Service Quality Measurement Using Fuzzy AHP-Based Approach

Yong Li
Kunming University of Science and Technology, Kunming, China
Email: Dr.Leon@foxmail.com

***Abstract*—Service quality is widely taken as a driver of firms' marketing and financial performance. Evaluating service satisfaction is a multi-criterion decision problem which includes both qualitative and quantitative factors, and it needs more critical analysis. The aim of this paper is to identify and discuss some of the important and critical decision criteria for service satisfaction measurement based on SERVQUAL method combing with fuzzy analytic hierarchy process (FAHP) based methodology. The implementation of the system is demonstrated by a problem having three stages of hierarchy which contains different criteria and attributes at wider perspective. The proposed model can provide not only a framework for the firm to measure service satisfaction of dealers but also has the capability to deploy the firm's service strategy.**

***Index Terms*—SERVQUAL, analytic hierarchy process, fuzzy logic, multi-attribute decision making problem**

I. Introduction

In order to remain competitive in developing markets, improving the service quality is a key strategy for firms. As service satisfaction of dealers directly impacts production sales, firms are especially concerned with increasing and maintaining the service quality, as well as identifying why service satisfaction decline. It is very important to get the whip hand of competition by providing the congruity of the services to the expectations of dealers. It is also important to achieve a desirable, qualified service because quality is achieved when the needs and expectations of the dealer are met. By the meaning, the qualities of the services should be measured.

Measuring service quality is among the most recurrent topics in management and marketing literature thoroughly in the past decades. The impact of the shift to dealer power in the firm–dealer relationship challenges firms to focus on developing dealer closeness as a way to provide higher levels of service operations effectiveness [8]. For those firms, understanding exactly what dealers expect is the most crucial step in defining and providing the high quality service. There are many affords to measure service quality, but SERVQUAL methodology is chosen because it is the most used and preferred methodology in different industries (retailing, hotels, hospitals, and so on) [11]. SERVQUAL method has five criteria to measure service quality, which implemented with a questionnaire use scales to evaluate respondents' attitude. The attitudes are normally used lingual expressions to describe, such as "very low", "low", "fair", "high", "very high", "absolutely", "strongly", "generally", "somewhat", "undecided", "satisfied", and "dissatisfied", etc [1]. To effectively evaluate service quality, both qualitative and quantitative factors must be considered. Thus, service quality performance measurement is a kind of multiple criteria decision making (MCDM) problem.

In reference to our former studies, this study includes a combined fuzzy analytic hierarchy process (AHP) and SERVQUAL measure service quality performance. Fuzzy set theory aids in measuring the ambiguity of concepts that are associated with human being's subjective judgment [2][3]. Since the performance evaluations are done with decision makers' preferences, its evaluation must therefore be conducted in an uncertain, fuzzy environment. Also by applying AHP in obtaining criteria weight and fuzzy theory in ranking, the comprehensiveness and reasonableness of the service quality measurement process is strengthened.

II. Review of Previous Studies

SERVQUAL instrument is a well-established model, which consists of five dimensions, mainly focus on the human aspects of service providing (*responsiveness*, *reliability*, *assurance*, and *empathy*) and the *tangibles* of service: *Tangibles* describe the appearance of physical facilities, equipments, communication materials, and appearance of service personnel; *Reliability* is the firm's ability to perform the promised service dependably and accurately; *Responsiveness* describes the willingness to help customers and provide prompt service and support; *Assurance* refers to the knowledge and courtesy of service personnel and their ability to inspire trust and confidence; *Empathy*-caring, individualized attention that the firm provides to its customers [12][21]. According to the work carried out by Ladhari [1], it is recommended that SERVQUAL model is a good scale to measure service quality in various specific industries but that it is appropriate to choose the most important dimensions of this model that fit to that particular service being evaluated in order to assure reliable and valid results in current business scenario.

MCDM is a powerful tool widely used for measuring decision making problems containing multiple and conflicting criteria [7]. AHP is a systematic procedure to solve MCDM problems. It includes both subjective and objective evaluation measures, implicitly assuming that a hierarchy can be used to completely control the

doi:10.4304/jcp.9.7.1697-1703

consistency of the evaluation criteria and alternatives preferred by decision makers to reduce bias in decision making process. The criteria at a particular level in a hierarchical structure are compared using nine-point numerical scale to define how much more an element is important than other in order to making pair-wise comparisons and obtaining the judgment matrix [5]. However, in many practical cases, human preference model and corresponding assessment criteria are subjective and qualitative in nature, and decision-makers might be reluctant or unable to assign exact numerical values to the pair-wise comparison judgments. All comparisons during AHP implementation may not include a certainty therefore the decision maker needs more than nine-point scale to describe the uncertainty [13][14]. Thus, the traditional AHP cannot be applied in a straightforward manner to solving uncertain decision-making problems [4][17][20].

