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E-Commerce Assessment in Fuzzy Situation

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1. Introduction

Customer satisfaction degree is critical for e-commerce enterprises. Thus, more and more commercial organizations attend to "customer satisfaction " as their main strategy (Mihelis et al., 2001).

Customer satisfaction means the satisfaction degrees of customers purchasing commodities. Under electronic commerce, how to raise the consumers' degree of satisfaction and gain the consumers' loyalty has become the key factor relating with whether ecommerce enterprise can survive. The view of the philosophy of modern management scientific holds that, "customer satisfaction is the basic criteria of enterprise". Nowadays, more and more commercial organizations take customer satisfaction as their main strategy object (Mihelis et al., 2001).

Customer satisfaction and customer satisfaction index have been widely developed in both theory and applications (C. Albert, 2002, E.W. Anderson & C. Fornell, 2000, P. Hackl et al., 2000, D.J. Michael, 2004). Fornell (C. Fornell, 1992) developed the first model of customer satisfaction in 1992. The American customer satisfaction index (ASCI) was set up in 1994 (Yin Rongwu, 2000), Swedish SCSI, European ECSI and Korean KCSI etc. Chinese Customer satisfaction Index (CCSI) started in 1998, are still on the stage of exploration and learning (Zhao Pengxiang, 2001).

Customer satisfaction has been used frequently in the quality system certification of ISO9000 of 2000 edition, which shows the important of this concept (Xiaohong Liu et al., 2008). Also, Many countries are conducting Customer Satisfaction Index studies since Customer Satisfaction Index can be used as a predicator for profitability and value of the organizations (S.-H. Hsu, 2008).

Nowadays, more attention has been paid to the problem of e-commerce customer satisfaction (M. Wang, 2003). The e-commerce customer satisfaction parameters should be visible for customers. The more important parameters have been chosen based on the literature review: independency, comparable, and feasibility (Mihelis et al., 2001, Yan Xiao-Tian & Wei Hong-Jun, 2005, Yin Rongwu, 2000, Zheng Yue-Fang, 2005, Liu, 2007).

Each index should independently represent the service quality satisfaction from some aspect (Fasanghari & Roudsari, 2008). While customers represent their satisfaction value of e-commerce, the indexes should be comparable for different customer. Thus, the indexes of e-commerce customer satisfaction have been obtained based on literature review so that support all of the customer satisfaction area for e-commerce.

To evaluate the e-commerce customer satisfaction quantitatively, many countries established their own index of customer satisfaction degree, namely customer satisfactory Index, which is a new set of indexes evaluating an enterprise and a trade or an industry completely from customer's angle (Liu Peide, 2007).

The e-commerce customer satisfaction should pay attention to the parameters which are visible for customers. The more important parameters have been chosen based on the literature review: independency, comparable, and feasibility (Mihelis et al., 2001, Yan Xiao-Tian & Wei Hong-Jun, 2005, Yin Rongwu, 2000, Zheng Yue-Fang, 2005).

Customer evaluation for e-commerce would be possible if the independency among the indexes exist. The selection of indexes, therefore, should be high enough in resolution to help distinguish the factors. Each index should independently represent the service quality satisfaction from some aspect.

To clarify, indexes should be comparable, as the model should evaluate the different customer inputs, which express the satisfaction value for e-commerce; consequently, the indexes should be comparable for different customer while they represent their satisfaction value of e-commerce.

At last, identification and reduction of customer satisfaction are the objective of e-commerce customer satisfaction. The title and content of each index, hence, should be well understood by the customers.

In this paper, in the next section, fuzzy set theory and the principals of triangular fuzzy number have been presented. Then, the model for e-commerce customer satisfaction has been illustrated. A case study has been done, as validation of presented method; finally, conclusion has been presented.

2. Fuzzy Set Theory

Fuzzy set theory provides a framework for handling the uncertainties. Zadeh initiated the fuzzy set theory (Zadeh L. A., 1965). Bellman presented some applications of fuzzy theories to the various decision-making processes in a fuzzy environment (Bellman R. E. & Zadeh L. A., 1970). In non-fuzzy set every object is either a member of the set or it is not a member of the set but in fuzzy sets every object is to some extent member of a set and to some extent it is member of another set. Thus, unlike the crisp sets membership is a continuous concept in fuzzy sets. Fuzzy is used in support of linguistic variables and there is uncertainness in the problem. Fuzzy theory is widely applicable in information gathering, modeling, analysis, optimization, control, decision making, and supervision.

