A Fuzzy AHP Approach for Evaluating Customer Value of B2C Companies

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***Abstract*—With the development of electronic information technique, electronic ecommerce grows rapidly, including B2C electronic commerce company. The evaluation of customer value in B2C electronic commerce company is a multiple-criteria decision making (MCDM) problem with many quantitative and qualitative attributes. This paper proposes fuzzy analytical hierarchy process (FAHP) approach to evaluate customer value in B2C electronic commerce company. In addition, a case study is presented to demonstrate how the approach can help in solving such problems in practice.**

***Index Terms*—FAHP; electronic commerce; MCDM; B2C company; customer value**

I. Introduction

The development of e-commerce brings the boom of B2C electronic commerce company. Accordingly, on the one hand, the competitions between B2C electronic commerce companies become more intensive; on the other hand, customers have more choices when they are purchasing from B2C electronic commerce companies. Hence, the evaluation of customer value in B2C electronic commerce companies becomes a necessary process for B2C electronic commerce companies to maintain the valuable customers. A proper and effective evaluation requires the decision maker to analyze a lot of data and consider many factors. However, the evaluation of customer value in B2C electronic commerce companies is a multiple-criteria decision making (MCDM) problem with many quantitative and qualitative attributes. Because human decision-making process usually contains fuzziness and vagueness, the Fuzzy analytical hierarchy process (FAHP) approach is adopted to solve the problem. And it is an effective and practical approach. The aim of this paper is to propose FAHP to evaluate customer value of B2C electronic commerce companies. In addition, a case study is presented to make our approach more understandable.

II. LITERATURE OVERVIEW

There is a boom of e-commerce in recent decade. Strides in information technology and improvements in networking technology have set the pace of the rapid growth in new application of e-commerce in a variety of settings. According to China's online shopping market research reports in 2009 which is issued by CNNIC, the number of internet purchasers crowd in China reached 87.88 million by June 2009, 24.59 million more than the number in 2008 [1]. China's online shopping market research reports in 2008 shows that the number of internet user in China reached 46.41 million by December 2007, and the number of purchasers accounted for 34% of the number of the whole country’s [2]. The statistic shows that no enterprises can afford to ignore the tremendous potential of e-commerce in creating, processing and distributing the value of business. B2B, B2C, C2B and C2C are the most important business channels that have reshaped the marketplaces. B2C electronic commerce company is a sort of B2C business channel. In China, dangdang.com, joyo.com and 360buy.com are the most famous B2C electronic commerce companies and User penetration of 10.4%, 4.5% and 3.5% respectively. Furthermore, female customers, whose age range from 18 to 30 years old, are the main group.

Nowadays, managing and maximizing the value of customers, which do tremendous contributions to companies, becomes more and more important in almost all companies. What is the need to change from the traditional path of managing brands/products to a new approach of managing customers in E-commerce? The studies on E-commerce mainly focus on two points: one is the model of volume of business analyzes, the other is

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the model of visit number analyzes. Schmittlein[3] presented a model of NBD/Pareto, according to the history transaction degree, the transaction time and so on, and advanced a method to forecast the transaction volume in future. Sharma and Reinartz[4] analyzed the action of shopping behavior and studies the duration of customer lifetime value cycle in B2B, Pfeifer[5] try to make use of Markov chain to calculate the value of customer lifetime and found a structure of transaction and cash flow. These researches have better effect on practice in B2B mode. However, the evaluation effect in B2C is not good. Customer-centered management is a critical success factor of B2C e-commerce companies.

Thus, it is necessary to provide guidelines for B2C companies through a study on the components of customer value [6]. So the aim of the paper is studying and evaluating customer value in B2C companies, and attempts to find out the relationship among the factors of the customer value. Additionally, Lingyun Fang [7]set up an evaluation system of customer value, in which there contains five main factors such as Customer information value, Customer credit value, Customer purchase value, Customer public praise value and Customer loyalty value. All of these and related researches show the fact that the issue of customer value of E-commerce is a complex topic and involves multiple criteria. Based on the above literature, this paper uses three main factors (Customer information value, Customer contribution value and Customer loyalty value).

