International Journal of Information, Control and Computer Sciences
ISSN: 2517-9942
Vol:6, No:5, 2012

Applying Fuzzy Analytic Hierarchy Process for Evaluating Service Quality of Online Auction

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Abstract—This paper applies fuzzy AHP to evaluate the service quality of online auction. Service quality is a composition of various criteria. Among them many intangible attributes are difficult to measure. This characteristic introduces the obstacles for respondents on reply in the survey. So as to overcome this problem, we invite fuzzy set theory into the measurement of performance and use AHP in obtaining criteria. We found the most concerned dimension of service quality is Transaction Safety Mechanism and the least is Charge Item. Other criteria such as information security, accuracy and information are too vital.

Keywords—Fuzzy set theory, AHP, Online auction, Service quality

I. Introduction

THE online auction business model has developed and thrived in a short time and become one of the most outstanding electronic commerce models. Some of the online auction sites are Yahoo, Ruten, Taobao, Eachnet, and eBay, to name but a few. The success factors of auction sites are considered to be many. One of the main factors is that sellers and purchasers can have direct contacts with no time and geographical constraints. In this kind of setting, not only can sellers sell items for relatively high prices, but purchasers can transact satisfactorily [14]. In other words, both parties acquire best mutual economical benefits. Another factor is that auction sites bring intense network flow since bidders have to check newest prices offered by sellers while updating their bids when necessary. This intensity becomes the niche itself as well. Owing to these advantages, there is no doubt why auction business model is instantaneously popular and prosperous nowadays. With a plethora of auction sites, the good service quality offered turns out to be the key reason affecting consumer behavior and consumer loyalty. Thus, learning to evaluate the quality and upgrade it are our focus here.

In order to measure the service quality, we tend to adopt the well-known SERVQUAL model [18] to investigate, extract, adjust, and evaluate information found in both production business and service business. However, in our study [26], the SERVQUAL model modified by Parasuraman, Zeithaml and Berry (PZB) is not an appropriate management tool for on-line business at all. Another thing to note here is that advanced technology contributes to ever-growing demands from consumers. And using single evaluative criterion to measure appears to be inadequate, not to mention different evaluators hold subjective views and different results. In short, there are much uncertainty and fuzziness in this kind of analysis and the problems mentioned above are just too hard to tackle.

To solve the problems we enumerated earlier, we use Multiple Criteria Decision Making (MCDM) method to assist decision makers in quality and quantification evaluation. We then choose a group to demonstrate an alternative to assess and then measure pros and cons and decide execute priorities [5]. Additionally, the Analytic Hierarchy Process (AHP) [20] is widely used and proved successful in great many fields.

As for the cognitive uncertainty generated from users' subjective judgments, we then use fuzzy set theory [29] to deal with linguistic variables and linguistic values [28, 30-32]. We are convinced this will empower decision makers' ability in decision analysis.

This paper uses fuzzy numbers and AHP to develop a fuzzy evaluation model which prioritizes the relative weights of the factors influencing online auction. Also, an empirical study from a Taiwanese online auction is used to illustrate the feasibility of this method. The results of this study provide both a theoretical basis and empirical evidence indicating the relative importance of factors which prompt online auction. From an expert's perspective, it is important to understand what factors influence online auction behaviors. An identification of the relative importance of these different factors can help e-sellers take their managerial strategy into account in the business.

II. Literature reviews

A. Service quality

SERVQUAL was proposed by Parasuraman, Zeithaml and Berry in 1988, which is the most evaluative tool in the service quality domain. In SERVQUAL, there are five dimensions: tangibles, reliability, responsiveness, assurance, and empathy. In the service quality evaluation of information service industry [9,16] there are still some debate about using evaluative tools with the five dimensions of SERVQUAL despite many papers mentioned their achievement. In fact, the most important problem is whether it could be measured by the five dimensions. Xie et al.[26], for example, utilized the five dimensions to estimate the service quality of search websites and found they could not be used to describe the users' needs. Besides, some papers suggest that they have to be modified to adapt for different information service industries. Kettinger &

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Lee[13], for instance, deleted the dimension of Tangibles in their research. Pitt et al.[19] separated Tangibles and Empathy into another two dimensions through factor analysis. Such other related literatures are shown in Table I.