FAHP is the fuzzy extension of AHP to efficiently handle the uncertainty in the decision process to select the best decision by using both qualitative and quantitative data in the MCDM problems. Many FAHP methods are proposed for dealing with the uncertainty from the subjective perception and the experience of humans in the decision making process [9][10][22][24]. The trapezoidal fuzzy numbers are used based on arithmetic operations to express the decision maker's opinion to evaluate on alternatives with respect to criterion, and the final priority weights of the pair-wise comparisons are decided by the synthetic extent analysis method [6][16] .

The result of FAHP reached by each alternative is a fuzzy number. The defuzzified ranking method for fuzzy numbers that must be employed in order to compare the various strategies made by decision makers. There are various methods of defuzzification available, including the adaptive integration (AI), basic defuzzification distributions (BADD), center of area (COA), mean of maximal (MOM), quality method (QM) and so on [15] [23]. The COA is a simple and practical method to rank the order of importance of each strategy [7]. The procedure of defuzzification involves the location of the best non-fuzzy performance (BNP) value.

III. METHODOLOGY

A. Service Quality Elements: a Fuzzy Modified Approach

SERVQUAL is a mature service quality framework with 5 criteria and 20 sub-criteria, which has been incorporated into customer-satisfaction. But in a practical case, there is a need for more studies to find out the quantity of these criteria and sub-criteria. In our study, we use a mathematical method to quantify these criteria of dealer-satisfaction for firms. However, the operative dimensions of service quality involves much of the strategic decision making of firms. The degree of consensus of dealers with these dimensions or criteria was assessed by a modified fuzzy method. To acquire more precise priority weights of the criteria, fuzzy set theory has been used as a substitute for the conventional geometric average of the fuzzy modified method.

Many researchers have studied on the fuzzy modified approach based on Chang's work [6], Kilincci and Onal [22] discussed supplier selection in a washing machine company with one expert's views; Chen and Wang [23] proposed the approach to develop global business intelligence for information service firms with synthesized more than one experts' opinions, but they have not discussed the detailed pair-wised comparison matrices of experts, and inverse operation and roots of fuzzy numbers in calculating fuzzy weights of criteria; Chung and Chiang [24] studied the critical factors in evaluating schedule reliability in liner shipping, proposed a brief methodology without defining the membership function of fuzzy number and how to describe the pair-wised comparison matrices of many experts. Based on these researches, we firstly defined the triangles membership function, and then proposed our fuzzy modified approach with describing the detailed pair-wised comparison matrices integrated more than one experts' opinions in following.

Zadeh initiated the concept of fuzzy theory to formulate conclusions from imprecise or ambiguous information. To present ambiguous information in mathematics, a fuzzy set was developed, which is a class of objectives with continuum grades of membership. A membership function in fuzzy sets assigns to each object a grade of membership in [0, 1]. we utilize it for the primary membership functions. A triangles membership function *A*, as shown in Fig. 1., is specified by three parameters $\{l_A, m_A, u_A\}$.

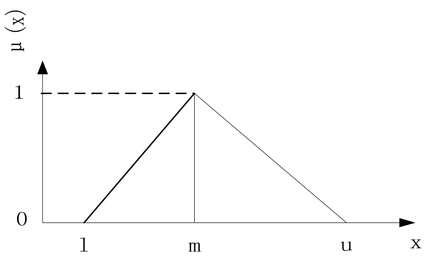

Figure 1. A triangular fuzzy number.

The parameter l_A denotes the smallest possible value of factor "*A*", where m_A denotes the most promising value and u_A is the largest possible value that describe a fuzzy event. Therefore, the values within l_A and u_A represent the possibilities for a different consensus. The subjective opinion of decision makers is expressed as a number that represents an ambiguous concept in the pair-wise comparison matrix. Fuzzy numbers are intuitively easy to use in expressing the decision maker's qualitative assessments. The triangular fuzzy numbers $\mu(x)$ are established as follows:

$$\mu(x) = (l, m, u),\ l \le m \le \mu \text{ and } l, m, u \in [1/9, 1] \cup [1, 9]. \quad (1)$$

$$l = Min(x_{Ai}),\ i = 1, 2, \cdots, n. \quad (2)$$

$$m = \sqrt[n]{\prod_{i=1}^{n} x_{Ai}}, \ i = 1,2,\cdots,n. \quad (3)$$

$$\mu = Max(x_{Ai}), i = 1,2,\cdots,n. \quad (4)$$

where A presents a factor or a problem; the triangles membership functions of factor "A" is denoted as $\mu(A)$; i express expert; the value of "A" from the i[th] expert is evaluated with x_{Ai}. The parameter l_A is the smallest possible value of the factor "A" from expert s, where m_A denotes the mean value and u_A is the largest possible value that describe the factor A from experts.

B. Weights of Criteria: A Fuzzy Analytic Hierarchy Process (FAHP)

In our research, more accurate priority weights of criteria and sub-criteria are assigned by using FAHP. Correspondingly, the priority weights are useful for firms to design or adopt a better strategy in providing service process for improving its' service level. There are six major steps in the fuzzy analytic hierarchy process.