Special cases of fuzzy numbers include crisp real number and intervals of real numbers. Although there are many shapes of fuzzy numbers, the triangular and trapezoidal shapes are used most often for representing fuzzy numbers. The following describes and definitions show that membership function of triangular fuzzy number, trapezoidal fuzzy number, and its operations.

A fuzzy number $\tilde{A}$ is convex, if

$$\mu_{\tilde{A}}[\lambda x_1 + (1-\lambda)x_2] \geq \min[\mu_{\tilde{A}}(x_1), \mu_{\tilde{A}}(x_2)]. \qquad x_1, x_2 \in X, \quad \lambda \in [0,1] \qquad (1)$$

Alternatively, a fuzzy set is convex if all α-level sets are convex.

A fuzzy set Ã in the universe of discourse X is normal if (A. Kaufmann & M.M. Gupta, 1988, S. Mabuchi, 1988)

$$\sup_x \mu_{\tilde{A}}(x) = 1 \tag{2}$$

A nonempty fuzzy set Ã can always be normalized by $\mu_{\tilde{A}}(x) / \sup_x \mu_{\tilde{A}}(x)$.

A triangular fuzzy number can be defined by $\tilde{A} = (a_1, a_2, a_3)$, where $a_1 \le a_2 \le a_3$, its member function represented as follows.

$$\mu_{\tilde{A}} = \begin{cases} 0 & x < a_1 \\ (x - a_1) \big/ (a_2 - a_1) & a_1 \le x \le a_2 \\ (x - a_3) \big/ (a_3 - a_2) & a_2 \le x \le a_3 \\ 0 & x > a_3 \end{cases} \tag{3}$$

Let $\tilde{A}$ and $\tilde{B}$ be two fuzzy numbers parameterized by the (a_1, a_2, a_3) and (b_1, b_2, b_3), respectively. Then the operations of triangular fuzzy numbers are expressed as (S.J. Chen & C.L. Hwang, 1992a):

$$\begin{aligned} \tilde{A}(+)\tilde{B} &= (a_1, a_2, a_3) + (b_1, b_2, b_3) = (a_1 + b_1, a_2 + b_2, a_3 + b_3) \\ \tilde{A}(-)\tilde{B} &= (a_1, a_2, a_3) - (b_1, b_2, b_3) = (a_1 - b_1, a_2 - b_2, a_3 - b_3) \\ \tilde{A}(\times)\tilde{B} &= (a_1, a_2, a_3) \times (b_1, b_2, b_3) = (a_1 \times b_1, a_2 \times b_2, a_3 \times b_3) \\ \tilde{A}(\div)\tilde{B} &= (a_1, a_2, a_3) \div (b_1, b_2, b_3) = (a_1 \div b_3, a_2 \div b_2, a_3 \div b_1) \end{aligned} \tag{4}$$

Triangular fuzzy numbers are appropriate for quantifying the vague information about most decision problems (C.H. Cheng & Y. Lin, 2002), and the primary reason for using triangular fuzzy numbers can be stated as their intuitive and computational-efficient representation.

In this paper, the triangular fuzzy number is used for measuring customer satisfaction. More details about arithmetic operations laws of trapezoidal fuzzy number can be seen in (Lee et al., 2004).

