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The Fuzzy Evaluation of E-Commerce Customer Satisfaction

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Abstract: Effective customer satisfaction investigation is a very important precondition for e-commerce area to win in the market competition. It is the problems need to be solved for e-commerce customer satisfaction and how to use advanced methods to evaluate the customer satisfaction and how to use the evaluation result to improve their services. This paper establishes a customer satisfaction evaluation method based on combination of linguistic variables, fuzzy triangular numbers, fuzzy entropy, and also do some example research. The results of demonstrated example show that the designed evaluation method creates suitable results and the evaluation could be done as well as possible.

Key words: linguistic Variable · Fuzzy Triangular Numbers · Fuzzy Entropy

INTRODUCTION

E-commerce enterprises have understood raising the customer satisfaction degree in the key factor which can survive them. Thus, customer satisfaction is the most important criteria of an enterprise. Nowadays, more and more commercial organizations take "customer satisfaction "as their main strategy object [1].

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 a enterprise, a trade or an industry completely from customer's angle [2]. Among them having much influence are American ACSI [3], 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 [4].

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 [1-3,5,6].

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, while they 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.

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 have been done, as validation of our method, finally, conclusion have been presented.

Fuzzy set theory: Fuzzy set theory provides a framework for handling the uncertainties. Zadeh initiated the fuzzy set theory [7]. Bellman presented some applications of fuzzy theories to the various decision-making processes in a fuzzy environment [8]. 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

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fuzzy numbers. The following describes and definitions show that membership function of triangular and trapezoidal fuzzy number and its operations.

A fuzzy number Ã is convex, if

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

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 [9, 10]

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

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

A fuzzy number is a fuzzy subset in the universe of discourse *X* that is both convex and normal.

One of the most important concepts of fuzzy sets is the concept of an α-cut and its variant. It is a bridge from well-defined structure to fuzzy environment.

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

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

Let Ã and be two fuzzy numbers parameterized by the quadruplet (a_1,a_2,a_3) and (b_1,b_2,b_3), respectively. Then the operations of triangular fuzzy numbers are expressed as [11]:

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

Triangular fuzzy numbers are appropriate for quantifying the vague information about most decision problems [12]. 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 Intellectual Capitals. More details about arithmetic operations laws of trapezoidal fuzzy number can be seen in [13].

Considering experts E_i provide the possible realization rating of a certain Intellectual Capital. The evaluation value 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

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

The Model for E-commerce Customer Satisfaction Evaluation: The indexes of customer satisfaction have been constructed based on based on consumer's concern, website design, safety of website financial interaction, customer service information, information accuracy, integrity, system rapidity, service respond in time, guarantee service, performance of system, reliability and product strategy [2, 14-18].

All of the indexes in figure 1 have been obtained through literature review and the opinion of the Iranian experts in e-commerce area (especially in B2C e-commerce). As this indexes area especially for direct consumer of e-commerce, this evaluation could be useful for all of the business to consumer (B2C) e-commerce. Some researchers have been used fuzzy methods for their evaluation methods [2,14,15], but in this paper, we construct customer satisfaction index of B2C e-commerce enterprise, which is illustrated in figure 1 and evaluates customer satisfaction of B2C e-commerce enterprise by adopting Linguistic Variables and Fuzzy Triangular Numbers. In addition, we will evaluate it by a fuzzy entropy method.

Evaluation system have been designed to conform to the systemic principles, scientific and advanced principles, hierarchy principles, Maneuverability principles and Comparability principles [17,19].

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The entropy method is objective, for the weight of an index is larger when the value of the same index on different objects varies greatly [20,22]. It is because such

