The Evaluation Study of Customer Satisfaction Based on Gray –AHP Method for B2C Electronic-Commerce Enterprise

Minghe Wang,Peide Liu,Guoli Ou

***Abstract*—Under electronic commerce, how to raise the consumers' degree of satisfaction and gain the consumers' loyalty have become the key factor relating with whether e-commerce enterprise can survive, so it's vital to evaluate status of customer satisfaction for B2C Electronic-Commerce Enterprise . According to the investigation result by internet, this paper brings forward the indicator system of customer satisfaction evaluation for B2C electronic-commerce enterprise on the basis of current study of home and oversea and the related reference, and establishes the performance evaluation model based on combination of Grey Evaluation Method and AHP method(Grey-AHP), and also do some example research. The examples demonstrated that: Grey-AHP method can do well in evaluation.**

***Index Terms*—Customer Satisfaction, BtoC, Gray Evaluation Method, AHP Method**

I. Introduction

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 have become the key factor relating with whether e-commerce 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[1].

To evaluate the customer satisfaction quantitatively, scholars proposed a series of theoretical analysis models. Among these models there are several influential ones including: Richard L.Oliver, an American scholar, brought forward that "expectation-performance model", Robert B. Woodruff, Ernest R. Cadotte and Roger L. Jenkins's "the comparative model of the experiences of the customers", Robert Westbrook and Michael D.Reilly's the model of the customer satisfaction". Many countries also 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. Among them having much influence are American ACSI[2], 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[3].

Under BtoC e-commerce the main research on customer satisfaction at home and abroad including: Lan lee(1999) constructed evaluation index from commercial content, customer's concern, effective navigation, website design, safety etc; Szymanski Hise (2000) constructed evaluation index from convenience, merchandise planning, website design, financial safety etc.; Shim , Shin (2002) etc. constructed evaluation index from contact convenience, customer service information, convenience of getting product information etc.; Cheun Lee (2005) constructed evaluation index from information accuracy, content relatedness and integrity, variety in displaying, information timely updating, convenient navigation, easy application, system rapidity, safety and privacy, service response in time, guaranteed service, individuation service etc.; Schaupp, Bélanger (2005) established evaluation index from safety, performance of system using, website design, privacy, convenience of purchasing, reliability, distribution, product strategy, product value, customization etc.; in domestic , Duo Qi[4] etc. proposed an customer satisfaction evaluation system based on AHP and fuzzy method to meet the demand of enterprise under e-commerce; Yu Hongyan[5] ,Gao Dan[6] from Philip. Evaluation index summarize BtoC e-commerce customer satisfaction on the theoretical foundation of " the customer amortizes value " which the department specially ties tight (Customer satisfaction includes two parts of total value of the customer and total cost of the customer, among them the total value of the customer includes serving value, independent value , convenient value, linking up the value, amusement value, value of the goods; the total cost of the customer includes time cost, monetary cost, risk cost, spiritual cost, opportunity cost, evaluation index to form customer satisfaction of e-commerce.); Gan Yong [7]constructed customer satisfaction index from product, service and system based on study and summarization of general enterprises and customer satisfaction model of B2C e-commerce enterprise,

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and made quantitative analysis using Fuzzy Comprehensive Evaluation method.

Based on literature [7] and the summarization of index system at home and abroad, this paper constructs customer satisfaction index of BtoC e-commerce enterprise, and evaluates customer satisfaction of BtoC e-commerce enterprise by adopting AHP method and Grey evaluation.

table-1 Indicator system of customer satisfaction evaluation in BtoC e-commerce enterprises

Criterion level	Indicator level
A1 Product	B1 Product customization
	B2 Product value
	B3 Product information
	B4 Product scope
A2 Service	B5 Service attitude
	B6 Service information
	B7 Payment method
	B8 Distribution
	B9 Response and feedback
A3 Network system	B10 Safety
	B11 Reliability
	B12 Operability
	B13 System accessibility
	B14 System humanization