Considering experts E_i provide the satisfaction degree with $\tilde{A}^{(i)}$. The evaluation values given by each expert (E_i) are presented in the form of a triangular fuzzy number:

$$\tilde{A}^{(i)} = (a_1^{(i)}, a_2^{(i)}, a_3^{(i)}), where \quad i = 1, 2, ..., n \tag{5}$$

The average $\tilde{A}_m$ of all $\tilde{A}^{(i)}$ is computed using average means

$$\tilde{A}_m = (a_{m1}, a_{m2}, a_{m3}) = (\frac{1}{n}\sum_{i=1}^{n} a_1^{(i)}, \frac{1}{n}\sum_{i=1}^{n} a_2^{(i)}, \frac{1}{n}\sum_{i=1}^{n} a_3^{(i)}) \tag{6}$$

For defuzzification of $\tilde{A}_m$, the following formula can be used:

$$A_m = \frac{a_{m1} + 2a_{m2} + a_{m3}}{4} \tag{7}$$

3. The Model for E-Commerce Customer Satisfaction Evaluation

3.1 Determination of Indexes

Some of the researches constructed evaluation index from commercial content, customer's concern, effective navigation, website design, safety, convenience, merchandise planning, contact convenience, customer service information, convenience of getting product information, accuracy, content relatedness, integrity, variety in displaying, information timely updating, easy application, system rapidity, service response in time, and guaranteed service (Duo Qi, 2003, Liu Peide, 2007, Yu Hongyan, 2006, Gao Dan, 2004, Gan Yong, 2006).

Based on literature, this paper constructs customer satisfaction index of BtoC e-commerce enterprise, and evaluates customer satisfaction of BtoC e-commerce enterprise by adopting Fuzzy Triangular Numbers for Linguistic Variables and using fuzzy TOPSIS method Table1.

Object	Indicator	Description
Product	Customization (Pr1)	The degree of customer needs satisfying
	Value (Pr 2)	The unique product characteristics
	Information (P r3)	Accessibility to the information of the products
	Scope (Pr 4)	The dimensions which the product satisfy them
	Accuracy of quality (Pr 5)	The quality parameters satisfaction
	Guaranty (Pr 6)	The confidence of the product quality
Service	Attitude (S1)	How services are received
	Information (S2)	Accessibility to the information of the services
	Distribution (S3)	The method and tools of service delivery
	Response and feedback (S4)	The quality of feedback of services
	Call center (S5)	Availability of a call center for customer care
	Quality (S6)	The quality parameters satisfaction
	Management (S7)	Determination of service process and control indexes
Network system	Safety (N1)	Security degree of networks
	Reliability (N2)	The amounts of risk
	Operability (N3)	The network support of the customer needs
	Accessibility (N4)	The availability of network in 24*7
	Humanization (N5)	Consideration of human computer interaction
payment	Accuracy of fee calculation (Pa1)	The trust in financial computation
	Accuracy of fee collection (Pa2)	The trust to the system of fee collection
	Method (Pa3)	The technical methods relating to the payment
	Facilities (Pa4)	The quality and suitability of facilities used for payment

Table 1. Indexes of e-commerce customer satisfaction evaluation

3.2 Determination the Weight of Indexes

TOPSIS (Technique for Order Preference by Similarity to an Ideal Solution) method is presented in Chen and Hwang (S.J. Chen & C.L. Hwang, 1992b), with reference to Hwang and Yoon (C.L. Hwang & K. Yoon, 1981). TOPSIS is a multiple criteria method to identify solutions from a finite set of alternatives. The basic principle is that the chosen alternative should have the shortest distance from the positive ideal solution and the farthest distance

from the negative ideal solution. The procedure of fuzzy TOPSIS can be expressed in a series of steps:

E-commerce customer satisfaction is a typical Multi Criteria Decision Making (MCDM) problem. An MCDM problem can be formulated as follows:

$$X_k = \begin{array}{c} \\ A_1 \\ \vdots \\ A_i \\ \vdots \\ A_m \end{array} \begin{array}{c} C_1 \quad ... \quad C_j \quad ... \quad C_n \\ \left[\begin{array}{cccc} x_{11k} & x_{1jk} & & x_{1nk} \\ \vdots & \vdots & \vdots & \vdots \\ x_{i1k} & ... & x_{ijk} & ... & x_{ink} \\ \vdots & \vdots & \vdots & \vdots \\ x_{m1k} & ... & x_{mjk} & ... & x_{mnk} \end{array} \right] \end{array} \tag{8}$$

$$W_k = \begin{bmatrix} w_{1k} \\ \vdots \\ w_{jk} \\ \vdots \\ w_{nk} \end{bmatrix} \tag{9}$$

where $K = 1,...,p$ decision makers select an alternative out of $i = 1,...,m$ alternatives (A_i) according to $j = 1,...,n$ criteria (C_j).

x_{ijk} is the performance of alternative A_i with respect to criterion C_j estimated by decision maker k, while W_{jk} is the weight of criterion C_j given by the decision maker k. X_k and W_k are respectively the decision matrix and the weight vector for the decision maker k.