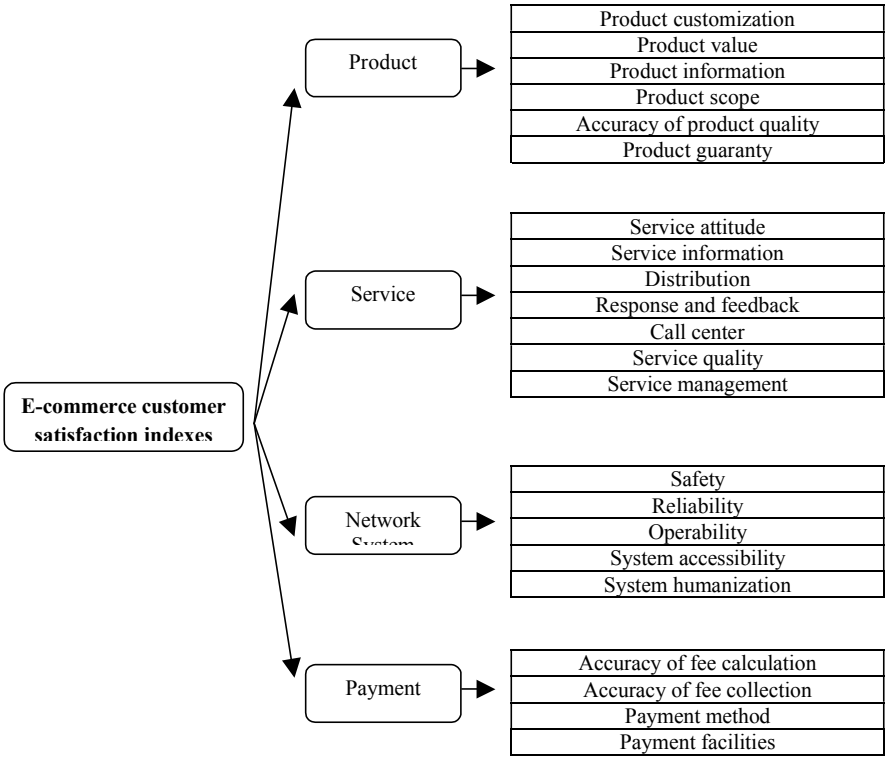

Fig. 1: indexes of e-commerce customer satisfaction evaluation

index is high in resolution and thus reflects more information, which means it is more helpful in distinguishing the objects. The steps of fuzzy entropy method are:

1) Same trending: When reversal indexes and ordinal indexes coexist, the reversal indexes should be transformed into ordinal indexes.

2) Convert the actual index value into evaluation value

$$x_{ij} = (x_{ij}^1, x_{ij}^2, x_{ij}^3) \tag{7}$$

$$b_{ij}^k = \frac{x_{ij}^k}{\sum_{i=1}^{n} x_{ij}^k} \qquad ,k = 1,2,3 \tag{8}$$

where x_{ij}^k denotes the value of index j on object i for the k^{th} value of triangular fuzzy number since each customer presents his opinion in triangular fuzzy numbers. n is the total number of objects and $i = 1,2,...,n$. p is the total number of indexes and $j = 1,2,..., p$.

3) The entropy of index i is

$$e_i^k = -\frac{1}{\ln n} \sum_{\substack{i=1 \\ e_{j\geq 0}}}^{n} b_{ij}^k \ln b_{ij}^k \qquad ,k = 1,2,3 \tag{9}$$

4) The index weight vector

is $w = (w_1, w_2, ..., w_p)$ which $w_j = (w_j^1, w_j^2, w_j^3)$

$$w_j^k = \frac{1-i}{\sum_{i=1}^{p}(1-e_j)} \qquad ,k = 1,2,3 \tag{10}$$

5) The final value for w_j can be obtain by defuzzification of w_j, which is illustrated in equation 11.

$$w_j = \frac{w_j^1 + 2w_j^2 + w_j^3}{4} \tag{11}$$

The gap between customer satisfaction and expectation consisted of the calculation steps as below.

1- Collect customer evaluation and expectation of each index of electricity supply service quality. Suppose

the set of customers is $p=\{p_1,p_2,...,p_n\}$ and the evaluation and expectation of index u_j, is z_{kj} and h_{kj}, respectively, according to customer k. Therefore, the evaluation and expectation of index u_j, is $z_j=\sqrt[l]{\prod_{k=1}^{l} z_{kj}}$ and $h_j=\sqrt[l]{\prod_{k=1}^{l} h_{kj}}$, respectively, according to all customers.