B. Fuzzy set theory and fuzzy AHP

1) Fuzzy set theory: To deal with the ambiguity of human thought, Zadeh [29] introduced the concept of fuzzy set theory, which can effectively describe imprecise knowledge or human subjective judgment using linguistic terms. The linguistic terms are used to express people's feelings and judgment, which are considered vague. Because linguistic terms merely approximate subjective judgments of decision makers, the widely adopted triangular fuzzy number technique is applied to represent the vagueness of these linguistic terms [6].

a) ***Triangular fuzzy numbers****:* A fuzzy set $\widetilde{F}$ in a universe of discourse U is characterized by a membership function $\mu_{\widetilde{F}}(x)$ which associates a real number in the interval [0,1] with each element x in X, to represent the grade of membership of x in $\widetilde{F}$. A triangular fuzzy number is a special type of fuzzy set, widely used in fuzzy applications. As shown in Fig. 1, a triangular fuzzy number can be defined as $\widetilde{T} = (l, m, u)$ and its membership function is equal [12] to:

$$\mu_{\widetilde{F}}(x) = \begin{cases} \frac{x-l}{m-l} & l \leq x \leq m \\ \frac{u-x}{u-m} & m \leq x \leq u \\ 0 & otherwise \end{cases} \quad (1)$$

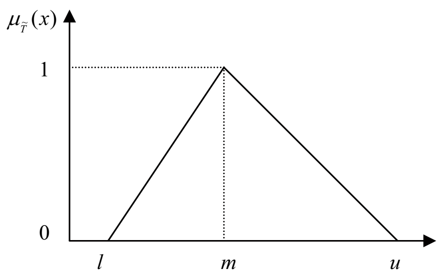

Fig. 1: Triangular fuzzy number $\widetilde{T}$

where l and u are the lower and upper limits of the support of $\widetilde{T}$, respectively, and m is the mid-value of $\widetilde{T}$.

b) ***α-cut of triangular fuzzy number****:* The α-cut of a fuzzy number $\widetilde{T}$ is the crisp set $\widetilde{T}^\alpha$ that contains all the elements of the universal set U whose membership grades in $\widetilde{T}$ are greater than or equal to the specified value α, as shown in Fig. 2. By defining the interval of confidence at level α, the α-cut of a triangular fuzzy number $\widetilde{T}$ is defined [33] as:

$$\widetilde{T}^\alpha = [(m-1)\alpha + l, u - (u-m)\alpha], 0 \leq \alpha \leq 1 \quad (2)$$

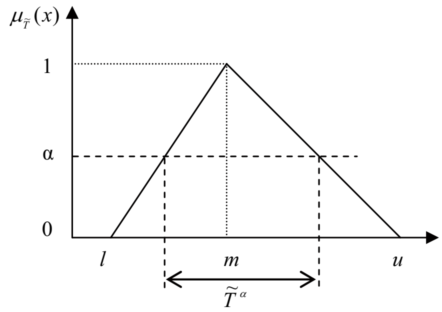

Fig. 2: α-cut of triangular fuzzy number $\widetilde{T}$

c) ***Useful operations using triangular fuzzy numbers****:* Given any two triangular fuzzy numbers, $\widetilde{T}_1 = (l_1, m_1, u_1)$ and $\widetilde{T}_2 = (l_2, m_2, u_2)$, and a positive real number r, some useful operations on triangular fuzzy numbers $\widetilde{T}_1$ and $\widetilde{T}_2$ can be expressed as follows:

$$\widetilde{T}_1 \oplus \widetilde{T}_2 = (l_1 + l_2, m_1 + m_2, u_1 + u_2) \quad (3)$$

$$\widetilde{T}_1 \otimes \widetilde{T}_2 = (l_1 \times l_2, m_1 \times m_2, u_1 \times u_2) \quad (4)$$

$$r \otimes \widetilde{T}_1 \cong (rl_1, rm_1, ru_1) \quad (5)$$

$$\widetilde{T}_1^{-1} \cong (\frac{1}{l_1}, \frac{1}{m_1}, \frac{1}{u_1}) \quad (6)$$

d) ***Distance measurement method****:* The distance between two triangular fuzzy numbers can be defined using the vertex method [4]. Let $\widetilde{T}_1 = (l_1, m_1, u_1)$ and $\widetilde{T}_2 = (l_2, m_2, u_2)$ be two triangular fuzzy numbers; the distance between them is

$$d(\widetilde{T}_1, \widetilde{T}_2) = \sqrt{\frac{1}{3}[(l_1 - l_2)^2 + (m_1 - m_2)^2 + (u_1 - u_2)^2]} \quad (7)$$

2) Essence of the fuzzy analytic hierarchy process: The analytic hierarchy process (AHP) is a useful method for solving complex decision making problems involving subjective judgment [21]. In AHP, the multi-attribute weight measurement is calculated via pairwise comparison of the relative importance of two factors. Assuming there are n number of decision elements, denoted as $(E_1, E_2, \ldots, E_n)$, its judgment matrix would be $A = [a_n]$, in which a_n represents the relative importance of E_1 and E_2. Using the two vector average normalization proposed by Saaty [20], the weight of E_1 is calculated as:

$$w_i = \frac{(\prod_{j=1}^{n} a_{ij})^{\frac{1}{n}}}{\Sigma_{j=1}^{n} (\prod_{j=1}^{n} a_{ij})^{\frac{1}{n}}} \quad i, j = 1, 2, \cdots, n \quad (8)$$

where w_i denotes the weight of the ith decision element, and wight vector $W = (w_i)$, $i = 1, \cdots, n$.