In the fuzzy TOPSIS procedure, the criteria weights ($\tilde{w}_j, j = 1,2,...$ triangular fuzzy number of criteria) and characteristic values of alternatives at criteria ($\tilde{x}_{ij}$, $i = 1,2,...$ number of alternatives, $j = 1,2,...$ number of criteria) are inputs and placed in matrix form (P. Sen & J-B. Yang, 1998, C.-T. Chen, 2000, Fasanghari et al., 2008) as shown in step 1.

Step 1: Inputs are expressed in matrix format as;

$$\begin{bmatrix} \tilde{x}_{11} & \tilde{x}_{12} & ... & \tilde{x}_{1n} \\ \tilde{x}_{21} & \tilde{x}_{22} & ... & \tilde{x}_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ \tilde{x}_{m1} & \tilde{x}_{m2} & ... & \tilde{x}_{mn} \end{bmatrix} \tag{10}$$

$$\tilde{W} = \begin{bmatrix} \tilde{w}_1, \tilde{w}_2, ..., \tilde{w}_n \end{bmatrix} \tag{11}$$

$\tilde{w}_j$ are triangular fuzzy numbers as $\tilde{w}_j = (w_{j1}, w_{j2}, w_{j3})$.

Step 2: the normalized decision matrix is constructed using equation (12) (H.S. Byun & K.H. Lee, 2004, P. Sen & J-B. Yang, 1998).

$$\tilde{n}_{ij} = \frac{\tilde{x}_{ij}}{\sqrt{\sum_{i=1}^{n} \tilde{x}_{ij}^2}} \tag{12}$$

Step 3: The weighted normalized decision matrix is,

$$\tilde{V} = \left[\tilde{v}_{ij}\right]_{m \times n}, i = 1,2,...,m, j = 1,2,...,n. \tag{13}$$

where,

$$\tilde{v}_{ij} = \tilde{n}_{ij} \otimes \tilde{w}_j \tag{14}$$

Set 4: each fuzzy number is defuzzified using equation(15). For triangular fuzzy number $\tilde{v}_{ij} = (a_{ij}, b_{ij}, c_{ij})$ its defuzzification value is defined to be

$$v_{ij} = \frac{a_{ij} + 2b_{ij} + c_{ij}}{4} \tag{15}$$

And defuzzified weighted normalized matrix determined as $V = \left[v_{ij}\right]_{m \times n}$, $i = 1,2,...,m$, $j = 1,2,...,n$.

Step 5: The ideal solution, $A^+(A_i^+; i = 1,2,...,N)$, is made of all the best performance scores and the negative-ideal solution, $A^-(A_i^-; i = 1,2,...,N)$, is made of all the worst performance scores at the measures in the defuzzified weighted normalized decision matrix. They ate calculated using equations (16) and (17). In these equations, the measures can be divided into two classes: the first is of an input or cost nature, so that smaller performance scores at these measure are preferred; the second is of an output or benefit nature and larger performance scores at these measures are preferred (H.S. Byun & K.H. Lee, 2004, P. Sen & J-B. Yang, 1998).

$$A^+ = \left\{v_1^+, v_2^+,...,v_n^+\right\} = \left\{(\max_j v_{ij} \mid j \in I),(\min_j v_{ij} \mid j \in J)\right\}, \tag{16}$$

$$A^- = \left\{v_1^-, v_2^-,...,v_n^-\right\} = \left\{(\min_j v_{ij} \mid j \in J),(\max_j v_{ij} \mid j \in I)\right\}. \tag{17}$$

Step 6: The distance of an alternative j to the ideal solution (d_i^+), and from the negative ideal solution (d_i^-) are calculated using equation (18) and (19) (H.S. Byun & K.H. Lee, 2004, P. Sen & J-B. Yang, 1998).