III. AHP OVERVIEW

Developed by a Pittsburgh University professor, Thomas L. Saaty in 1971, the AHP is a decision approach created to solve complex multiple criteria problems that involve qualitative decisions[8]. This method has been found to be an effective and practical approach that can consider complex and unstructured decisions [9]. Since its inception from Saaty, the AHP technique has been widely studied [10][11][12]. It has been applied to a host of MCDM problems, including corporate-credit-granting problem[13], assignment of sovereign debt ratings [14], determination of investor suitability [15], benchmarking the performance of a postal company against its competitors[16], evaluating risk in the supply chain [17], selection of vendors[18] and so on.

Basically, there are three steps for considering decision problems by AHP: constructing hierarchy, establishing comparison matrices, and synthesizing priorities, described as follows.

A. Establishment of a structural hierarchy

The first step in AHP is to construct a hierarchy. In doing this, participants decompose a complex decision into a hierarchy with an overall goal, criteria, sub-criteria and decision alternatives. A hierarchy is a system of ranking and organizing goal, criteria and alternatives on purpose, where each element in the system, except the top one, is subordinate to one or more other elements. A hierarchy can be constructed by creative thinking, recollection, and using people's perspectives and there is no set of procedures for generating the levels in the hierarchy [19]. The structure of the hierarchy will depends not only on the nature or type of problem at hand, but also on the knowledge, judgments, values, opinions, needs, wants, etc. of the participants in the process [10]. Hence, the hierarchical representation of a system may vary from one person to another.

B. Establishment of comparison matrices

TABLE I.
SCALE OF PREFERENCE BETWEEN TWO ELEMENTS [20]

Preference weights	Definition	Explanation
1	Equally preferred	Two activities contribute equally to the objective.
3	Moderately	Experience and judgment slightly favor one activity over another.
5	Strongly	Experience and judgment strongly or essentially favor one activity over another.
7	Very strongly	An activity is strongly favored over another and its dominance demonstrated in practice.
9	Extremely	The evidence favoring one activity over another is of the highest degree possible of affirmation.
2,4,6,8	Intermediate values	Used to represent compromise between the preferences listed above.
Reciprocals	Reciprocals for inverse comparison	

After the establishment of structural hierarchy, participants determine the priorities of all elements at each level in hierarchy. In doing this, participants construct comparison matrices. The structure of hierarchy notes that an element of a higher level takes several sub-elements, just as the overall goal takes several criteria and as criteria in a higher level follows several sub-criteria. A comparison matrix of elements in a level of the hierarchy with respect to an element of the immediately higher level is constructed to prioritize and convert individual comparative importance into ratio scale measurements. The preferences are quantified by using a nine-point scale. The meaning of each scale measurement is explained in Table I.

The number of comparison matrices depends on the number of elements at each level. Suppose that there is a comparison matrix A, which has been constructed to measure the individual comparative weight of n elements (elements from e_1 to e_n) in level k. The order of matrix A depends on the number of elements at the lower level that it links to. All of n elements in level k are sub-elements of the element E in the higher level $k-1$. Hence, matrix A is a $n \times n$ matrix, showed as follows:

$$A\ (a_{ij})_{n\times n} = \begin{pmatrix} a_{11} & a_{12} & \cdots & a_{1\mathrm{n}} \\ a_{21} & a_{22} & \cdots & a_{2\mathrm{n}} \\ \cdots & \cdots & \cdots & \cdots \\ a_{\mathrm{n}1} & a_{\mathrm{n}2} & \cdots & a_{\mathrm{nn}} \end{pmatrix} \quad (1)$$

The entry a_{ij} that lies in the i-th row and the j-th column of matrix $A(a_{ij})_{n\times n}$ represents the comparative weight of element e_i to element e_j. The value of a_{ij} satisfies following features: $a_{ij} > 0, \quad a_{ii} = 1, \quad a_{ij} = 1/a_{ji}$.

As the AHP approach is a subjective methodology [21], information and the relative weights of elements could be obtained from decision makers or experts by using direct questioning or a questionnaire.