Though, AHP is designed to capture decision makers' knowledge, and conventional AHP does not fully reflect thinking styles. However, it is well recognized that human perceptions and judgements are represented by imprecise

TABLE I: Service quality measurement in prior studies

Study	Context	Dimensions
Shohreh and Christine [23]	Service quality of online travel agencies	Content & purpose, accessibility, navigation, design & presentation, responsiveness background, personalization & customization
Barnes and Vidgen [1]	Website quality of online shopping	Tangibles, reliability, responsiveness, assurance, empathy
Loiacono et al. [15]	Website quality of website usage	Information quality, tailored communications, trust, response time, ease of understanding, intuitive operations, visual appeal, innovativeness, emotional appeal, consistent image, on-line completeness, relative advantage
Wolfinbarger and Gilly [25]	E-service quality of B2C commerce	Efficiency, system availability, fulfillment, privacy, responsiveness, compensation, contact
Shih T. L. [22]	Decision making factors of C2C online auction	Transaction safety mechanism, website promotion, operation convenience, charge item, customer service
Hsieh T. Y. [10]	E-service quality of online auction	Efficiency, system availability, privacy/ security, compensation, personalization, reputation, playfulness

linguistic patterns for complex problems. Linguistic and imprecise descriptions were difficult to comprehend by using AHP before recent developments in fuzzy decision making [3, 24]. Fuzzy set theory resembles human reasoning in its use of approximate information and uncertainty in decision generation. A major contribution of fuzzy set theory is its capability to represent vagueness. At the same time, AHP was developed to solve multiple criteria decision making problems. By combining fuzzy set theory with AHP, fuzzy AHP allows a more accurate description of the multiple criteria decision making process [2]. The earliest work in fuzzy AHP was from Laarhoven and Pedrycz [24] who compared fuzzy ratios described with triangular membership function. Many studies using fuzzy AHP are designed to calculate the importance (weights) of evaluation items [8, 17, 27]. Therefore, in this study, we prefer the fuzzy AHP method since this method is to explicitly capture the importance assessments of imprecise human judgments.

III. Research method

In this section, a fuzzy AHP method is used to determine the relative weights of the service quality of online auction. The steps are summarized as follows.

A. Constructing the hierarchy framework

To validate the main influences on online auction structure, measurement items were developed using expert interview method dealing with these factors. A questionnaire was used to verify the factors that had been identified in the literature, with the aim of investigating their degree of importance. Twelve experts are invited to discuss the problem of the hierarchical structure of service quality of online auction. A five-point Likert scale is used (ranging from 1 = strongly disagree to 5 = strongly agree).

After discussing, five criteria (‘accuracy’, ‘information’, ‘innovation’, ‘entertainment’ and ‘appearance’) have a dimension 1, which was called rename ‘Website Design’. Criteria ‘system stabilization’, ‘speed of items browse’ and ‘usage’ were from the dimension ‘Operation Convenience’. Criteria ‘auction type of diversification’, ‘number of members’, ‘category and number of items’ and ‘community discussion’ were from the dimension ‘website promotion’. Criteria ‘listing fee’, ‘transaction fee’ and ‘advertising fee’ were from the dimension ‘Charge Item’. Criteria ‘ability to arbitrate dispute of transaction’, ‘providing prompt service of transaction information’, ‘providing fraud and repair of policy’ and ‘function’ were integrated to form the dimension ‘Customer Service’. And the ‘feedback of reliability’, ‘item listing of reliability’, ‘cash and logistics flow the safety’ and ‘information security’ criteria were combined as ‘Transaction Safety Mechanism’. On the basis of the analysis results presented above, this study developed a hierarchical structure for the research problem (see Fig. 3). The goal is to evaluate the relative weights of the factors influencing online auction (Level 1). Level 2 contains the six dimensions which promote online auction. Finally, the twenty-three criteria form Level 3.

B. Computational procedure for fuzzy AHP

1) Scaling the relative importance of decision elements: The design of the questionnaire incorporated pairwise comparisons of decision elements within the hierarchical framework. Each decision maker was asked to express the relative importance of two decision elements in the same level using a nine point rating scale. The collection pairwise comparison scores were then used to form pairwise comparison matrices for each of the K decision makers.