$$d_i^+ = \sqrt{\sum_{j=1}^{m}(v_{ij} - v_j^+)^2} \quad i = 1,2,...,n; j = 1,2,...,m, \tag{18}$$

$$d_i^- = \sqrt{\sum_{j=1}^{m}(v_{ij} - v_j^-)^2} \quad i = 1,2,...,n; j = 1,2,...,m \tag{19}$$

Step 7: The ranking score (R_i) is calculated using equation (20) (H.S. Byun & K.H. Lee, 2004, P. Sen & J-B. Yang, 1998).

$$R_i = \frac{d_i^-}{d_i^- + d_i^+}, \qquad i = 1,2,..,m. \tag{20}$$

The object of fuzzy TOPSIS method is to choose the alternatives that have the shortest distance from the positive ideal solution and the farthest distance from the negative ideal solution. Even though TOPSIS introduce two reference point, it does not consider the relative importance of the distance from the points (G.R. Jahanshahloo et al., 2006).

4. Case study

In order to assess the proposed methodology, we select 5 e-commerce websites as our alternatives and 10 customers which procure their needful. Experts fill in the questionnaire with fuzzy triangular numbers. Table 1 presents the index of the e-commerce assessment; we use these indexes for the selected websites assessment. As the first step, equation (10) is formed as Table 2. The weights of the indexes are equal in view point of the experts. Steps 2, 3, 4 and 5 are done and the defuzzified weighted normalized decision matrix, A^+, and A^- is computed. In step 6, the $d_1^+, d_2^+, d_3^+, d_4^+, d_5^+, d_1^-, d_2^-, d_3^-, d_4^-,$ and d_5^- are calculated respectively: 3.6675, 3.8247, 2.9372, 4.9262, 5.3357, 6.3497, 7.4314, 6.7605, 5.3349, and 4.2002. The final results of fuzzy TOPSIS method is obtained as $R_1 = 0.6339$, $R_2 = 0.6602$, $R_3 = 0.6971$, $R_4 = 0.5199$, and $R_5 = 0.4405$. Obviously, the third website (alternative number 3) is in first row of the website ranking and has the highest score in ranking. Unlike, the fifth website (alternative number 5) has the lowest score in ranking method of fuzzy TOPSIS.

5. Conclusions

The main contribution of this paper is proposing a ranking method for assessing the e-commerce under uncertain situations. In fact, combination of fuzzy triangular rubbers, TOPSIS method, and e-commerce indexes is proposed in this paper. Hence we can assess the customer satisfaction of e-commerce, and we run a case study in which the 5 e-commerce websites are assessed with 10 experts of e-commerce who are familiar with the selected websites. Fortunately, all of the experts are pleased of the obtained results.

Index	Fuzzy number	A1	A2	A3	A4	A5
Pr1	a1	8.06	0.98	6.13	3.72	5.55
	a2	9.54	7.95	8.67	4.70	9.27
	a3	9.87	9.29	8.92	7.51	9.67
Pr2	a1	1.45	1.98	9.62	0.69	7.20
	a2	4.39	6.06	9.65	8.26	8.18
	a3	8.11	9.99	9.84	8.77	9.67
Pr3	a1	7.52	6.49	1.62	4.89	1.68
	a2	9.18	9.45	9.44	8.36	2.38
	a3	9.78	9.79	9.57	8.80	7.35
Pr4	a1	1.37	1.00	8.52	4.97	3.41
	a2	5.92	4.30	9.08	9.73	6.58
	a3	8.89	8.67	9.59	9.98	8.60
Pr5	a1	5.70	3.65	8.27	8.78	6.27
	a2	6.95	4.92	9.05	9.42	9.47
	a3	7.10	9.95	9.75	9.48	9.74
Pr6	a1	5.29	8.33	9.67	1.23	5.28
	a2	7.95	9.72	9.80	3.95	6.60
	a3	9.87	9.77	9.95	5.14	9.25
S1	a1	7.99	6.15	6.14	5.82	4.61
	a2	8.51	6.28	7.95	6.68	9.06
	a3	9.66	7.32	9.47	6.88	9.29
S2	a1	5.01	0.80	6.35	1.58	0.33
	a2	8.75	2.14	7.78	7.92	4.56
	a3	8.98	3.69	8.50	9.48	9.21