C. Synthesis of priorities and the measurement of consistency

In this step, participants need to measure the consistency and then synthesize priorities to be an advice for decision makers. First, according to the method in step 2, pair-wise comparison is used to generate the matrix of relative rankings for each level of the hierarchy. After all the matrices were built, participants calculate the eigenvectors or the relative weights (the degree of relative importance amongst the elements), global weight vector, and the maximum eigenvalue ($\lambda_{\max}$) for each matrix. Then, participants use eigenvectors and maximum eigenvalue ($\lambda_{\max}$) to measure consistency, making sure that the pair-wise comparison matrix provides a completely consistent evaluation. Details are showed as follows:

1. Calculate the eigenvector of each comparison matrix.

We demonstrate to calculate eigenvector W of comparison matrix A here.

$$S_i = \sqrt[n]{\prod_{j=1}^{n} a_{ij}},\ i = 1, 2, \cdots, n \quad (2)$$

$$W = (W_1\ \ W_2\ \ \cdots\ \ W_n)^{\mathrm{T}} = \left(\frac{S_1}{\sum_{j=1}^{n} S_j}\ \ \frac{S_2}{\sum_{j=1}^{n} S_j}\ \ \cdots\ \ \frac{S_n}{\sum_{j=1}^{n} S_j} \right)^{\mathrm{T}} \quad (3)$$

W is the eigenvector of comparison matrix A, representing the relative weights of n elements in level k.

2. Calculate the maximum eigenvalue ($\lambda_{\max}$) for each matrix of order n by the formulae:

$$\lambda_{\max} = \frac{1}{\mathrm{n}} \sum_{i=1}^{n} \frac{(AW)_i}{W_i} \quad (4)$$

3. Compute the consistency index (CI) for each matrix of order n by the formulae:

$$\mathrm{CI} = \frac{\lambda_{\max} - n}{n-1} \quad (5)$$

4. Calculate the consistency ratio (CR) using the formulae:

$$\mathrm{CR} = \frac{\mathrm{CI}}{\mathrm{RI}} \quad (6)$$

RI is a known random consistency index obtained from a large number of simulation runs and varies depending upon the order of matrix. Table II shows the value of the random consistency index (RI) for matrices of order 1 to 10 obtained by approximating random indices using a sample size of 500 [19].

TABLE II.
AVERAGE RANDOM INDEX (RI) BASED ON MATRIX SIZE

N	1	2	3	4	5
RI	0	0	0.52	0.89	1.11
N	6	7	8	9	10
RI	1.25	1.35	1.40	1.45	1.49

The acceptable CR range varies according to the size of matrix, i.e., 0.05 for a 3 by 3 matrix, 0.08 for a 4 by 4 matrix and 0.1 for all larger matrices (Saaty, 2000; Cheng and Li, 2001). If the value of CR is acceptable, it implies that the evaluation within the matrix is acceptable or indicates a good level of consistency in the comparative judgments represented in that matrix. In contrast, if the value of CR is not acceptable, it implies that the evaluation within the matrix is not acceptable or indicates inconsistency of judgments within that matrix. Then, the evaluation process should be reviewed, reconsidered and improved until the value of CR is acceptable.

5. Calculate global weights of final alternatives

After participants calculate the priorities and check the consistency of judgments for each matrix in each level, the next step is to calculate the global weight vector of the final alternatives. The calculation of global weight was conducted by synthesizing the priorities of all matrices from the top level to the lowest level in the hierarchy.

Suppose that the second level has m elements, $A_1, A_2, \cdots, A_m$,and that their comparative importance with respect to level 1 are $a_1, a_2, \cdots, a_m$ respectively. Suppose that the third level has n elements, $B_1, B_2, \cdots, B_n$, and that their comparative importance with respect to A_i are $b_1^i, b_2^i, \cdots, b_n^i$ respectively. Accordingly, the global weight b_j of element B_i in third level was calculated by the formulae:

$$b_j = \sum_{i=1}^{m} a_i b_j^i,\ j = 1, 2, \cdots, n \tag{7}$$

$$B_w = \left(b_1\ b_2\ \cdots\ b_n\right)^T = \left(\sum_{i=1}^{m} a_i b_1^i\ \ \sum_{i=1}^{m} a_i b_2^i\ \ \cdots\ \ \sum_{i=1}^{m} a_i b_n^i\right)^T \tag{8}$$

B_w is the global weight vector of n elements in the third level. Hence, under the above procedures, the global weight vector of the final alternatives will be obtained by calculating from top level to lowest level.

