A fuzzy model of customer satisfaction index in e-commerce

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Abstract

Customer satisfaction index (CSI) is an important concept for evaluating the quality of service in e-commerce. It permits to evaluate the validity of an e-commerce operation from the point of view of consumers. In this paper, we present a model of CSI in e-commerce using fuzzy techniques and provide a method for calculating CSI, expressed in a five levels quantity table.

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1. Introduction

Since Oliver [17] put forward a cognitive model for characterizing antecedents and consequences of satisfaction in 1980, customer satisfaction and customer satisfaction index (CSI) have been widely developed in both theory and applications [3,5,7,9,13,14,16,18,19], especially in the fields of marketing, education, medical treatment, guesthouse management. In 1989, the first model of CSI was built by Swedish researchers [12]. The American customer satisfaction index (ASCI) was set up in 1994 [1]. Another well-known CSI was built by 11 countries of European Union in 1999 [15,22]. In practice, these CSI play a very important role in the improvement of enterprises’ performance [6,11].

Also, e-commerce through Internet has become an important transaction model in international trade [2,20]. In this situation, more attention has been paid to the problem of e-commerce customer satisfaction [8,21]. For example, the fourth quarter 2004 e-commerce aggregate customer satisfaction score of USA is 78.61 [4]. However, most of existing CSI are rather similar between them. Each of them generally includes 4–7 indices and uses numerical scores in related computing. In fact, in many cases, it is very difficult to assign exact numerical scores to an index. Moreover, these proposed indices of CSI are not completely accepted by general public. In this background, we present in this paper a new model for evaluating customer satisfaction in e-commerce and a new method for calculating the e-commerce customer satisfaction index (ECSI) using fuzzy techniques.

In the quality system certification of ISO9000 of 2000 edition, the term \textit{customer satisfactory degree} has been used frequently. ECSI is used for measuring this concept in e-commerce by evaluating the criteria of customers’ cognition and expectation, customers’ loyalty behavior and grumble behavior. As there exists uncertain information in the evaluation of customer satisfaction, this paper uses fuzzy logic to calculate ECSI. The basic ideas for evaluating customer satisfaction and calculating ECSI are given as follows. First, customers compare their cognition with the
perception in e-commerce. The result of comparison is denoted as ECSI1. Second, customers express their loyal behavior and grumble behavior in e-commerce. It is denoted as ECSI2. Third, ECSI is obtained by aggregating ECSI1 and ECSI2 using a specific fuzzy composition operator.

Since Zadeh built fuzzy set theory in 1965 [23], a lot of fuzzy logic based applications have been successfully put forward in many fields [10]. As there exist uncertainty and imprecision in the nature and human perception, fuzzy logic can be considered as a powerful and practical tool for solving human related problems, such as classification, evaluation and decision support in the fields of industry, economy, society, safety and management.

The organization of this paper is as follows: Section 2 describes the concept of ECSI using the ideas of system analysis and system control. The model of ECSI and its basic formalization are given in this section. More details on the description and computing of the related indices are proposed in Section 3. It includes two parts, i.e. the description of the input (denotes as ECSI1) and the output (denotes as ECSI2) of the model of ECSI as well as the fuzzy logic based method for computing synergistic values of different indices. Section 4 introduces the main steps for measuring ECSI. In Section 5, one application of evaluation with ESCI is given in order to validate the effectiveness of our method. A conclusion is provided in Section 6 to show the significance of our method.

2. Model of ECSI

ECSI can be considered as a system with input and output variables. The input variables concern the comparison between customer’s expectation and cognition in e-commerce while the output part generates two variables, i.e. customers’ loyalty behavior and grumble behavior. In general, it is easier to obtain the result from the output than from the input of ECSI. The model of ESCI is shown in Fig. 1.

In Fig. 1, U, V, S and T denote the sets of linguistic variables related to expectation index, cognition index, loyal behavior index and grumble index of customers in e-commerce respectively. \( \Delta \) represents a vector of adjustment values for improving the quality of ECSI by taking into account the difference between ECSI1 and ECSI2. If ECSI1 = ECSI2, then \( \Delta = 0 \). More details on the formalization of these concepts are given below.

2.1. Index of expectation and cognition of quality of customers in e-commerce

Formally, ECSI1 is defined by

\[
ECSI_1 = R\left( \frac{V}{U} \right)
\]  

(1)

In (1), the relation between V and U is bijective, and \( R(V/U) \) expresses the result of comparison between V and U. ECSI1 is one \( r \)-dimensional vector of membership degrees related to \( r \) predefined linguistic evaluation terms describing customer satisfaction levels. Each membership degree varies between 0 and 1.