1) Define decision making problems. For obtaining correct and accurate results in future analyses, the problems should be defined clearly and rational. In our study, we focuses on "Service satisfaction of dealer for firms in improving its' service level".

2) Define the main criteria and sub-criteria for decision maker to design the FAHP tree structure. Indentify the main criteria and sub-criteria as the hierarchic layer in a family tree in this step. At the highest layer is the ultimate goal of this decision making problem, and the alternatives are at the lowest layer. Between them are criteria and sub-criteria. After defining this hierarchy structure and summarizing questionnaires, weights of criteria and sub-criteria should be calculated by FAHP, and firms could acknowledge the satisfaction degree of dealers, adjust their service strategy for improving the service quality.

3) Development of fuzzy judgment matrices (a_{ij}) by pair-wise comparisons. Make a pair-wise comparison of the decision criteria and sub-criteria given by decision makers or experts, and then assign them relative scores constructing paired comparison matrices. As shown in (5), the specific value a_{ij} is substitued by triangular fuzzy numbers ($\tilde{a}_{ij}$) (denoted by l, m, and u mentioned above) that be substituted into the pair-wise comparison matrix.

$$\tilde{A}^k = [\tilde{a}^k_{ij}] = \begin{matrix} & C_1 & \cdots & \cdots & C_n \\ C_1 & 1 & \tilde{a}^k_{12} & \cdots & \tilde{a}^k_{1n} \\ \vdots & \tilde{a}^k_{21} & 1 & \cdots & \tilde{a}^k_{2n} \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ C_n & \tilde{a}^k_{n1} & \tilde{a}^k_{n2} & \cdots & 1 \end{matrix}. \quad (5)$$

where $\tilde{a}^k_{ij} = (\tilde{a}^k_{ji})^{-1}$, $i \neq j$, i, j= 1, 2, . . . , n and k=1...m.

Equation (5) denotes a single pair-ware comparison matrix of the k^{th} expert. a_{ij} is fuzzy number of pair-wise comparison matrix at column i and row j, n is the number of criteria and m is the number of experts.

In our research, 20 questionnaires are found to be valid. The validity of questionnaires ensures that if a_{ij} was consistent, then its corresponding triangular fuzzy numbers $\tilde{a}_{ij}$ were consistent too. In this condition, these specific figures could be converted to fuzzy numbers with the descriptions in Fig. 2 and Table I. And we could obtained the fuzzy pair-wise comparison matrices by calculating the geometric mean.

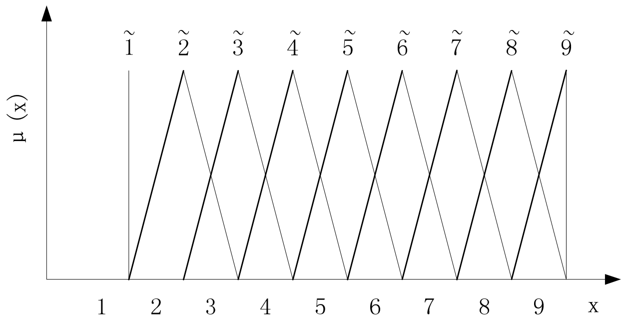

Figure 2. Scale for relative importance of linguistic values.

TABLE I.
DEFINITION OF FUZZY SCALE

Fuzzy number	Definition
$\tilde{1} = (1,1,1)$	Equally important
$\tilde{2} = (1,2,3)$	Judgment values between equally and moderately
$\tilde{3} = (2,3,4)$	Moderately more important
$\tilde{4} = (3,4,5)$	Judgment values between moderately and strongly
$\tilde{5} = (4,5,6)$	Strongly more important
$\tilde{6} = (5,6,7)$	Judgment values between strongly and very strongly
$\tilde{7} = (6,7,8)$	Very strongly more important
$\tilde{8} = (7,8,9)$	Judgment values between very strongly and extremely
$\tilde{9} = (8,9,10)$	Extremely more important

4) Compute the relative weight of the criteria for each level. The value of three parameters {l_A, m_A, u_A} in paried comparison matrices were calculated by using the "Column Vector Geometric Mean Method" as the following [9]:

$$\tilde{Z}_i = \sqrt[n]{\tilde{a}_{i1} \otimes \tilde{a}_{i2} \otimes \ldots \otimes \tilde{a}_{in}}, \ i = 1,2,\cdots,n. \quad (6)$$

$$\tilde{\omega}_i = \tilde{Z}_i \otimes (\tilde{Z}_1 \oplus \tilde{Z}_2 \oplus \ldots \oplus \tilde{Z}_n)^{-1}. \quad (7)$$

where

$\tilde{Z}_i$: Mean of column vector, i = 1, 2, . . . , n.

$\tilde{\omega}_i$: Weight of i[th] factor.