II. THE INDICATOR SYSTEM OF CUSTOMER SATISFACTION EVALUATION FOR B2C ELECTRONIC-COMMERCE ENTERPRISE

The restriction factors of customer satisfaction evaluation is a multiplayer dynamic system, and the involved factors are too many and the structure is rather complex, so that, in order to reflect the performance correctly, we should design the indicator system from diverse angles and layers. Evaluation system should be designed to conform to the following principles[8][9]:

Systemic principles: the indicator system should evaluate comprehensively reflect the overall situation, demonstrate the logical relationship, seizing the main factors, reflecting the direct effects and indirect effects.

Scientific and advanced Principles: it should effectively reflect the basic features of customer satisfaction.

Hierarchy principles: Indicators can not be subjected to each other, and can not contain different aspects into the same indicators.

Maneuverability principles: indicator meaning is clear, and data collection is convenient. If the indicator is too complicated, the evaluation will be difficult.

Comparability principles: indicators have horizontal and vertical comparability.

Subdivision principle: there will not be too many meaning of indicators, in case different assessors have different interpretations of the meaning of the indicators.

Based on the literature[7] and research situation of abroad and home, and according to the investigation result by internet, This paper proposes the indicator system following table 1.

III. THE GREY-AHP METHOD OF CUSTOMER SATISFACTION EVALUATION FOR B2C ELECTRONIC-COMMERCE ENTERPRISE

A. The Ascertainment of Evaluating Factors

The set of evaluating factors (table 1) is a muster of customer satisfaction's evaluating indicators.

B. Computing the Weighted Set of Evaluating Factors Using AHP

The analytic hierarchy process method, just AHP method for short, is to express a complex decision-making problem as a sequential step-up hierarchy structure, compute the comparatively weightiness measurement of diversified decision-making behaviors, scheme and decision-making object under different rule and the whole rule, and then rank them according to the measurement, providing decision-making evidence for the decision-makers[12]. The steps to solve the real problems using AHP method is as follows:

(1)Establishing the problem's step-up hierarchy structure. According to the elementary analysis, divides the factors into several groups, and each group present a hierarchy. Then, ranks them as the sequence: the top layer, several relative middle layers and the bottom layer. The top layer presents the purpose of solving problems, just at which the AHP wants to arrive. The middle layers is the involved intermediate links while reaching the purpose, namely tactic layer, restricted layers, rule layer etc. The bottom layer displays the measures or policies used to solving problems.

(2) Determining the comparative judgment matrix. The judgment matrix presents the situation of the comparative weightiness of this layer's relative factors, aiming at some factors of the upper layer. Supposing that the factors Ak of A layer have relation to the next layer B1,B2, …,Bn, constitutes the judgment matrix as follows (figure 1). In the figure, Bij presents the weight indicator of comparative weightiness of Bi toBj, relative to factor Ak. It's crucial to determine this weight. We usually adopt the two methods: expert decision and individually subjective decision[10]. Expert decision is to invite relatively specialized experts considering the content of the evaluating problems, let the experts make comparison between factors using AHP according to the form of experts' suggestion designed in advance. We constitute the judging matrix by filling in the result of the comparison, then synthetically analysis and compute the experts' judging matrix to obtain the problem's ordered weighted value. The individually subjective decision constitutes the judging matrix by comparing the cognitive and understanding level of individuals. This paper adopts the first method which let the experts give their determination to the

A_k	B_1	B_2	$\cdots$	B_n
B_1	b_{11}	b_{12}	$\cdots$	b_{1n}
B_2	b_{21}	b_{22}	$\cdots$	b_{2n}
$\vdots$	$\vdots$	$\vdots$	$\vdots$	$\vdots$
B_n	b_{n1}	b_{n2}	$\cdots$	b_{nn}

Fig. 1. Judgment matrix

mutually important degree of indicator system's each layer.

