4, 4-3)=(-3, -1, 1)$$

This means there is a service quality gap between the expectation and perception from the customer. In other words, the customer is not satisfactory with the service quality provided by the service company.

- The division operation on A_1

$$A_1 / r=(c_1/r, a_1/r, b_1/r) \tag{4}$$

where r is a real numbers.

For example, the total subjective expectation from 10 customers is a fuzzy number $A_1=(23.50, 33.00, 42.00)$.

By formula (4), we can obtain the average subjective expectation of 10 customers.

$$A_1 / 10=(23.50/10, 33.00/10, 42.00/10)$$
$$=(2.35, 3.30, 4.20)$$

IV. A NUMERICAL EXAMPLE OF SERVICE QUALITY

The scores of expectations and perceptions, and the gap between expectation and perception from consumers are shown in Table 1. The computational procedure is shown as follows.

Let fuzzy number A_{ein} be the service quality expectation from the n^{th} consumer under service item i. Let fuzzy number A_{pin} be the service quality perception from the n^{th} consumer under service item i. Let fuzzy number TA_{ei} be the total service quality expectations from all consumers under service item i. Let fuzzy number TA_{pi} be the total service quality perceptions from all consumers under service item i.

$$TA_{ei}=\sum_{1}^{N} A_{ein} \tag{6}$$

$$TA_{pi} = \sum_{1}^{N} A_{pin} \quad (7)$$

According to the formulas (2) and (6), we can obtain easily the total service quality expectation from 10 customers under service item 1.

$$TA_{e1} = (23.50, 33.00, 42.00)$$

Similarly, according to the formulas (2) and (7), we can obtain easily the total service quality perception from all customers under service item 1.

$$TA_{p1} = (25.00, 34.00, 42.00)$$

Let fuzzy number MA_{ei} be the average service quality expectations from all customers under service item *i*. Let fuzzy number MA_{pi} be the average service quality perceptions from all customers under service item *i*.

$$MA_{ei} = TA_{ei}/N \quad (8)$$

$$MA_{pi} = TA_{pi}/N \quad (9)$$

According to the formulas (4) and (8), we can obtain easily the average service quality expectation from all customers under service item 1.

$$MA_{e1} = (23.50/10, 33.00/10, 42.00/10) = (2.35, 3.30, 4.20)$$

Similarly, according to the formulas (4) and (9), we can obtain easily the average service quality perception from all customers under service item 1.

$$MA_{p1} = (25.00/10, 34.00/10, 42.00/10) = (2.50, 3.40, 4.20)$$

Let fuzzy number Gap_i be the service quality gap between the expectation and perception from all customers under item *i*.

$$Gap_i = MA_{pi} \ominus MA_{ei} \quad (10)$$

According to the formulas (3) and (10), we can obtain easily the service quality gap between the expectation and perception from all customers under service item 1.

$$Gap_1 = (2.50, 3.40, 4.20) \ominus (2.35, 3.30, 4.20)$$

$$= (2.50\text{-}4.20, 3.40\text{-}3.30, 4.20\text{-}2.35)$$

$$= (-1.70, 0.10, 1.85)$$

According to the formula (1), we can obtain the representation of fuzzy numbers $MA_{e1} = 3.29$, $MA_{p1} = 3.38$ and $Gap_1 = 0.09$. This means customers are satisfactory with the service quality provided by the service company. Similarly, we can obtain all fuzzy expectations, fuzzy perceptions, fuzzy gaps, expectations, perceptions and gaps shown in Table 1.

V. CONCLUSION

The aim of this paper is to construct a fuzzy SERVQUAL method for evaluating the service quality of service industry. This assessment model is tested by a numerical example. The results show that this assessment model proposed in this paper seems to be promising. The fuzzy SERVQUAL model proposed in this paper will be applied to evaluate the service quality of service companies in the real world in future studies.