2.2. Index of customers’ behavior in e-commerce

The index of customers’ behavior in e-commerce ECSI2 is formally expressed by

\[
ECSI_2 = (w_S \ w_T) \circ \begin{pmatrix} S \\ T \end{pmatrix}
\]  

(2)

Fig. 1. A model of ECSI.
In (2), \( w_S \) and \( w_T \) are the weights of \( S \) and \( T \) respectively. \( \circ \) is a fuzzy matrix composition operator [10]. This operator is determined according to the related real application. In our project, we use \((+\cdot)\) in this operation. ECSI2 is also a \( r \)-dimensional vector of membership degrees related to these \( r \) predefined linguistic evaluation terms describing customer satisfaction levels.

2.3. Index of satisfactory of customers in e-commerce

The index of satisfaction of customers in e-commerce ECSI is considered as a system in which ECSI1 and ECSI2 constitute the input and the output respectively. The difference of ECSI1 and ECSI2 (the feedback in Fig. 1) is not considered in the design of ECSI. In this paper, ECSI is a weighted combination of ECSI1 and ECSI2 using the same composition operator. Formally, it is expressed by

\[
ECSI = (w_1 \ w_2) \circ \begin{pmatrix} ECSI_1 \\ ECSI_2 \end{pmatrix}
\]

where \( w_1 \) and \( w_2 \) denote the weights of ECSI1 and ECSI2 respectively. In practice, the customer satisfaction index ECSI can be further improved by taking into account the feedback of this system. This feedback can be determined according to the difference between the input (ECSI1) and the output (ECSI2). Then, we use ECSI\(_f\) to denote the improved customer satisfaction index and obtain

\[
ECSI_f = ECSI + \Delta
\]

In (4), \( ECSI = (a_1 \ldots a_r) \) represents the vector of membership degrees related to the \( r \) predefined linguistic evaluation terms describing customer satisfaction levels and \( \Delta \) its improved vector, if \( 1 \leq i \leq j \leq r \), then \( a_i \) is more satisfactory than \( a_j \), and in general, \( r \) is an odd number, i.e. \( r = 2m + 1 \), \( m \in \mathbb{Z} \). \( \Delta \) is a vector of adjustment values, and \( \Delta = (c_1 \ldots c_r) \), which is used to reflect the difference between ECSI1 and ECSI2. We define \( \Delta \) as follows.

\[
\Delta = f(ECSI_2, ECSI_1)
\]

where \( f \) is a function permitting to determine the adjustment values according to the comparison between ECSI2 and ECSI1. Its principle is given as follows. For positive evaluation values, if the difference between ECSI1 and ECSI2 is bigger, then the value of \( f \) is smaller. In the same way, for negative evaluation values, the value of \( f \) is just opposite to the positive index.

Concretely, the values of \( \Delta \) can be calculated according to the following procedure:

**Step 1.** we initially set \( \Delta = (0 \ldots 0) \). It means that the initial adjustment values taking into account the difference between ECSI1 and ECSI2 are 0, i.e. ECSI1 = ECSI2.

**Step 2.** we adjust the value of \( \Delta \) according to the difference between ECSI1 and ECSI2. The corresponding rules for adjustment are following:

**Rule 1.** If \( (ECSI_2)_i > (ECSI_1)_i \), then we increase the value of the \( i \)-th element of \( \Delta \), and \( c_i := \rho_i a_i \), \( 0 < c_i < 1 \).

**Rule 2.** If \( (ECSI_2)_i < (ECSI_1)_i \), then we decrease the value of the \( i \)-th element of \( \Delta \), and \( c_i := -\rho_i a_i \), \( 0 < c_i < 1 \).

A formula for calculating \( \rho_i \) is given below.

\[
\rho_i = \begin{cases} 
0, & (ECSI_1)_i = 0, (ECSI_2)_i = 0 \\
\frac{|(ECSI_1)_i - (ECSI_2)_i|}{\max\{(ECSI_1)_i, (ECSI_2)_i\}} & \text{otherwise}
\end{cases}
\]

In this paper, we adopt a five levels quantity table to measure ECSI for one action in e-commerce. Then, we have 5 linguistic evaluation terms with \( r = 5 \). The corresponding terms can be: **very satisfactory**, **satisfactory**, **general**, **unsatisfactory** and **very unsatisfactory**. In general, we consider that customer’s satisfaction correspond to the cases in which ECSI takes the values of **very satisfactory**, **satisfactory** or **general**. In the two other cases, we consider that customers are not satisfied.
Table 1
The index system of ECSI₁