$\otimes$: Fuzzy numbers multiplication, for example, assuming two triangular fuzzy numbers: $\tilde{A} = (l_1; m_1; \mu_1)$, $\tilde{B} = (l_2; m_2; \mu_2)$,

$$\tilde{A} \otimes \tilde{B} = (l_1; m_1; \mu_1) \otimes (l_2; m_2; \mu_2) = (l_1 \times l_2; m_1 \times m_2; \mu_1 \times \mu_2). \quad (8)$$

$\oplus$: Fuzzy numbers addition, for example,

$$\widetilde{A} \oplus \widetilde{B} = (l_1; m_1; \mu_1) \oplus (l_2; m_2; \mu_2)$$
$$= (l_1 + l_2; m_1 + m_2; \mu_1 + \mu_2) . \quad (9)$$

Θ : Fuzzy numbers division, for example,

$$\widetilde{A} \Theta \widetilde{B} = (l_1; m_1; \mu_1) \Theta (l_2; m_2; \mu_2)$$
$$= (l_1 / \mu_2; m_1 / m_2; \mu_1 / l_2) . \quad (10)$$

$(.)^{-1}$ ： Fuzzy numbers inverse, for example,

$$\widetilde{A}^{-1} = (1/\mu_1 ; 1/m_1 ; 1/l_1) . \quad (11)$$

$(.)^{1/n}$ ： The n^{th} roots of fuzzy numbers, for example,

$$\widetilde{A}^{1/n} = (l_1{}^{1/n}; m_1{}^{1/n}; \mu_1{}^{1/n}) . \quad (12)$$

5) Defuzzification. In our research, we utilize the COA method to defuzzify weights of the criteria, and calculate the BNP value of the weights using (10).

$$BNP = ((\mu_A - l_A) + (m_A - l_A)) / 3 + l_A . \quad (13)$$

6) Determine the overall level hierarchy weight. The composite priorities of the alternatives and the overall level hierarchy weight are then determined by aggregating the calculated weights throughout the hierarchy and criteria.

IV. A Numeric Application of Proposed Model

An assessment framework of service quality has been proposed in our research, which contains weights of five criteria and 28 sub-criteria (Table II). And in a practical case, their strategic advantages in these five criteria were discussed. According to all literature surveys in Part II, our assessment framework of service quality are determined as *Tangibles*, *Reliability*, *Responsiveness*, *Assurance*, and *Empathy* [18][19][21]:

The dimension *Tangibles* is determined as service capable of being perceived by dealers, which includes service personnel's dressing, service promise and service instructions. Service personnel's should dress uniform and clean, bring with complete certifications, make a clear service promise. And there are clear service instructions and as well as others that can contribute to enhance the tangible items of the QOS and the image of the firm. This dimension expresses the interaction between dealers and related service personnel, and carries weight with dealers for visual aspect of firms.

Reliability is demonstrated as the quality of being trustworthy of the firms through service personnel. If dealers cannot trust an firm to perform the promised service dependably and accurately, they will be dissatisfied. Reliability can be guaranteed by specialization, standardization, and accuracy of service. If service personnel can keep their promises, answer dealers' questions patiently, treat dealers' needs with kindness and consideration, then dealers can put faith in that firm, and will enhance the collaboration with firms. And more, if supply allocation is fair and equitable, dealer can be kept informed of the supplies information and has reasonable profit margins, then the collaboration relation between dealers and firms will be continuous and stable.

Responsiveness defines willingness to help dealers and provide prompt service accurately, consistently and timely. It includes the firm's ability for dealer to get help if there is a problem or question, and effective handling of problems. Typically, even service personnel are too busy to immediately resolve question, they still respond dealers' requirements and can reply in time. Dealers can be kept informed of the products and relevant market information. And there are telephone or other consulting and complaints channels for dealers' communicating with service personnel; And more, phone ordering or Network ordering is convenient and fast.

Assurance dimension means knowledge and courtesy of service personnel and their ability to inspire trust and confidence of dealers. If service personnel's attitudes are polite, warm and thoughtful during service process, familiar with the performance of products, and provide effective guidance and necessary marketing support on dealers' sales including positively anti-counterfeiting, cleaning up the market, ensuring the rational distribution of retail outlets, avoiding vicious competition among dealers, then the more dealers would feel having guaranteed benefits and trust the firm, the more competitive the firm will be.

Empathy symbolizes the service firm's caring, understanding and individualized attention to its dealers through the service process. So, these are the important points in empathy that service personnel can know initiatively the dealers' demands at any time and provide targeted services for the different demands of different dealers. It includes adapting individual dealers' preferences, histories, offering a variety of ordering ways, etc.

These issues compose our criteria and sub- criteria for evaluating the dealer's service satisfaction, and can be summarized in Table II as following.