Index	Fuzzy number	A1	A2	A3	A4	A5
S3	a1	5.12	2.40	0.73	3.03	0.29
	a2	8.44	8.23	6.27	8.12	0.68
	a3	9.26	9.31	8.61	8.72	6.04
S4	a1	0.69	0.98	1.44	5.17	5.19
	a2	1.68	9.97	4.21	9.95	7.19
	a3	4.09	9.97	4.69	9.98	7.84
S5	a1	6.51	3.16	4.08	9.59	9.57
	a2	9.16	5.15	5.09	9.70	9.98
	a3	9.66	6.37	7.01	9.84	9.98
S6	a1	5.96	1.92	2.27	9.30	2.66
	a2	6.43	9.50	9.45	9.56	7.81
	a3	8.67	9.72	9.51	9.63	9.94
S7	a1	8.96	9.35	6.78	1.12	2.40
	a2	9.79	9.75	7.24	3.49	7.54
	a3	9.87	9.99	9.37	5.09	8.17
N1	a1	7.22	9.96	0.89	4.85	0.36
	a2	9.80	10.00	8.21	5.92	2.19
	a3	9.85	10.00	9.62	6.57	6.68
N2	a1	7.04	7.43	7.64	2.24	8.18
	a2	9.78	9.47	8.35	6.88	9.01
	a3	9.87	9.51	9.26	8.36	9.73
N3	a1	5.82	4.63	5.96	9.24	9.42
	a2	9.44	6.75	7.54	9.36	9.72
	a3	9.50	6.87	8.14	9.94	9.75

Index	Fuzzy number	A1	A2	A3	A4	A5
N4	a1	6.82	7.52	2.64	4.67	2.41
	a2	9.50	8.15	9.32	7.89	3.71
	a3	9.90	9.19	9.64	9.44	5.51
N5	a1	1.80	4.53	5.77	3.42	7.64
	a2	3.99	5.56	7.98	5.41	8.82
	a3	6.14	5.66	8.85	7.45	9.47
Pa1	a1	0.78	5.83	3.34	4.50	4.42
	a2	1.97	9.10	7.54	9.74	5.44
	a3	8.39	9.97	8.25	9.82	7.41
Pa2	a1	6.32	7.56	3.40	1.85	1.73
	a2	7.06	9.29	8.57	6.90	1.81
	a3	7.72	9.97	9.76	8.51	7.14
Pa3	a1	9.47	9.04	5.06	8.04	6.39
	a2	9.70	9.10	8.36	9.39	7.73
	a3	9.94	9.25	8.75	9.67	8.76
Pa4	a1	7.48	8.38	7.18	0.72	4.36
	a2	7.80	9.97	8.74	4.58	8.74
	a3	8.39	9.97	9.77	4.90	9.14

Table 2. E-commerce customer satisfaction value for the 5 selected e-commerce website

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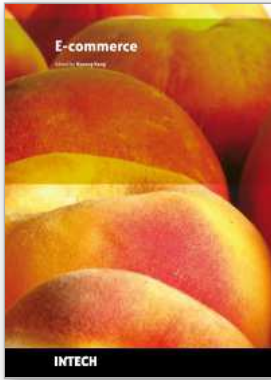
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E-commerce provides immense capability for connectivity through buying and selling activities all over the world. During the last two decades new concepts of business have evolved due to popularity of the Internet, providing new business opportunities for commercial organisations and they are being further influenced by user activities of newer applications of the Internet. Business transactions are made possible through a combination of secure data processing, networking technologies and interactivity functions. Business models are also subjected to continuous external forces of technological evolution, innovative solutions derived through competition, creation of legal boundaries through legislation and social change. The main purpose of this book is to provide the reader with a familiarity of the web based e- commerce environment and position them to deal confidently with a competitive global business environment. The book contains a numbers of case studies providing the reader with different perspectives in interface design, technology usage, quality measurement and performance aspects of developing web-based e-commerce.

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