AHP adopts the 1~9 marking method, brought forward by Satie, to constitute the judging matrix. The marking value of b_{ij} is indicated in the following table (table 3):

Table 3. AHP mark and its meaning

Mark	Its meaning
1	B_i factor compares with B_j factor, which have the same importance.
3	B_i is slightly important than B_j.
5	B_i is clearly important than B_j.
7	B_i is very important than B_j.
9	B_i is extremely important than B_j.
2,4,6,8	The intermediate valve of the above two adjacent judgment.

Obviously, relative to the judging matrix, there have:

$$b_{ij} = 1/b_{ji},\ b_{ii} = 1. \qquad (1)$$

(3) The single hierarchy sort. The single hierarchy sort computes the weighted value of this layer's factors' weightiness, according to some of the upper layer's factors.

The single hierarchy sort can come down to compute the eigenvector and eigenvalue of judging matrix B. That is to compute the eigenvector and eigenvalue which can satisfy the formula 2.

$$BW = \lambda_{MAX} W \qquad (2)$$

Thereinto, λ_{MAX} is the maximum of eigenvalue of B. W is the normalized eigenvector corresponding to λ_{MAX}. Adopting the square root method, compute it as:

$$W_i = \sqrt[n]{\prod_{j=1}^{n} b_{ij}} \Big/ \sum_{i=1}^{n} \sqrt[n]{\prod_{j=1}^{n} b_{ij}} \qquad (3)$$

Thereinto, i,j=1,2,…,n

So, W =($W_1, W_2, ...W_n$) just the eigenvector we are aftering.

$$\lambda_{MAX} = \frac{1}{n} \sum_{i=1}^{n} \frac{(BW)_i}{W_i} \qquad (4)$$

Thereinto, $(BW)_i$ means the ith heft of BW.

(4) The test of consistency.

Each judgment has difficulty to reach a complete consistency because of the complexity of objective things and diversity of individual's subjective judgment. In order to make the result of AHP method basically reasonable. We need to test the consistency of each judging matrix using the following formula 5.

$$CR = CI / RI,\ CI = (\lambda_{MAX} - n)/(n-1). \qquad (5)$$

Thereinto, CR is the random consistent proportion of judging matrix. RI is the averagely random consistent indicator of judging matrix. The 1-10 ranks matrix's RI is as the following table (table 2):

Table 2. The averagely random consistent indicator RI of 1-10 judging matrix

The number of tiers	1	2	3	4	5	6	7	8	9	10
RI	0	0	0.52	0.89	1.12	1.25	1.35	1.42	1.46	1.49

n is the number of ranks of judging matrix. When the CR< 0. 10, we think the judging matrix has satisfying consistency. Otherwise, we should adjust it to obtain the satisfying consistency.

(5) The whole hierarchy sort

The whole hierarchy sort. The whole hierarchy sort is to compute the weighted value of all factors' weightiness in this layer according to the upper layer by taking advantage of all results of the single hierarchy sort in the same layer. The single hierarchy sort is just the whole hierarchy sort for the top layer. Similarly, when CR< 0. 10, we think the result of the whole hierarchy sort has satisfying consistency. Otherwise, we should adjust each judging matrix of this layer to obtain the satisfying consistency.

Level A / Level B	A_1	A_2	⋯	A_m	The total sort of level B
	a_1	a_2	⋯	a_m	
B_1	b_1^1	b_1^2	⋯	b_1^m	$I_1 = \sum_{i=1}^{m} a_i b_1^i$
B_2	b_2^1	b_2^2	⋯	b_2^m	$I_2 = \sum_{i=1}^{m} a_i b_2^i$
⋮	⋮	⋮	⋮	⋮	⋮
B_n	b_n^1	b_n^2	⋯	b_n^m	$I_n = \sum_{i=1}^{m} a_i b_n^i$

Figure 2. The matrix of the whole hierarchy sort

C. Grey–AHP Evaluation Model

(1) Constituting comment set of Evaluation indicator. We make out all the comment set of Evaluation indicator, whose quality grades is divided into five criteria "better", "good", "moderate", "bad", "worse", unified regulations for the sake of convenience: V={y1,y2,…yp}={9,7,5,3,1}.The grade is between two adjacent grades, which is marked by 8, 6, 4, and 2.