IV. FAHP OVERVIEW

Analytic Hierarchy Process (AHP) has wide application in multi-criteria decisions but it has its drawbacks. Cheng and Mon (1994) noted that AHP applied upon specific (not fuzzy) decision-making and that AHP cannot include uncertainty factors of people toward objects. In real world, fuzzy phenomenon problems and vague human thoughts limit the application of AHP. Professor L.A. Zadeh in 1965 introduced fuzzy set theory, trying to solve fuzzy and vague problem. Fuzzy Analytic Hierarchy Process that combines fuzzy set theory with AHP provides an approach to solve the fuzzy phenomenon problems in real world.FAHP can also be used in evaluating various kinds of MCDM problems in both academic researches and practices. The FAHP-based decision-making method could provide the managers of B2C companies with a valuable reference for evaluating the customer value.

A. Fuzzy number

A fuzzy number is a special fuzzy set $F = \{(x,\ \mu_F(x)),\ x \in R\}$, where x takes its value on the real line $R_1 : -\infty < x < +\infty$ and $\mu_F(x)$ is a continuous mapping from R_1 to the close interval [0, 1]. A triangular fuzzy number can be denoted as $M = (l,\ m,\ u)$. Its membership function $\mu_M(x) : R \to [0,\ 1]$ is equal to:

$$\mu_M(x) = \begin{cases} \dfrac{1}{m-l}x - \dfrac{l}{m-l}, x \in [l, m] \\ \dfrac{1}{m-u}x - \dfrac{u}{m-u}, x \in [m, u]\,. \\ 0, \quad \text{otherwise} \end{cases} \tag{9}$$

In formulae (9), $l \le m \le u$, l and u stand for the lower and upper value of the support of M respectively, and m for the modal (mid) value, as shown in Fig. 1. When $l = m = u$, it is a non-fuzzy number by convention [22].

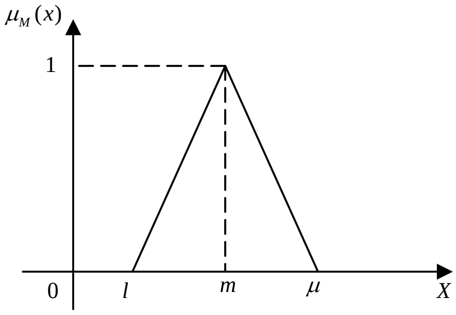

Figure 1. A triangular fuzzy number M

Assume two triangular fuzzy numbers, $M_1 = (l_1,\ m_1,\ u_1)$ and $M_2 = (l_2,\ m_2,\ u_2)$. The main operational laws for two triangular fuzzy numbers M1 and M2 are as follows [23]:

$$M_1 \oplus M_2 = (l_1 + l_2, m_1 + m_2, u_1 + u_2) \tag{10}$$

$$M_1 \otimes M_2 = (l_1 l_2, m_1 m_2, u_1 u_2) \tag{11}$$

$$\lambda M_1 = \lambda(l_1, m_1, u_1) = (\lambda l_1, \lambda m_1, \lambda u_1),\quad \lambda > 0, \lambda \in R \tag{12}$$

$$M_1^{-1} = \frac{1}{M_1} = \left(\frac{1}{u_1}, \frac{1}{m_1}, \frac{1}{l_1}\right) \tag{13}$$

The degree of possibility of $M_1 \ge M_2$ is defined as: $V(M_1 \ge M_2) = \sup_{x \ge y}(\min(\mu_{M_1}(x), \mu_{M_2}(y)))$.