2) Constructing the fuzzy positive reciprocal matrix: The pairwise comparison scores were transformed into linguistic variables, which were represented by fuzzy numbers (see Table II). A fuzzy reciprocal judgment matrix $\widetilde{A}^k$ can be established as

$$\widetilde{A}^k = [\widetilde{a}_{ij}]^k \tag{9}$$

where n is the number of related decision elements at this level, $\widetilde{a}_{ij}^k = 1, \forall i = j$ and $\widetilde{a}_{ij}^k = 1/\widetilde{a}_{ij}^k, \forall i, j = 1, 2, \ldots, n$

Once fuzzy reciprocal judgment matrix $\widetilde{a}^k$ is established, the fuzzy numbers in $\widetilde{a}^k$ are transformed into triangular fuzzy numbers based on Table II and equation (6). According to Buckley [3], a fuzzy positive reciprocal matrix can be defined as

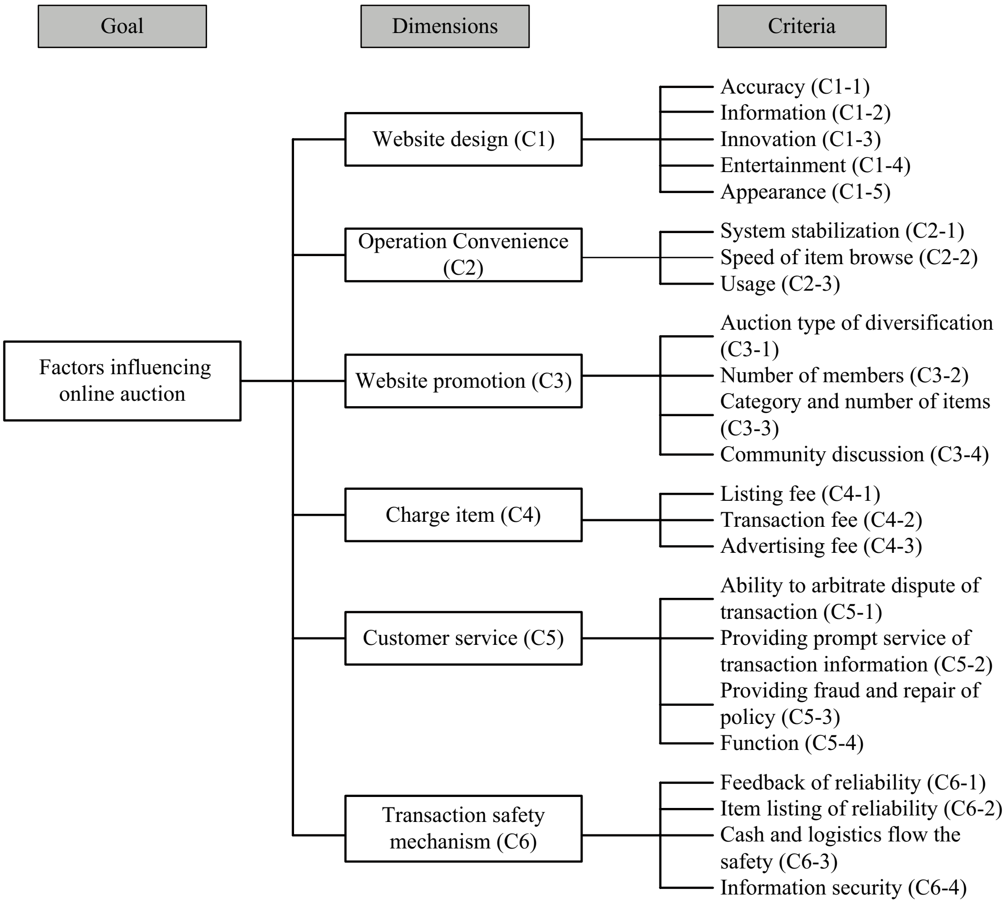

Fig. 3: The hierarchical structure of this research problem

$$\widetilde{R}^k = [\widetilde{r}_{ij}]^k \tag{10}$$

where $\widetilde{R}^k$ is the fuzzy positive reciprocal matrix for decision maker k, $\widetilde{r}_{ij} = (l_{ij}, m_{ij}, n_{ij})$. $\widetilde{r}_{ij}$ is the relative difference in the importance between decision elements i and j. $r_{11} = (1,1,1), \forall i = j, \widetilde{r}_{ij} = 1/\widetilde{r}^k_{ij}, \forall i, j = 1, 2, \ldots, n$