(2) Confirmation of evaluation sample matrix. Under the circumstance of determining the evaluation indicator system and the evaluation indicator weight, we can give l evaluation indicators' values according to evaluation indicator Bi. Then the evaluation sample matrix is as follows:

$$D=\begin{bmatrix} d_{111} & d_{112} & \cdots & d_{11l} \\ d_{121} & d_{122} & \cdots & d_{12l} \\ \vdots & \vdots & \vdots & \vdots \\ d_{mn1} & d_{mn2} & \cdots & d_{mnl} \end{bmatrix} \begin{matrix} B_1 \\ B_2 \\ \vdots \\ B_m \end{matrix} \quad (6)$$

(3) Determining evaluation gray cluster. First, We divided the gray cluster into five grades: “better”, “good”, “moderate”, “bad”, “worse”, e =1, 2 ,3, 4, 5. The corresponding gray cluster and The first gray cluster are as follows:

The first gray cluster ‘better’ (e =1). Grey number $\otimes_1 \in [0,9,\infty)$, its whitenization function $f_1(x)$ (Figure 3 (a)) ◦

The second gray cluster ‘good’ (e =2). Grey number $\otimes_1 \in [0,7,14)$, its whitenization function $f_2(x)$ (Figure3 (b)) ◦

The third gray cluster ‘moderate’ (e =3). Grey number $\otimes_1 \in [0,5,10)$, its whitenization function $f_3(x)$ (Figure 3(c)) ◦

The forth gray cluster ‘bad’ (e =4). Grey number $\otimes_1 \in [0,3,6)$, its whitenization function $f_4(x)$ (Figure 3 (d)) ◦

The fifth gray cluster ‘worse’ (e =5). Grey number $\otimes_1 \in [0,1,2)$, its whitenization function $f_5(x)$ (Figure 3 (e)) ◦

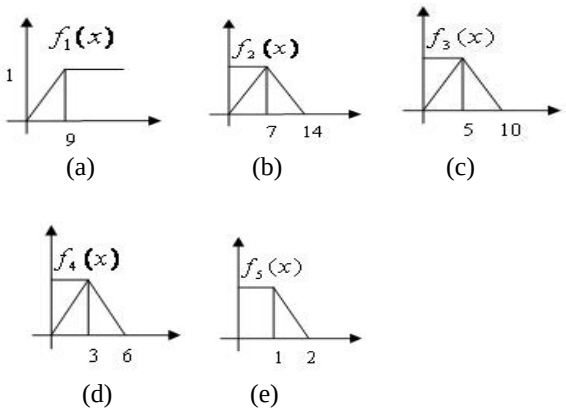

Fig. 3. whitenization function of the gray cluster

(4) Calculating Gray Evaluation weight. To one of the evaluation indicator B, Candidate which belongs to the No. $\ell(\ell=1, 2, 3, 4, 5)$ evaluation gray cluster has the grey evaluation coefficient:

$$X_{ije} = \sum_{k=1}^{l} f_e(d_{ijk}) \quad (7)$$

Then to the evaluation indicator B, Candidate which belongs to all the evaluation gray cluster has the total quantity of Gray Evaluation:

$$X_{ij} = \sum_{e=1}^{5} X_{ije} \quad (8)$$

The grey evaluation weight of No.e evaluation gray cluster:

$$r_{ije} = X_{ije} / X_{ij} \quad (9)$$

Therefore the indicator B which belongs to the grey evaluation weight vectors $r_{ij} = (r_{ij1}, r_{ij2}, r_{ij3}, r_{ij4}, r_{ij5})$, A_i for all evaluation gray cluster has the grey evaluation weight matrix:

$$R_i = \begin{bmatrix} r_{i1} \\ r_{i2} \\ \vdots \\ r_{in} \end{bmatrix} = \begin{bmatrix} r_{i11} & r_{i12} & \cdots & r_{i15} \\ r_{i21} & r_{i22} & \cdots & r_{i25} \\ \vdots & \vdots & \vdots & \vdots \\ r_{in1} & r_{in2} & \cdots & r_{in5} \end{bmatrix} \quad (10)$$

(5) Calculating total appraisement value. First, evaluating Ai synthetically, and its conclusion of comprehensive evaluation is Pi:

$$P_i = W_i \bullet R_i = (p_{i1}, p_{i2}, p_{i3}, p_{i4}, p_{i5}) \quad (11)$$

A_i for all evaluation gray cluster has the grey evaluation weight matrix:

$$P = \begin{bmatrix} P_1 \\ P_2 \\ \vdots \\ P_m \end{bmatrix} = \begin{bmatrix} p_{11} & p_{12} & \cdots & p_{15} \\ p_{21} & p_{22} & \cdots & p_{25} \\ \vdots & \vdots & \vdots & \vdots \\ p_{m1} & p_{m2} & \cdots & p_{m5} \end{bmatrix} \quad (12)$$

Therefore evaluating candidate synthetically, the conclusion of comprehensive evaluation is as follows:

$$B = W \bullet P = (b_1, b_2, b_3, b_4, b_5) \quad (13)$$

According to (formula 12) the maximum principle, we can determine the grey grades of the enterprise. But sometimes judgments will be distorted because of losing too much information. At this time, we can deal with B further, make it Single-value:

$$Z = B \bullet V^T \quad (14)$$

IV. The Customer Satisfaction EVALUTION and demonstration research For B2C Electronic-Commerce Enterprise

A. Construct judgment matrix

Via the investigation of 15 experts, it structure the judging matrix, eigenvector and consistency examine:

(1). Judgment matrix A-A1:

A	A1	A2	A3	W	λ_{MAX}	CI	CR
A1	1/1	2/1	2/1	0.5			
A2	1/2	1/1	1/1	0.25	3	0	0<0.100
A3	1/2	1/1	1/1	0.25			

(2). Judgment matrix A1-B:

A1	B1	B2	B3	B4	W_1	λ_{MAX}	CI	CR
B1	1/1	1/2	3/1	4/1	0.288			
B2	2/1	1/1	5/1	7/1	0.533	4.0214	0.0071	0.008<0.100
B3	1/3	1/5	1/1	2/1	0.112			
B4	1/4	1/7	1/2	1/1	0.067			

(3). judgment matrix A2-B:

A2	B5	B6	B7	B8	B9	W_2	λ_{MAX}	CI	CR
B5	1/1	2/1	1/2	1/3	1/1	0.131			
B6	1/2	1/1	1/4	1/7	1/2	0.063			
B7	2/1	4/1	1/1	1/2	2/1	0.247	5.0092	0.0023	0.002<0.100
B8	3/1	7/1	2/1	1/1	3/1	0.428			
B9	1/1	2/1	1/2	1/3	1/1	0.131			

(4). Judgment matrix A3-B:

A3	B10	B11	B12	B13	B14	W_3	λ_{MAX}	CI	CR
B10	1/1	1/1	3/1	4/1	2/1	0.329			
B11	1/1	1/1	2/1	3/1	2/1	0.286			
B12	1/3	1/2	1/1	2/1	1/2	0.122	5.0717	0.018	0.016<0.100
B13	1/4	1/3	1/2	1/1	1/3	0.074			
B14	1/2	1/2	2/1	3/1	1/1	0.189			