Note $V(M_2 \ge M_1) = \mu(d)$, where d is the ordinate of the highest intersection point D between μ_{M_1} and μ_{M_2} (see Fig. 2), and we have that:

$$V(M_2 \ge M_1) = \begin{cases} 1, & \text{if } m_2 \ge m_1 \\ \dfrac{l_1 - u_2}{(m_2 - u_2) - (m_1 - l_1)}, & \text{if } l_1 \le u_2 \\ 0, & \text{otherwise} \end{cases} \tag{14}$$

The degree possibility for a triangular fuzzy number to be greater than k triangular fuzzy numbers $M_i\ (i = 1, 2, \cdots, k)$ can be defined by:

$$V(M \ge M_1, M_2, \cdots M_k) = V[(M \ge M_1), (M \ge M_2), \cdots (M \ge M_k)] = \min V(M \ge M_i),\quad i = 1, 2, \cdots, k. \tag{15}$$

B. Calculation steps of FAHP

First, FAHP decompose a complex decision into a hierarchy with an overall goal, criteria, sub-criteria and alternatives. FAHP calculation process can be divided into four steps after the establishment of structural hierarchy.

Step 1: Constructing original fuzzy comparison

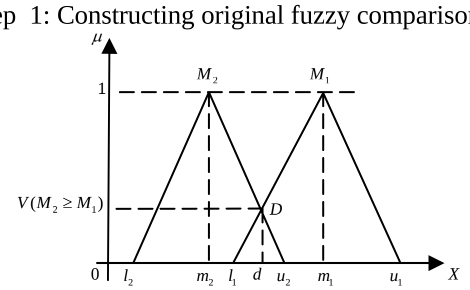

Figure 2. The intersection between M1 and M2.

matrix. Triangular fuzzy numbers are used to indicate the relative weight of each pair of elements in the same level. Through pair-wise comparison, the fuzzy judgment matrix A is constructed, where the entry a_{ij} is a triangular fuzzy number.

Step 2: Calculating synthetic weight to obtain synthetic matrix. Assume that there are n_k elements in level k which are sub-elements of an element in the immediately higher level k-1 and there are T experts take part in the evaluation on criteria. $a_{ij}^t = (l_{ij}^t, m_{ij}^t, u_{ij}^t)$, $i, j = 1, 2, \cdots, n_k$, $t = 1, 2, \cdots, T$ refers to the fuzzy number which represents the comparison weight of i-th criterion to j-th criterion in level k evaluated by t-th expert. The fuzzy number of the comparison weight evaluated by all experts for i-th criterion to j-th criterion in level k is calculated by the formulae:

$$M_{ij}^k = \frac{1}{T} \otimes (a_{ij}^1 + a_{ij}^2 + \cdots + a_{ij}^T) \tag{16}$$

Through the formulae, we could obtain a synthetic matrix of relative rankings for all elements in level k. Then, the synthetic weight of each element in level k is calculated by the formulae:

$$S_i^k = \sum_{j=1}^{n} M_{ij}^k \bullet (\sum_{i=1}^{n_k} \sum_{j=1}^{n_k} M_{ij}^k)^{-1}, i = 1, 2, \cdots, n_k \tag{17}$$

Step 3: Rating in a single level. In this step, participants begin with computing $V(S_i^k \ge S_j^k), i, j = 1, 2, \cdots, n_k, i \ne j$, the degree of possibility of $S_i^k \ge S_j^k$. Then priority for each element in level k with respect to h-th element in the immediate higher level k-1 is calculated by:

$$P_{ih}^k (A_i^k) = \min V(S_i^k \ge S_j^k), i, j = 1, 2, \cdots, n_k, i \ne j \tag{18}$$

where A_i^k refers to the i-th element in level k. Weight vector $P_h^k = (P_{1h}^k, P_{2h}^k, \cdots, P_{n_k h}^k)^T$ is obtained after normalization.

Step 4: Calculating global weights of final alternatives. Assume $h = 1, 2, \cdots, n_{k-1}$. Then P_h^k is a $n_k \times n_{k-1}$ matrix: $P_h^k = (P_{1h}^k, P_{2h}^k, \cdots, P_{n_k h}^k)^T$.

Suppose the global weight vector of level k-1 is $W^{k-1} = (W_1^{k-1}, W_2^{k-1}, \cdots, W_{n_{k-1}}^{k-1})^T$. Then the global weight vector of level k calculated by the formulae:

$$W^k = (W_1^k, W_2^k, \cdots, W_{n_k}^k)^T = P_h^k W^{k-1} \tag{19}$$

Hence, under the above procedures, the global weights of the final alternatives will be obtained by calculating from top level to lowest level.