TABLE II: Triangular fuzzy numbers

Linguistic variables	Fuzzy number	Triangular fuzzy numbers
Equally important	$\widetilde{1}$	(1,1,1)
Intermediate	$\widetilde{2}$	(1,2,3)
Weakly more important	$\widetilde{3}$	(2,3,4)
Intermediate	$\widetilde{4}$	(3,4,5)
Strongly more important	$\widetilde{5}$	(4,5,6)
Intermediate	$\widetilde{6}$	(5,6,7)
Very strongly more important	$\widetilde{7}$	(6,7,8)
Intermediate	$\widetilde{8}$	(7,8,9)
Absolutely more important	$\widetilde{9}$	(9,9,9)

3) Consistency test: According to the analysis of Csutora & Buckley [7], let $\widetilde{R} = [\widetilde{r}_{ij}]$ be a fuzzy positive reciprocal matrix with triangular fuzzy number $\widetilde{r}_{ij} = (\alpha_{ij}, \beta_{ij}, \gamma_{ij})$ and form $R = [\beta_{ij}]$. If R is consistent, then $\widetilde{R}$ is consistent. Saaty [21] provides a consistency index to measure any inconsistency within the judgments in each pairwise comparison matrix as well as the entire hierarchy. The consistency index (*CI*) is formulated as

$$CI = \frac{\lambda_{max} - n}{n - 1} \tag{11}$$

where λ_{max} is the maximum eigenvalue and the dimension of matrix.

Accordingly, the consistency ration (*CR*) can be computed as

$$CR = \frac{CI}{RI} \tag{12}$$

for each size of matrix *n*, random matrices were generated; their mean *CI* value, called the random index (*RI*), is shown in TABLE III. If the calculated *CR* of a pairwise comparison matrix is less than 0.1, the consistency of the pairwise judgment can be thought of as being acceptable. If the consistency test is not passed, the original values in the pairwise comparison matrix must be revised by the decision maker.

TABLE III: Random index (*RI*)

N	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
RI	0.00	0.00	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49	1.51	1.48	1.56	1.57	1.58

4) Calculating fuzzy weights: This procedure is as follows:
(a) Based on the α-cut method (equation (2)), set α = 1 to obtain the positive matrix of decision maker *k*, $\widetilde{R}^k_m = [\widetilde{r}_{ij}]^k_m$.
(b) Next, set α = 0 to obtain the lower bound and upper bound positive matrices of decision maker *k*, $\widetilde{R}^k_l = [\widetilde{r}_{ij}]^k_l$ and $\widetilde{R}^k_u = [\widetilde{r}_{ij}]^k_u$.
(c) Following the weight calculation procedure proposed in AHP, use equation (8) and (9) to calculate weight vertices $W^k_m = (w_i)^k_m$, $W^k_l = (w_i)^k_l$ and $W^k_u = (w_i)^k_u$.
(d) By [7], two constants, the smallest possible S^k_l and largest possible S^k_u, are used to minimize the fuzziness of the weight. S^k_l and S^k_u can be expressed as follows:

$$S^k_l = min\{\frac{w^k_{im}}{w^k_{il}}|1 \leq i \leq n\} \tag{13}$$

$$S^k_u = max\{\frac{w^k_{im}}{w^k_{iu}}|1 \leq i \leq n\} \tag{14}$$

The lower bound and upper bound of the weight are defined as

$$w^{*k}_{il} = S^k_l w^k_{il}, i = 1, \ldots, n \tag{15}$$

$$w^{*k}_{iu} = S^k_u w^k_{iu}, i = 1, \ldots, n \tag{16}$$

Thus, the lower and upper weight vectors are $(w^*_i)^k_l$ and $(w^*_i)^k_n$, $i = 1, \ldots, n$.
(e) By combining the lower, the middle, and the upper bound weight vectors, the fuzzy weight matrix for decision maker *k* can be obtained, and is defined as

$$\widetilde{W}^k_u = (w^{*k}_{il}, w^{*k}_{im}, w^{*k}_{iu}), i = 1, \ldots, n. \tag{17}$$

5) Combine the opinions of decision makers: This procedure is used to combine the fuzzy weights of decision makers, that is

$$\widetilde{\widetilde{W}}_i = \frac{1}{K}(\widetilde{W}^1_i \oplus \widetilde{W}^2_i \oplus \cdots \oplus \widetilde{W}^k_i) \tag{18}$$

where $\widetilde{\widetilde{W}}_i$ is the combined fuzzy weight of decision element *i* for *K* decision makers, $\widetilde{W}^k_i$ is the fuzzy weight of decision element *i* for *K* decision makers, and *K* is the number of decision makers.