REFERENCES

[1] J.M. Adamo, "Fuzzy decision trees," Fuzzy Sets and Systems 4, 207-219, 1980.

[2] R.E.Bellman and L.A. Zadeh, "Decision-making in a fuzzy environment," Management Science 17(4), 141-164, 1970.

[3] L. Campos and J.L. Verdegay, "Linear programming problems and ranking of fuzzy numbers," Fuzzy Sets and Systems 32, 1-11, 1989.

[4] S.H. Chen and C.H. Hsieh, "Graded mean integration representation of generalized fuzzy number," Proceedings of 1998 sixth Conference on Fuzzy Theory and its Application (CD-ROM), filename: 031.wdl, Chinese Fuzzy Systems Association, Taiwan, Republic of China, 1-6, 1998.

[5] N. Chiadamrong, "An integrated fuzzy multiple criteria decision making method for manufacturing strategies selection," Computers and Industrial Engineering 37, 433-436, 1999.

[6] C.C. Chou, "The canonical representation of multiplication operation on triangular fuzzy numbers," Computers & Mathematics with Applications 45, 1601-1610, 2003.

[7] C.C. Chou, "A fuzzy MCDM method for solving marine transshipment container port selection problems." Applied Mathematics and Computation 186, 435-444, 2007.

[8] M. Delgado, M.A. Vila and W. Voxman, "On a canonical representation of fuzzy numbers," Fuzzy Sets and Systems 93, 125-135, 1998.

[9] D. Dubois and H. Prade, "Operations on fuzzy numbers," International Journal of Systems Sciences 9, 613-626, 1978.

[10] C. Gronroos, Service Management and Marketing: Managing the Moments-of-truth in Service Competition, Lexington Books, Lexington, M.A., 1990.

[11] H.M. Hsu and C.T. Chen, "Fuzzy credibility relation method for multiple criteria decision-making problems," Information Sciences 96, 79-91, 1997.

[12] G.S. Liang and M.J. Wang, "A fuzzy multiple criteria decision-making method for facilities site selection," International Journal of Production Research 29(11), 2313-2330, 1991.

[13] S. O'Connor, H. Trinh and R. Shewchuk, "Perceptual gaps in understanding patient expectations for health care service quality," Health Care Management Review 25, 7-23, 2000.

[14] A. Parasuraman, V.A. Zeithaml and L.L. Berry, "SERVQUAL: a multiple item scale for measuring consumer perceptions of service quality," Journal of Retailing 64, 12-40, 1988.

[15] V.A. Zeithaml, L.L. Berry and A. Parasuraman, "The behavioral consequences of service quality," Journal of Marketing 60, 31-52, 1996.

[16] V.A. Zeithaml, A. Parasuraman and L.L. Berry, Developing Quality Service: Balancing Customer Perception and Expectations, The Free Press, New York, 1990.

[17] L.A. Zadeh, "Fuzzy sets," Information and Control 8, 338-353, 1965.