2- Derive the customer satisfaction of service quality

$$z_{wx}=\sum_{j=1}^{p} z_j w_j \tag{12}$$

3- Calculate the gap between customer satisfaction and expectation of electricity supply service quality

$$SQ_x=\sum_{j=1}^{p}(z_j-e_j)w_j \tag{13}$$

Case study: According to the gathered indexes in Error! Reference source not found., a questionnaire has been prepared and five customers, who do their purchases through e-commerce, fill in the questionnaire in both their satisfaction degree and expected degree. Satisfaction of e-commerce customer satisfaction and the gap between satisfaction and expectation can be derived in table 1. From the calculation below (table 1), the general satisfaction evaluation value is low and further efforts should be done to promote the service quality. In all the aspects involved, prosecute disposal, where the expectation and satisfaction yield the largest gap, is seriously in need of improvement, while payment brings obviously higher satisfaction with a small gap. Furthermore, the model in this paper derives general service quality for e-commerce suppliers and the gap between customer expectation and service performance for different service category (table 1). Such function helps the company find those indexes where the gap exists and the size of gap as well, which points the breakthrough for service quality improvement. For e-commerce suppliers, different kinds of customers, e.g. industrial, commercial and residual call for different weight distributions. The model is also suitable for various kinds of customer satisfaction evaluation and thus helps the supplier promoting the service quality satisfaction, by providing services for each kind of customers accordingly.

Table 1: Calculation of e-commerce customer satisfaction value and the gap between satisfaction and expectation

Objective	Objective weight	Index	Index weight	Expected value	Actual value	Customer satisfaction	Gap
Product	(2.1,3.2,4.1)	Product customization	(2.3,5.2,6.4)	(6,7,8)	(4,5.2,6.7)	5.3	2.3
		Product value	(3,3.8,4.7)	(5,6.2,6.9)	(5,5.8,7.2)		
		Product information	(2.1,3.6,3.9)	(7,8.2,9)	(3.4,5.2,7)		
		Product scope	(2.5,2.6,2.9)	(4,4.5,5.3)	(2,3.4,5.7)		
		Accuracy of product quality	(6.6,7.8,8.2)	(7.8,8.8,9.2)	(6,7.2,8.4)		
		Product guaranty	(5.6,5.7,6.8)	(5.8,7.5,8.9)	(4,6.2,7.2)		
Service	(3.1,3.5,4.3)	Service attitude	(3,5,4.6,5.4)	(5.6,6.4,6.9)	(2,3,3.5)	6.1	1.7
		Service information	(4.6,5.6,7)	(6.2,7.6,8.8)	(4,4.2,4.8)		
		Distribution	(3,4,6)	(7.5,8.8,9.7)	(2.2,3.1,3.6)		
		Response and feedback	(1.2,2.1,2.5)	(5.6,7.2,7.3)	(4,4.5,6)		
		Call center	(0.2,0.9,1.7)	(5.9,6.8,9)	(2,3,3.9)		
		Service quality	(1.4,2.4,3)	(7,8,10)	(5,7.2,9)		
		Service management	(2.2,3.1,3.6)	(5.6,6.4,7.8)	(3,5.6,7.4,)		
Network system	(2.1,3,5.1)	Safety	(2.2,3,3.4)	(6,7.2,8.4)	(5,6.4,7.6)	5.8	1.9
		Reliability	(3,4,6)	(8.8,9.2,10)	(7,8.8,10)		
		Operability	(2.8,3.2,4.1)	(5.2,5.8,6.7)	(3,4.2,4.8)		
		System accessibility	(2,3.2,4.6)	(5,6.2,6.8)	(5,6.7,8.7)		
		System humanization	(4,5.6,6.8)	(5.5,6.2,8.2)	(3,5.2,6.7)		
Payment	(4,5.2,6.4)	Accuracy of fee calculation	(4.2,4.9,5.6)	(6.2,7.8,9.8)	(5,6,7.6)	5.3	3.1
		Accuracy of fee collection	(3.6,5.2,7)	(5.2,6.2,7.1)	(5,6,8.2)		
		Payment method	(2.3,2.8,3)	(6.2,8.2,9.4)	(5,6.2,6.8)		
		Payment facilities	(3.2,4.7,5.1)	(4.2,6.2,7)	(5,5.8,6.9)		

CONCLUSION

This paper evaluates the customer satisfaction of B2C e-commerce based on the proposed fuzzy entropy and triangular fuzzy numbers. The applied fuzzy set theory could decrease the uncertainty of customer's opinion and the applied indexes could map the customer satisfaction degree of B2C e-commerce since all of the customers which participated in this research were pleased.

In a sense, a company with high satisfaction holds loyal customers even at a price higher than his rivals and better adapts to the market with its technology, product and service.

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