6) Undertaking defuzzication and obtaining the final ranking: Applying the distance measurement method to undertake defuzzification, the defuzzification value of fuzzy weights $R_{\overline{w}_i}$ is calculated using the [4]. The ranking order of the decision elements is determined by $R_{\overline{w}_i}$, which can be expressed as follows:

$$R_{\overline{w}_i} = \frac{d^-(\widetilde{\widetilde{W}}_i, 0)}{d^-(\widetilde{\widetilde{W}}_i, 0) + d^*(\widetilde{\widetilde{W}}_i, 1)} \quad i = 1, 2, \cdots, n, 0 \leq R_{\overline{w}_i} \leq 1 \tag{19}$$

where $d^-(\widetilde{\widetilde{W}}_i, 0)$ and $d^*(\widetilde{\widetilde{W}}_i, 1)$ are the distance measurement between two fuzzy numbers (seen equation (7)).

The weight ω_i for decision element *i* is the normalization of $R_{\overline{w}_i}$, which can be expressed as:

$$\omega_i = \frac{R_{\overline{w}_i}}{\Sigma^n_{i=1} R_{\overline{w}_i}}, i = 1, 2, \cdots, n \tag{20}$$

IV. Empirical study of online auction

After fuzzy AHP process is applied, an empirical study is used to illustrate this method.

A. Background and problem description

Thanks to the growth of online action market in Taiwan, slotting and bidding process is increasingly common for online auction. InsightXplorer [11] indicated that there are 80% of people buying items and more than 40% of people selling. The online auction does not need a physical transaction place. As long as you can surf online, can be carried out transactions any time or any places. Besides, buyers are not equal to traders, anyone would like to sell items and find buyers though online auction.

Taiwanese online auctions, which provide relative auction services including website design, operation convenience, website promotion, charge item, customer service and transaction safety mechanism, are selected to identify critical criteria of evaluating e-service quality for online auction. Since the major factor of these online auctions management is customers, how to promote service quality of online auction and add to transaction times or amounts of customers to generate online shopping loyalty becomes an important issue. Thus, we use an empirical study to illustrate the use of fuzzy AHP to evaluate the relative importance of factors which affect online auction.

B. Constructing the fuzzy AHP method for the factors influencing online auction

1) Scaling the relative importance of influence factors: A questionnaire is designed in the form of a pairwise comparison based on the hierarchical structure described Fig. 3. A conventional AHP questionnaire format is used to indicate the relative importance of each attribute in the same hierarchy.

We interviewed five managers from the Website company in Taiwan and five teachers whose specialty is Electronic Commerce to evaluate the online auction hierarchy framework. These ten experts were selected because of their familiarity with multiple aspects of online auctions. The aim of the interview was to collect participant's opinions, to measure the relative weight of the influences on online auction. Therefore, these participants were asked to complete the questionnaire and their subjective judgments analysed for factors which affect online auction.

2) Constructing fuzzy positive reciprocal matrix: The fuzzy reciprocal judgment matrices for decision maker 1's opinions, collected through the questionnaire developed in previous step, are Tables IV-X. Triangular fuzzy numbers were used to construct fuzzy positive reciprocal matrices for each level in the hierarchy, formulated using equation (10).

3) Consistency test: The consistency of Tables IV-X was tested using equations (11) and (12). The results of the consistency test gave the *CR* of Tables 6-10 as 0.077, 0.082, 0.093, 0.078, 0.081, 0.091 and 0.094, respectively, which shows that all of the judgments of decision maker 1 are consistent.

4) Calculating fuzzy weights: After testing *CR*, we adopted the method of [7] to calculate the fuzzy weights of the factors influencing online auction of each level. Equations (13)-(17) were used to obtain fuzzy weight matrix for decision maker 1.

5) Combine the opinions of decision makers: Above 2-4 are performed for decision makers 2-10. The fuzzy weights from all decision makers were combined using equation (18) to generate the overall fuzzy weights.

6) Undertaking defuzzication and obtaining final ranking: Finally, using equations (19) and (20), the overall importance weights for all decision makers were determined. In order to compare all factors influencing online auction at the same layer of the hierarchical structure, the priority weights and ranking are summarized in Table XI.

C. Results and discussion

The final weights for the six dimensions affecting online auction are shown in Table XI, which are 'transaction safety mechanism' (0.2485) and 'website design' (0.2075). There are the two most important dimensions affecting online auction in the Taiwanese online industry, followed by 'customer service' (0.1786), 'operation convenience' (0.1489), 'website promotion' (0.1157) and 'charge item' (0.1008). The criteria 'accuracy' (0.3086), 'system stabilization' (0.3451), 'community discussion' (0.3321), 'advertising fee' (0.3462), 'providing promote service of transaction information' (0.3303) and 'information security' (0.3840) show the highest importance with respect to each dimension.