TABLE II.
Hierarchy Structure of Service Satisfaction

Level 1 Goal	Level 2 Criteria	Level 3 Sub-Criteria
Service quality of firms for dealers	Tangibles (E1)	Cleanliness of service personnel's dressing (C1). Clarity of service promises made by service personnel (C2). Clarity of service instructions delivered by service personnel (C3).
	Reliability (E2)	Service personnel's keeping their promises (C4). Service personnel's attitude in answering dealers' questions (C5). Service personnel's attitude in treatment on dealers' demands (C6). Fairness of firms' supply allocation (C7). Timeliness of supply information supported for dealers(C8). Rationality of dealers' profit margins. (C9).
	Responsi-veness (E3)	Service personnel's speed in providing service (C10). Service personnel's responding on dealers' requirements (C11). Service personnel's speed in resolving dealers' questions (12). Accuracy and timeliness of delivery (C13). Timeliness of products and relevant market information supported for dealers (C14). Consulting and complaints channels supported by firms for dealers'

Level 1 Goal	Level 2 Criteria	Level 3 Sub-Criteria
		communicating with service personnel (C15). Convenience and fastness of phone ordering (C16). Convenience and fastness of network ordering (C17).
	Assurance (E4)	Service personnel's attitude during service processes (C18). Service personnel's familiarity with the performance of products (C19). Service personnel's ability in providing effective guidance on dealers' sales (C20). Service personnel's in providing the necessary market support for dealers (C21). Service personnel's attitude and ability in anti-counterfeiting and cleaning up the market (C22). Service personnel's familiarity with market (C23). Service personnel's ability in grasping information about dealers' demands (C24). Firms' effectiveness in ensuring the rational distribution of retail outlets, avoiding vicious competition among dealers (C25).
	Empathy (E5)	Timeliness of service personnel acknowledging the dealers' demands (C26). Firms' ability in providing targeted services for the different demands of different dealers (C27). Variousness of ordering ways offered by firms (C28).

In order to measure the criteria of SERVQUAL for firms in improving its' service level, we collected data from 50 cigarette dealers in Nanning city, Guangxi province in China, with a survey system developed by ourselves. With the help of Guangxi tobacco company, in-depth interviews with over 10 consultants and 20 dealers have been conducted. Based the survey, we invited 5 experts to evaluate our criteria of service satisfaction of dealers. And then, according to the experts' suggests and with the FAHP method, we computed weights of our hierarchy structure of service satisfaction, and here we give the calculated results of level 2 of the criteria structure only to introduce our approach, which listed in Table III, Table IV and Table V:

TABLE III.
FUZZY SYNTHETIC DEGREE VALUES

	E1	E2	E3	E4	E5
E1	(1,1,1)	(1.66,2.95, 4.66)	(2.29,5.08,6.88)	(2.14,3.33,5.25)	(4.08,6.12,8.14)
E2	(0.21,0.34,0.60)	(1,1,1)	(0.60,1.12,1.72)	(0.57,1.12,1.81)	(1.00,1.61,2.71)
E3	(0.15,0.20,0.35)	(0.58,0.89,1.66)	(1,1,1)	(0.53,0.79,1.48)	(0.62,1.25,2.26)
E4	(0.19,0.30,0.47)	(0.55,0.89,1.75)	(0.68,1.27,1.90)	(1,1,1)	(0.67,1.02,1.72)
E5	(0.12,0.16,0.25)	(0.37,0.62,1.00)	(0.44,0.80,1.64)	(0.58,0.98,1.48)	(1,1,1)

TABLE IV.
AVERAGE FUZZY VALUES

	Average fuzzy value
E1	(1.86,2.60,3.33)
E2	(0.65,0.94,1.31)
E3	(0.55,0.75,1.12)
E4	(0.60,0.84,1.18)
E5	(0.48,0.66,0.92)

TABLE V.
WEIGHTS AND RANKING OF MAIN CRITERIA

	Average fuzzy value	Fuzzy weights	BNP	Rank
E1	(1.86,2.60,3.33)	(0.24,0.45,0.81)	0.50	1
E2	(0.65,0.94,1.31)	(0.08,0.16,0.32)	0.19	2
E3	(0.55,0.75,1.12)	(0.07,0.13,0.27)	0.16	4
E4	(0.60,0.84,1.18)	(0.08,0.14,0.28)	0.17	3
E5	(0.48,0.66,0.92)	(0.06,0.11,0.22)	0.13	5