V. CASE STUDY

In this section, we present a case to make our approach more understandable. First, we arrange an evaluation committee consisting of e-commerce experts, experienced consumers. The committee advice us to construct the following model to help in solving the evaluation of customer value in B2C company with FAHP based approach. The model is a hierarchy with four levels, shown in Figure 3.

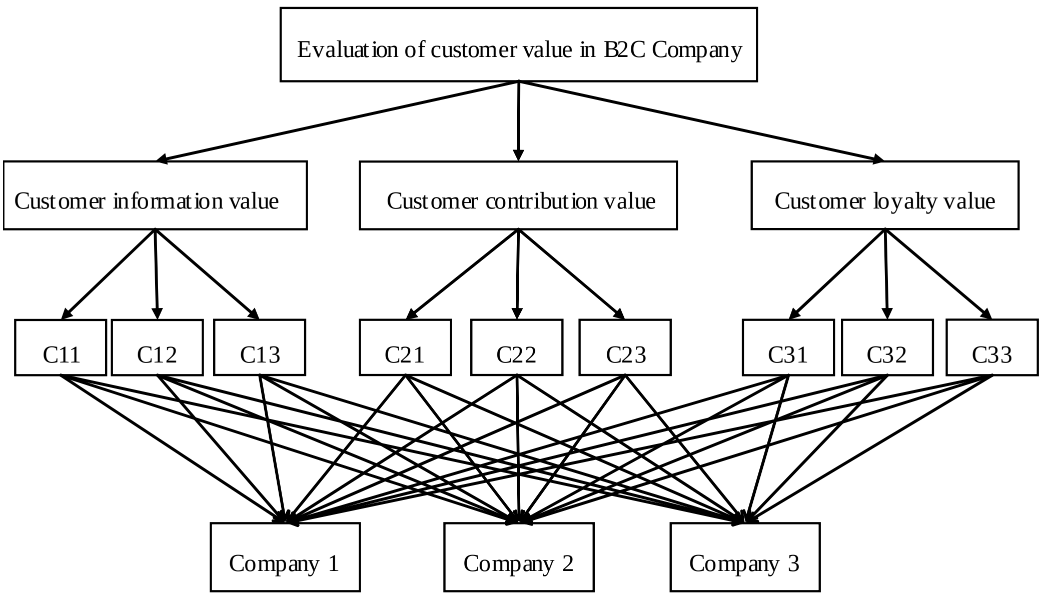

Figure 3. The hierarchy of criteria for customer value evaluation

A. Constructing hierarchy

The committee suggests us to construct a four levels hierarchy (see Fig.3) to help in solving the evaluation of customer value in B2C companies with FAHP.

Initially, the overall goal of the decision, evaluating the B2C companies which one has the largest customer value, is presented in the top level of the hierarchy. The second level consists of three major criteria that are identified to achieve the overall goal. Specifically, the three major criteria are customer information value, customer contribution value and customer loyalty value. The third level contains sub-criteria of three major criteria in second level. These sub-criteria play a role of recommendation for committee to carry out pair-wise comparison of three major criteria. The coding for the criteria and sub-criteria are given in Table III. The fourth level of the hierarchy represents the alternative B2C companies.

In order to make our approach more understandable, we assume that there are three representative B2C companies. Company 1 has relative advantages in customer information value. Company 2 has relative advantages in customer loyalty value. Company 3 has relative advantages in customer contribution value.

B. Evaluating by FAHP

We asked the committee members to make a fuzzy evaluation respectively on the all elements in the proposed hierarchy. Followed by calculation steps of FAHP, we began with the constitution of original fuzzy comparison matrices, and use the committee's judgments. Then, formulae (8) and (9) are used to calculate the synthetic weights of each original fuzzy comparison matrix to obtain synthetic comparison matrices (A, B_1, B_2, B_3) .Matrix A shown in Table IV represents the fuzzy comparison weights of the three major criteria in the second level with respect to the overall goal in the top level. Matrix (B_1, B_2, B_3), each represents the fuzzy comparison weights of three alternative B2C companies with respect to customer information value, customer contribution value and customer loyalty value, shown in Table V.