The relatively slight difference in weights between the six dimensions implies they are all significant. The result indicates that 'transaction safety mechanism' outweighs all other dimensions. This shows that consumers care for the feedback of reliability, cash and logistics flow, and the safety and information security on any online auction sites. Therefore, in order to encourage more buyers, every online auction site has to handle these concerns carefully. The second rank following 'transaction safety mechanism' is 'website design', which implies adequate information included on one auction site will influence buyers' willingness to visit that site again. Thus, paying attention to designs is also another success factor. As for the attributes, 'information security' and 'accuracy' are all prominent. All these figures demonstrate consumers' privacy concern and accurate transaction wishes.

V. Conclusions

In the past, many auction sites all targeted at providing best service quality. It is not hard for us to see some tangible service approaches dominating the market, such as the functionality of website designs, abundant information values, customer service skills ... etc. However, we tend to neglect the fact that good service lies in whether consumers' expectations have been met, and we are aware that this can never be solved by looking at one single layer. This paper aims to look at this problem in every aspect and determines to offer a solution with multiple criteria of evaluation.

In investigating both concerns, we establish the procedures for identifying the most important attributes of service qualify for four online auctions base on these attributes. The evaluation procedures consist of the following steps:

1) Identify the evaluation criteria for online auction service quality;
2) Establish the hierarchical structure for online auction service quality;
3) Assess the average important of each criterion by applying Fuzzy Analytic Hierarchical Process over all the respondents;
4) Discuss how dimensions or criteria influence one other.

Finally, this paper emphasizes method application, and the alternative method we adopted may not all-inclusively meet each standard. Therefore, we believe the Multi-Objective Programming Method can be applied in the near future to withdraw a fairer and more accurate principle.

Acknowledgements

This work was supported in part by the National Science Council of the Republic of China.

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TABLE XI: Weighted dimensions and attributes of factors influencing online auction

Dimension/attribute	Weight of each dimension	Weight within dimension (ranking)	Weight over all dimensions (ranking)
Website design (C1)	0.2075		
Accuracy (C1-1)		**0.3086 (1)**	0.0640 (2)
Information (C1-2)		0.2686 (2)	0.0594 (3)
Innovation (C1-3)		0.1358 (4)	0.0282 (20)
Entertainment (C1-4)		0.1267 (5)	0.0263 (21)
Appearance (C1-5)		0.1427 (3)	0.0296 (19)
Operation convenience (C2)	0.1489		
System stabilization (C2-1)		**0.3451 (1)**	0.0514 (8)
Speed of items browse (C2-2)		0.3216 (3)	0.0479 (10)
Usage (C2-3)		0.3333 (2)	0.0496 (9)
Website promotion (C3)	0.1157		
Auction type of diversification (C3-1)		0.1862 (4)	0.0215 (22)
Number of members (C3-2)		0.1952 (3)	0.0226 (23)
Category and number of items (C3-3)		0.2865 (2)	0.0331 (15)
Community discussion (C3-4)		**0.3321 (1)**	0.0384 (12)
Charge Item (C4)	0.1008		
Listing fee (C4-1)		0.3327 (2)	0.0335 (14)
Transaction fee (C4-2)		0.3211 (3)	0.0324 (17)
Advertising fee (C4-3)		**0.3462 (1)**	0.0349 (13)
Customer Service (C5)	0.1786		
Ability to arbitrate dispute of transaction (C5-1)		0.1716 (4)	0.0306 (18)
Providing prompt service of transaction information (C5-2)		**0.3303 (1)**	0.0590 (4)
Providing fraud and repair of policy (C5-3)		0.147 (2)	0.0562 (6)
Function (C5-4)		0.1834 (3)	0.0328 (16)
Transaction safety mechanism (C6)	**0.2485**		
Feedback of reliability (C6-1)		0.1592 (4)	0.0396 (11)
Item listing of reliability (C6-2)		0.2317 (2)	0.0576 (5)
Cash and logistics flow the safety (C6-3)		0.2251 (3)	0.0559 (7)
Information Security (C6-4)		**0.3840 (1)**	**0.0954 (1)**

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TABLE IV: Fuzzy reciprocal matrix about the overall goal for decision maker 1

Goal	C1	C2	C3	C4	C5	C6
C1	$\widetilde{1}$	$\widetilde{5}^{-1}$	$\widetilde{3}^{-1}$	$\widetilde{2}^{-1}$	$\widetilde{4}^{-1}$	$\widetilde{3}^{-1}$
C2	$\widetilde{5}$	$\widetilde{2}$	$\widetilde{2}^{-1}$	$\widetilde{1}$	$\widetilde{4}^{-1}$	$\widetilde{5}^{-1}$
C3	$\widetilde{3}$	$\widetilde{2}$	$\widetilde{1}$	$\widetilde{1}$	$\widetilde{2}^{-1}$	$\widetilde{3}^{-1}$
C4	$\widetilde{2}$	$\widetilde{1}$	$\widetilde{1}$	$\widetilde{1}$	$\widetilde{1}$	$\widetilde{3}^{-1}$
C5	$\widetilde{4}$	$\widetilde{4}$	$\widetilde{2}$	$\widetilde{1}$	$\widetilde{1}$	$\widetilde{1}$
C6	$\widetilde{3}$	$\widetilde{5}$	$\widetilde{3}$	$\widetilde{3}$	$\widetilde{1}$	$\widetilde{1}$