In Table III, the fuzzy pair-wise comparison matrix of criteria is obtained by calculating triangular fuzzy numbers ($\tilde{a}_{ij}$) with (5) from five experts' fuzzy judgment matrices as following:

$$\tilde{A}_G^1 = \begin{array}{cc} & \begin{matrix} C_1 & C_2 & C_3 & C_4 & C_5 \end{matrix} \\ \begin{matrix} C_1 \\ C_2 \\ C_3 \\ C_4 \\ C_5 \end{matrix} & \begin{bmatrix} 1 & 1/\tilde{3} & \tilde{5} & \tilde{7} & \tilde{5} \\ \tilde{3} & 1 & \tilde{3} & \tilde{5} & \tilde{3} \\ 1/\tilde{5} & 1/\tilde{3} & 1 & 1/\tilde{3} & 1/\tilde{5} \\ 1/\tilde{7} & 1/\tilde{5} & \tilde{3} & 1 & 1/\tilde{5} \\ 1/\tilde{5} & 1/\tilde{3} & \tilde{5} & \tilde{5} & 1 \end{bmatrix} \end{array},$$

$$\tilde{A}_G^2 = \begin{array}{cc} & \begin{matrix} C_1 & C_2 & C_3 & C_4 & C_5 \end{matrix} \\ \begin{matrix} C_1 \\ C_2 \\ C_3 \\ C_4 \\ C_5 \end{matrix} & \begin{bmatrix} 1 & \tilde{5} & \tilde{5} & \tilde{5} & \tilde{7} \\ 1/\tilde{5} & 1 & \tilde{3} & \tilde{3} & \tilde{5} \\ 1/\tilde{5} & 1/\tilde{3} & 1 & 1/\tilde{3} & \tilde{3} \\ 1/\tilde{5} & 1/\tilde{3} & \tilde{3} & 1 & \tilde{3} \\ 1/\tilde{7} & 1/\tilde{5} & 1/\tilde{3} & 1/\tilde{3} & 1 \end{bmatrix} \end{array},$$

$$\tilde{A}_G^3 = \begin{array}{cc} & \begin{matrix} C_1 & C_2 & C_3 & C_4 & C_5 \end{matrix} \\ \begin{matrix} C_1 \\ C_2 \\ C_3 \\ C_4 \\ C_5 \end{matrix} & \begin{bmatrix} 1 & \tilde{3} & \tilde{9} & 1/\tilde{3} & \tilde{7} \\ 1/\tilde{3} & 1 & \tilde{7} & 1/\tilde{5} & \tilde{5} \\ 1/\tilde{9} & 1/\tilde{7} & 1 & 1/\tilde{9} & 1/\tilde{3} \\ \tilde{3} & \tilde{5} & \tilde{9} & 1 & \tilde{9} \\ 1/\tilde{7} & 1/\tilde{5} & \tilde{3} & 1/\tilde{9} & 1 \end{bmatrix} \end{array},$$

$$\tilde{A}_G^4 = \begin{array}{cc} & \begin{matrix} C_1 & C_2 & C_3 & C_4 & C_5 \end{matrix} \\ \begin{matrix} C_1 \\ C_2 \\ C_3 \\ C_4 \\ C_5 \end{matrix} & \begin{bmatrix} 1 & \tilde{5} & \tilde{3} & \tilde{7} & \tilde{5} \\ 1/\tilde{5} & 1 & 1/\tilde{5} & \tilde{3} & \tilde{1} \\ 1/\tilde{3} & \tilde{5} & 1 & \tilde{5} & \tilde{5} \\ 1/\tilde{7} & 1/\tilde{3} & 1/\tilde{5} & 1 & \tilde{1} \\ 1/\tilde{5} & 1/\tilde{1} & 1/\tilde{5} & 1/\tilde{1} & 1 \end{bmatrix} \end{array},$$

$$\tilde{A}_G^5 = \begin{array}{cc} & \begin{matrix} C_1 & C_2 & C_3 & C_4 & C_5 \end{matrix} \\ \begin{matrix} C_1 \\ C_2 \\ C_3 \\ C_4 \\ C_5 \end{matrix} & \begin{bmatrix} 1 & \tilde{9} & \tilde{5} & \tilde{5} & \tilde{7} \\ 1/\tilde{9} & 1 & 1/\tilde{7} & 1/\tilde{5} & 1/\tilde{7} \\ 1/\tilde{5} & \tilde{7} & 1 & \tilde{5} & \tilde{3} \\ 1/\tilde{5} & \tilde{5} & 1/\tilde{5} & 1 & 1/\tilde{5} \\ 1/\tilde{7} & \tilde{7} & 1/\tilde{3} & \tilde{5} & 1 \end{bmatrix} \end{array}.$$

With (6) , we obtained the synthetic judgment matrix as Table III. And With (7), we obtained the average fuzzy values as Table IV. Using (8) and (12), the fuzzy pair-wise comparison matrix $\widetilde{A}=[\widetilde{a}_{ij}]$ can be calculated as following:

$$\widetilde{a}_{ij}=(\widetilde{a}_{ij}^{1}\otimes\widetilde{a}_{ij}^{2}\otimes\widetilde{a}_{ij}^{3}\otimes\widetilde{a}_{ij}^{4}\otimes\widetilde{a}_{ij}^{5})^{1/5}.$$

which combines five experts' judgments. Here we compute $\widetilde{a}_{21}$ as an example:

$$\begin{aligned}\widetilde{a}_{21}&=(\widetilde{a}_{21}^{1}\otimes\widetilde{a}_{21}^{2}\otimes\widetilde{a}_{21}^{3}\otimes\widetilde{a}_{21}^{4}\otimes\widetilde{a}_{21}^{5})^{1/5}\\
&=((1,3,5)\otimes(1/7,1/5,1/3)\otimes(1/5,1/3,1)\\
&\quad\otimes(1/7,1/5,1/3)\otimes(1/9,1/9,1/7))^{1/5}\\
&=(1\times1/7\times1/5\times1/7\times1/9;3\times1/5\times1/3\\
&\quad\times1/5\times1/9;5\times1/3\times1\times1/3\times1/7))^{1/5}\\
&=(0.00045;0.00444;0.07936)^{1/5}\\
&=(0.00045^{1/5};0.00444^{1/5};0.07936^{1/5})\\
&\approx(0.21;0.34;0.60).\end{aligned}$$

In Table V, the fuzzy weights of criteria in level 2 of tree structure are obtained by aggregating triangular fuzzy numbers with (6), (9) and (11). Here we give an example to introduce the calculating process:

Supposing that the fuzzy weight $\widetilde{\omega}_i$ of Tangibles is $E_1^{\omega}: E_1^{\omega}=(E_1^{L_\omega},E_1^{M_\omega},E_1^{\mu_\omega})$,

$$\begin{aligned}E_1^{L_\omega}&=E_1^{L_1}\times(E_1^{\mu_1}+E_2^{\mu_2}+E_3^{\mu_3}+E_4^{\mu_4}+E_5^{\mu_5})^{-1}\\
&=1.86\times(3.33+1.31+1.12+1.18+0.92)^{-1}\\
&\approx0.24.\end{aligned}$$

$$\begin{aligned}E_1^{M_\omega}&=E_1^{M_1}\times(E_1^{M_1}+E_2^{M_2}+E_3^{M_3}+E_4^{M_4}+E_5^{M_5})^{-1}\\
&=2.60\times(2.60+0.94+0.75+0.84+0.66)^{-1}\\
&\approx0.45.\end{aligned}$$

$$\begin{aligned}E_1^{\mu_\omega}&=E_1^{\mu_1}\times(E_1^{L_1}+E_2^{L_2}+E_3^{L_3}+E_4^{L_4}+E_5^{L_5})^{-1}\\
&=3.34\times(1.86+0.65+0.55+0.61+0.46)^{-1}\\
&\approx0.81.\end{aligned}$$

$$E_1^{\omega}=(E_1^{L_\omega},E_1^{M_\omega},E_1^{\mu_\omega})=(0.24,0.45,0.81).$$

After then, the fuzzy weights of criteria are defuzzified with (9). For example, supposing that the weights of Tangibles (E_1) is $(E_1^{LD_\omega},E_1^{MD_\omega},E_1^{\mu D_\omega})$,

$$\begin{aligned}E_1&=((E_1^{\mu_\omega}-E_1^{L_\omega})+(E_1^{M_\omega}-E_1^{L_\omega}))/3+E_1^{L_\omega})\\
&=((0.81-0.24)+(0.45-0.24))/3+0.24)\\
&=0.50.\end{aligned}$$

Table V gives the corresponding values for the five criteria of service satisfaction. The ranking of the weights of the criteria are: *Tangibles* (0.50), *Reliability* (0.19), *Assurance* (0.16), *Responsiveness* (0.17), and *Empathy* (0.13). These results show *Tangibles* and *Reliability* are the two most influential aspects for Guangxi tobacco company in improving its' service quality. It suggests that Guangxi tobacco company should improve the service level in these two aspects, including service personnel's dress (C1), clear service promise (C2), clear service instructions and as well as others that can contribute to enhance the tangible items of the QOS and the image of the company (C3). The others have least influential in our research. That means the other three criteria decide the optimal outcome.

V. Conclusion and Future Research

In this study, we propose a FAHP method combining qualitative research and quantitative analysis for service firms planning strategy in improving its' service quality, and use a case study to verifies its' validity and practicability. The results show that the FAHP method is applicable and valid as an assessment technology for service strategies, and is useful for other similar MCDM problems. The proposed approach has been used in service satisfaction survey of dealers by Yunnan tobacco company and Guangxi tobacco company. By adjusting criteria and sub-criteria, the approach and survey system also have been used in satisfaction survey of organization culture construction by the China Culture Administration Association (CCAA). This study have considerable value for the firms in improving its' service quality or obtaining the status of organization culture construction.

With the development of the new technology, such as Software-as-a-service (SaaS), ''cloudy" technology and so on, more service types will impact service strategy of firms. More research about this issue will be explored in the near future.

References

[1] R. Ladhari, "A. Review of twenty years of SERVQUAL research," *International Journal of Quality and Service Sciences*, vol.1, pp. 172–198, July 2009.

[2] T. L. Saaty, "How to make a decision: The analytic decision processes," *Interfaces*, vol. 6, pp. 19–43, November 1994.