B. Demonstration analysis

Appraising one enterprise's customer satisfaction indicators by 5 experts, we construct the sample matrix D is as follows:.

$$D = \begin{bmatrix} 5 & 7 & 7 & 5 & 9 \\ 6 & 4 & 5 & 5 & 7 \\ 9 & 5 & 7 & 6 & 8 \\ 7 & 5 & 4 & 7 & 5 \\ 3 & 5 & 5 & 4 & 6 \\ 8 & 4 & 7 & 3 & 6 \\ 6 & 7 & 8 & 7 & 4 \\ 5 & 7 & 6 & 6 & 7 \\ 6 & 5 & 7 & 4 & 6 \\ 7 & 8 & 7 & 6 & 4 \\ 4 & 7 & 6 & 6 & 5 \\ 7 & 5 & 5 & 6 & 3 \\ 5 & 6 & 4 & 7 & 5 \\ 7 & 3 & 5 & 6 & 5 \end{bmatrix}$$

According to formula 6, 7, 8, 9, 10 ,we get the following matrixes:

$$R_1 = \begin{bmatrix} 0.309 & 0.349 & 0.286 & 0.056 & 0 \\ 0.242 & 0.311 & 0.339 & 0.108 & 0 \\ 0.342 & 0.365 & 0.264 & 0.029 & 0 \\ 0.250 & 0.322 & 0.321 & 0.107 & 0 \end{bmatrix}$$

$$R_2 = \begin{bmatrix} 0.207 & 0.266 & 0.339 & 0.188 & 0 \\ 0.266 & 0.313 & 0.274 & 0.143 & 0 \\ 0.304 & 0.366 & 0.273 & 0.057 & 0 \\ 0.287 & 0.369 & 0.316 & 0.028 & 0 \\ 0.257 & 0.330 & 0.330 & 0.083 & 0 \end{bmatrix}$$

$$R_3 = \begin{bmatrix} 0.304 & 0.336 & 0.273 & 0.057 & 0 \\ 0.257 & 0.330 & 0.330 & 0.083 & 0 \\ 0.235 & 0.303 & 0.326 & 0.136 & 0 \\ 0.242 & 0.311 & 0.339 & 0.108 & 0 \\ 0.235 & 0.303 & 0.326 & 0.136 & 0 \end{bmatrix}$$

$$P_1 = W_1 * R_1 = [\,0.273 \;\; 0.329 \;\; 0.314 \;\; 0.084 \;\; 0\,]$$

$$P_2 = W_2 * R_2 = [\,0.275 \;\; 0.346 \;\; 0.308 \;\; 0.071 \;\; 0\,]$$

$$P_3 = W_3 * \mathrm{R}_3 = [0.264 \;\; 0.322 \;\; 0.311 \;\; 0.093 \;\; 0]$$

$$P = \begin{bmatrix} P1 \\ P2 \\ P3 \end{bmatrix} = \begin{bmatrix} 0.273 & 0.329 & 0.314 & 0.084 & 0 \\ 0.275 & 0.346 & 0.308 & 0.071 & 0 \\ 0.264 & 0.322 & 0.311 & 0.093 & 0 \end{bmatrix}$$

$$B = \mathrm{W} * \mathrm{P} = [0.272 \quad 0.332 \quad 0.312 \quad 0.084 \quad 0]$$

$$Z = B \bullet V^T = 6.584$$

It is obvious that the range of the enterprise's customer satisfaction is between good and the general.

V. CONCLUSIONS

This paper combines the measures of the Grey evaluation and the hierarchy evaluation to evaluate synthetically the degree of customer satisfaction for B2C electronic-commerce enterprise. We builds Grey hierarchy evaluated mathematics model and builds general evaluation system of customer satisfaction through condensing the evaluation indicator system. It is approved by instance: we can get the good affection by using grey hierarchy evaluation method.

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