TABLE V: Fuzzy reciprocal matrix about website design for decision maker 1

Website design	C1-1	C1-2	C1-3	C1-4	C1-5
C1-1	$\widetilde{1}$	$\widetilde{3}$	$\widetilde{2}$	$\widetilde{1}$	$\widetilde{2}$
C1-2	$\widetilde{3}^{-1}$	$\widetilde{1}$	$\widetilde{2}^{-1}$	$\widetilde{3}^{-1}$	$\widetilde{2}^{-1}$
C1-3	$\widetilde{2}^{-1}$	$\widetilde{2}$	$\widetilde{1}$	$\widetilde{4}^{-1}$	$\widetilde{4}^{-1}$
C1-4	$\widetilde{1}$	$\widetilde{3}$	$\widetilde{4}$	$\widetilde{1}$	$\widetilde{4}$
C1-5	$\widetilde{2}^{-1}$	$\widetilde{2}$	$\widetilde{4}$	$\widetilde{4}^{-1}$	$\widetilde{1}$

TABLE VI: Fuzzy reciprocal matrix about operation convenience for decision maker 1

Operation convenience	C2-1	C2-2	C2-3
C2-1	$\widetilde{1}$	$\widetilde{3}$	$\widetilde{2}$
C2-2	$\widetilde{3}^{-1}$	$\widetilde{1}$	$\widetilde{4}^{-1}$
C2-3	$\widetilde{2}^{-1}$	$\widetilde{4}$	$\widetilde{1}$

TABLE VII: Fuzzy reciprocal matrix about website promotion for decision maker 1

Website promotion	C3-1	C3-2	C3-3	C3-4
C3-1	$\widetilde{1}$	$\widetilde{3}^{-1}$	$\widetilde{3}^{-1}$	$\widetilde{3}$
C3-2	$\widetilde{3}$	$\widetilde{1}$	$\widetilde{2}$	$\widetilde{3}$
C3-3	$\widetilde{3}$	$\widetilde{2}^{-1}$	$\widetilde{1}$	$\widetilde{4}$
C3-4	$\widetilde{3}^{-1}$	$\widetilde{3}^{-1}$	$\widetilde{4}^{-1}$	$\widetilde{1}$

TABLE VIII: Fuzzy reciprocal matrix about charge item for decision maker 1

Charge item	C4-1	C4-2	C4-3
C4-1	$\widetilde{1}$	$\widetilde{5}$	$\widetilde{4}$
C4-2	$\widetilde{5}^{-1}$	$\widetilde{1}$	$\widetilde{2}^{-1}$
C4-3	$\widetilde{4}^{-1}$	$\widetilde{2}^{-1}$	$\widetilde{1}$

TABLE IX: Fuzzy reciprocal matrix about customer service for decision maker 1

Customer service	C5-1	C5-2	C5-3	C5-4
C5-1	$\widetilde{1}$	$\widetilde{3}^{-1}$	$\widetilde{4}^{-1}$	$\widetilde{6}^{-1}$
C5-2	$\widetilde{3}$	$\widetilde{1}$	$\widetilde{2}$	$\widetilde{4}^{-1}$
C5-3	$\widetilde{4}$	$\widetilde{2}^{-1}$	$\widetilde{1}$	$\widetilde{7}^{-1}$
C5-4	$\widetilde{6}$	$\widetilde{4}$	$\widetilde{7}$	$\widetilde{1}$

TABLE X: Fuzzy reciprocal matrix about transaction safely mechanism for decision maker 1

Transaction safely mechanism	C6-1	C6-2	C6-3	C6-4
C6-1	$\widetilde{1}$	$\widetilde{3}$	$\widetilde{3}$	$\widetilde{3}^{-1}$
C6-2	$\widetilde{3}^{-1}$	$\widetilde{1}$	$\widetilde{3}^{-1}$	$\widetilde{4}^{-1}$
C6-3	$\widetilde{3}^{-1}$	$\widetilde{3}$	$\widetilde{1}$	$\widetilde{5}^{-1}$
C6-4	$\widetilde{3}$	$\widetilde{4}$	$\widetilde{5}$	$\widetilde{1}$