TABLE I. THE SCORES OF EXPECTATIONS AND PERCEPTIONS

Dimension	Fuzzy expectation	Fuzzy perceptions	Fuzzy gap	Expectation	Perceptions	Gap
Tangibles						
Comfort and cleanness of seat	(2.35 3.30 4.20)	(2.50 3.40 4.20)	(-1.70 0.10 1.85)	3.29	3.38	0.09
Quality of food and beverage	(2.70 3.60 4.40)	(2.85 3.70 4.40)	(-1.55 0.10 1.70)	3.58	3.68	0.09
Newspapers, magazines and books	(3.15 4.00 4.70)	(3.05 3.90 4.60)	(-1.65 -0.10 1.45)	3.98	3.88	-0.10
Internet, email, fax and phone	(3.50 4.30 4.90)	(3.15 4.00 4.70)	(-1.75 -0.30 1.20)	4.27	3.98	-0.29
Entertainment facilities and programs	(2.25 3.20 4.10)	(2.05 3.00 3.90)	(-2.05 -0.20 1.65)	3.19	2.99	-0.20
Availability of waiting lounges	(2.15 3.30 4.00)	(1.90 3.10 3.90)	(-2.10 -0.20 1.75)	3.23	3.03	-0.19
Size of space	(2.50 3.40 4.20)	(2.10 3.00 3.80)	(-2.10 -0.40 1.30)	3.38	2.98	-0.40
Responsiveness						
Courtesy of employee	(2.35 3.30 4.20)	(2.05 3.00 3.90)	(-2.15 -0.30 1.55)	3.29	2.99	-0.30
Handling of delay	(2.50 3.40 4.20)	(2.15 3.10 4.00)	(-2.05 -0.30 1.50)	3.38	3.09	-0.29
Efficient check-in/ baggage handling services	(2.25 3.20 4.10)	(2.15 3.10 4.00)	(-1.95 -0.10 1.75)	3.19	3.09	-0.10
Employee's speed handling request	(2.65 3.50 4.20)	(2.30 3.20 4.00)	(-1.90 -0.30 1.35)	3.48	3.18	-0.29
Quality of the reservation services	(3.50 4.30 4.90)	(3.15 4.00 4.70)	(-1.75 -0.30 1.20)	4.27	3.98	-0.29
Employee's approach against unexpected situations	(3.40 4.20 4.80)	(3.05 3.90 4.60)	(-1.75 -0.30 1.20)	4.17	3.88	-0.29
Employee's willingness to help	(2.95 3.80 4.50)	(2.45 3.40 4.30)	(-2.05 -0.40 1.35)	3.78	3.39	-0.38
Appearance of employee	(2.20 3.10 3.90)	(1.95 2.90 3.80)	(-1.95 -0.20 1.60)	3.08	2.89	-0.19
Reliability and assurance						
Safety	(2.10 3.00 3.80)	(1.45 2.40 3.30)	(-2.35 -0.60 1.20)	2.98	2.39	-0.59
On-time	(2.50 3.40 4.20)	(2.25 3.20 4.10)	(-1.95 -0.20 1.60)	3.38	3.19	-0.19
Consistent services	(1.45 2.40 3.30)	(1.15 2.10 3.00)	(-2.15 -0.30 1.55)	2.39	2.09	-0.30
Empathy						
Employee's behavior to delayed customer	(3.75 4.50 5.00)	(3.40 4.20 4.80)	(-1.60 -0.30 1.05)	4.46	4.17	-0.29
Individual attention to customer	(3.40 4.20 4.80)	(3.05 3.90 4.60)	(-1.75 -0.30 1.20)	4.17	3.88	-0.29
Understanding of customer's specific Needs	(2.95 3.80 4.50)	(2.60 3.50 4.30)	(-1.90 -0.30 1.35)	3.78	3.48	-0.29
Extent services	(2.10 3.00 3.80)	(1.85 2.80 3.70)	(-1.95 -0.20 1.60)	2.98	2.79	-0.19
Convenient process	(3.20 4.00 4.60)	(2.95 3.80 4.50)	(-1.65 -0.20 1.30)	3.97	3.78	-0.19
Customer complaint handling	(2.85 3.70 4.40)	(2.60 3.50 4.30)	(-1.80 -0.20 1.45)	3.68	3.48	-0.19
Other						
Other problems	(2.70 3.60 4.40)	(2.35 3.30 4.20)	(-2.05 -0.30 1.50)	3.58	3.29	-0.29
Convenient schedules	(2.30 3.20 4.00)	(1.80 2.80 3.80)	(-2.20 -0.40 1.50)	3.18	2.80	-0.38
Parking	(3.00 3.90 4.70)	(2.50 3.50 4.50)	(-2.20 -0.40 1.50)	3.88	3.50	-0.38
Location	(3.10 3.90 4.50)	(2.75 3.60 4.30)	(-1.75 -0.30 1.20)	3.87	3.58	-0.29