[3] C. Kahraman, U. Cebeci, and Z. Ulukan, "Multi-criteria supplier selection using uzzy AHP," *Logistics Information Management*, vol. 16, pp. 382–394, December 2003.

[4] D. H. Wang, X. W. Liu, L. X. Jiang, X. T. Zhang, Y. G. Zhao, "Rough set approach to multivariate decision trees inducing," *Journal of Computers*, vol. 7, pp. 870–879, April 2012.

[5] Jose A. Martinez, Laura Martinez, "Some insights on conceptualizing and measuring service quality," *Retailing and Consumer Services*, vol. 17, pp.29–42, January 2010.

[6] D. Y. Chang, "Applications of the extent analysis method on fuzzy AHP," *European Journal of Operational Research*, vol. 95, pp. 649–655, December 1996.

[7] T. Y. Hsieh, S. T. Lu, and G. H. Tzeng, "Fuzzy MCDM approach for planning and design tenders selection in public office buildings," *International Journal of Project Management*, vol. 22, pp.573–584, Jan. 2004.

[8] L. Thomason, K. Lincoln, and A. Aconis, *Retailization: Brand survival in the age of retail power,* Kogan Page Ltd., UK, 2006.

[9] J. J. Buckley, "Fuzzy hierarchical analysis revisited," *European Journal of Operational Research*, vol.129, pp. 48–64, February 2001.

[10] Y. W. Du, W. CH. Duan, and L. Xu, "An integrated method for DS/AHP under ambidextrous decision

information PDF," *Journal of Software,* vol. 8, pp. 1027–1034, April 2013.
[11] F. Buttle, "SERVQUAL: review, critique, research agenda," *European Journal of Marketing*, vol. 30, pp. 8–32, January 1996.
[12] A. Parasuraman, V. A. Zeithaml, and L. L. Berry, "A conceptual model of service quality and its implications for future research," *Journal of Marketing*, vol.49, pp. 41–50, Autumn 1985.
[13] G. Büyüközkan, "Determining the mobile commerce user requirements using an analytical approach," *Computer Standards and Interfaces*, vol. 31, pp. 144–152, January 2009.
[14] C. Kahraman, T. Ertay, and G. Büyüközkan, "A fuzzy optimization model for QFD planning process using analytic network process," *European Journal of Operational Research*, vol. 171, pp. 390–411, June 2006.
[15] S. Opricovic, G. H. Tzeng, "Defuzzification within a Multicriteria Decision Model," *International Journal of Uncertainty, Fuzziness and Knowledge-based Systems*, vol. 11, pp. 635–652, October 2003.
[16] T. Paksoy, N. Y. Pehlivan, and C. Kahraman, "Organizational strategy development in distribution channel management using fuzzy AHP and hierarchical fuzzy TOPSIS," *Expert Systems with Applications,* vol. 39, pp. 2822–2841, February 2012.
[17] L. A. Vidal, F. Marle, and J. C. Bocquet, "Using a Delphi process and the Analytic Hierarchy Process (AHP) to evaluate the complexity of projects," *Expert Systems with Applications*, vol. 38, pp. 5388–5405, May 2011.
[18] R. Ladhari, "Developing e-service quality scales: A literature review", *Journal of Retailing and Consumer Services* , vol. 17, pp. 464–477, November 2010.
[19] K. Hadwich, D. Georgi, S. Tuzovic, J. Büttner, and M. Bruhn, "Perceived quality of e-health services: A conceptual scale development of e-health service quality based on the C-OAR-SE approach," *International Journal of Pharmaceutical and Healthcare Marketing*, vol.4, pp. 112–136, June 2010.
[20] L. Shan, "Research on Green Logistics Service Providers Selection Based on Intuitionistic Language Fuzzy Entropy," *Journal of Computers,* vol. 7, pp. 540–546, February 2012.
[21] G. Buyukozkan, G. Cifci, "A combined fuzzy AHP and fuzzy TOPSIS based strategic analysis of electronic service quality in healthcare industry", *Expert Systems with Applications*, vol. 39, pp. 2341–2354, February 2012.
[22] O. Kilincci, S. A. Onal, "Fuzzy AHP approach for supplier selection in a washing machine company", *Expert Systems with Applications*, vol. 38, pp. 9656–9664, August 2011.
[23] M. K. Chen, S. C. Wang, "The use of a hybrid fuzzy-Delphi-AHP approach to develop global business intelligence for information service firms", *Expert Systems with Applications*, vol. 37, pp. 7394–7407, November 2010.
[24] C. C. Chung, C. H. Chiang, "The critical factors: an evaluation of schedule reliability in liner shipping", *International Journal of Operations Research*, vol. 8, pp. 3–9, September 2011.

Yong Li is an Associate Professor in School of Information Engineering and Automation, Kunming University of Science and Technology. He got Ph.D. in School of Information Science and Engineering, Yunnan University. His research interests are in conditional event algebra, random sets theory and their application in data fusion systems.