Simultaneously, we obtain the degree of possibility of $S_i^k \ge S_j^k, V(S_i^k \ge S_j^k), i, j = 1,2,\ldots,n_k, i \ne j$, in all synthetic comparison matrices. Then the weight vector of each matrix can be attained by formulae (10). After normalization, the relative weights vector of each matrix is also shown in Table IV and Table 5. After all relative weights vectors have been computed, we use formulae (11) to calculate the relative global weights of the three B2C companies.

$$W^{FAHP} = \left(W_{B1}^{FAHP}, W_{B2}^{FAHP}, W_{B3}^{FAHP}\right) W_A^{FAHP} = (0.335, 0.390, 0.275)^T$$

The result shows that company 2 has greatest customer value, followed by company 1 and company 3.

TABLE IV.
SYNTHETIC COMPARISON MATRIX AND RELATIVE WEIGHT VECTOR WAFAHP

Synthetic comparison matrix A of three major criteria with respect to the overall goal:			
Overall goal	C1	C2	C3
C1	(1, 1,1)	(1,3/2,2)	(4/3,2,8/3)
C2	(1/2,2/3,1)	(1,1,1)	(3/4,1,5/4)
C3	(3/8,1/2,3/4)	(4/5,1,4/3)	(1,1,1)
Relative weights vector (W_A^{FAHP}) = $(0.588,0.238,0.204)^T$			

TABLE III. THE INDEXES SYSTEMS OF CUSTOMER VALUE IN B2C COMPANIES

Criteria	Sub-critria
Customer information value (C1)	basic information (C11)
	Communication information (C12)
	Information resources integration goal (C13)
Customer contribution value((C2)	Yearly profit devotion (C21)
	Transaction value(C22)
	Recommendation value(C23)
Customer loyalty value (C3)	Desire to retain(C31)
	Trust degree(C32)
	Participate in marketing activities(C33)

TABLE V. SYNTHETIC COMPARISON MATRICES AND RELATIVE WEIGHT VECTOR WBIFAHP

Synthetic comparison matrix B1 of vendors with respect to Customer information value			
B1	Company1	Company2	Company3
Company1	(1,1,1)	(4/5,3/2,4/7)	(1,2,5/2)
Company2	(4/7,2/3,5/4)	(1,1,1)	(1,2,3)
Company3	(2/5,1/2,1)	(1/3,1/2,1)	(1,1,1)
Relative weights vector (W_{B1}^{FAHP}) = $(0.429,0.371,0.200)^T$			
Synthetic comparison matrix B2 of vendors with respect to Customer contribution value			
B2	Company1	Company2	Company3
Company1	(1,1,1)	(6/7,1,6/5)	(1/2,2/3,3/4)
Company2	(5/6,1,7/6)	(1,1,1)	(3/2,2,8/3)
Company3	(4/3,3/2,2)	(3/8,1/2,2/3)	(1,1,1)
Relative weights vector (W_{B2}^{FAHP}) = (0.224,0.198,0.578)T			
Synthetic comparison matrix B3 of vendors with respect to Customer loyalty value			
B3	Company1	Company2	Company3
Company1	(1,1,1)	(2/7,1/3,1/2)	(3/4,1,5/4)
Company2	(2,3,7/2)	(1,1,1)	(1/3,1/2,2/3)
Company3	(4/5,1,4/3)	(3/2,2,3)	(1,1,1)
Relative weights vector (W_{B3}^{FAHP}) = $(0.149,0.609,0.242)^T$			

VI. CONCLUSION

This paper proposes a model to evaluate customer value of B2C electronic commerce companies, using analytical hierarchy process based approach, Fuzzy AHP. A case study is presented to demonstrate how the model can help in solving such problems. The results show that FAHP have the capability to be flexible and apply to evaluate customer value. The final relative weight at the last level of the hierarchy will lead to a recommended best option. It can be concluded that the approach we proposed could facilitate decision making.

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