<table>
<thead>
<tr>
<th>I₁</th>
<th>I₂</th>
<th>I₃</th>
<th>W</th>
<th>X</th>
</tr>
</thead>
<tbody>
<tr>
<td>U</td>
<td>Expectation on service kinds or product kinds</td>
<td>(a_1)</td>
<td>(A_1)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Price expectation</td>
<td>(a_2)</td>
<td>(A_2)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Protect private right expectation</td>
<td>(a_3)</td>
<td>(A_3)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Trade time expectation</td>
<td>(a_4)</td>
<td>(A_4)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Payment expectation</td>
<td>(a_5)</td>
<td>(A_5)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Delivery and its time expectation</td>
<td>(a_6)</td>
<td>(A_6)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Post-sale service expectation</td>
<td>(a_7)</td>
<td>(A_7)</td>
<td></td>
</tr>
</tbody>
</table>

Table 2
The index system of ECSI₂

<table>
<thead>
<tr>
<th>I₁</th>
<th>I₂</th>
<th>I₃</th>
<th>W</th>
<th>X</th>
</tr>
</thead>
<tbody>
<tr>
<td>S</td>
<td>Look for service in e-commerce on customers’ own initiative</td>
<td>(c_1)</td>
<td>(C_1)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Pay on customers’ own initiative</td>
<td>(c_2)</td>
<td>(C_2)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>The number of suggestions for improvement</td>
<td>(c_3)</td>
<td>(C_3)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Money and time consumed in e-commerce</td>
<td>(c_4)</td>
<td>(C_4)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>The times of grumble</td>
<td>(d_1)</td>
<td>(D_1)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>The number of lost customers</td>
<td>(d_2)</td>
<td>(D_2)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>The times of crisis of technique or credit</td>
<td>(d_3)</td>
<td>(D_3)</td>
<td></td>
</tr>
</tbody>
</table>

Fuzzy membership functions for the five evaluation terms are shown in Fig. 2, in which \(x_1, x_2, x_3, x_4\) and \(x_5\) denote the numerical results of an index. The fuzzy membership functions are determined by experts or evaluators. For example, when \(x = x_1\), the values of fuzzy functions of an index belonging to the five evaluation terms can be \((10000)\).

3. Detailed formalization and computing of ECSI

3.1. Description of the indices of ECSI

In this section, we give a description on the indices composing the general index of ECSI. These indices are shown in Tables 1 and 2.

In these two tables, the whole set of related indices are classified into three levels, denoted as \(I_1, I_2, I_3\) respectively. In the level of \(I_1\), we have ECSI₁ and ECSI₂, whose combination directly constitutes ECSI. The indices of \(I_1\) are composed of the four indices in the level of \(I_2\), i.e. \(U, V, S\) and \(T\). In the same way, the indices of \(I_2\) are composed of the indices of \(I_3\), considered as basic indices of the whole evaluation system of ECSI. The set of basic indices and the set of their corresponding weights are denoted as \(X\) and \(W\) respectively. \(A_i\) and \(a_i\) \((i \in \{1,2,\ldots,7\})\) denote the \(i\)-th index of customers’ expectation and its weight respectively. \(B_j\) and \(b_j\) \((i \in \{1,2,\ldots,7\})\) denote the \(i\)-th index of customers’ cognition and its weight respectively. \(C_j\) and \(c_j\) \((j \in \{1,2,3,4\})\) denote the \(j\)-th index of customers’ loyal behavior and its weight respectively. \(D_k\) and \(d_k\) \((k \in \{1,2,3\})\) denote the \(k\)-th index of customers’ grumble behavior and its weight respectively.
In order to compare cognition and expectation of customers reasonably, we let \( \sum_{i=1}^{7} a_i = \sum_{i=1}^{7} b_i \), and \( 0 \leq a_i \leq 1, 0 \leq b_i \leq 1 \).

### 3.2. Calculating U, V, S and T

In Table 1, the basic indices can be determined using classical methods such as expert consultation. These indices include not only numerical values, but also linguistic values. For example, when adopting a five levels quantity table to evaluate customer satisfaction, we can take values from very satisfactory, satisfactory, general, unsatisfactory and very unsatisfactory. These values constitute an ordered list of intensities related to customer’s satisfaction.

The indices of \( I_2 \) can be calculated from the basic indices using the fuzzy composition operation. We have

\[
U = (a_1\ a_2\ a_3\ a_4\ a_5\ a_6\ a_7) \odot (A_1\ A_2\ A_3\ A_4\ A_5\ A_6\ A_7)^T
\]

\[
V = (b_1\ b_2\ b_3\ b_4\ b_5\ b_6\ b_7) \odot (B_1\ B_2\ B_3\ B_4\ B_5\ B_6\ B_7)^T
\]

\[
S = (c_1\ c_2\ c_3\ c_4) \odot (C_1\ C_2\ C_3\ C_4)^T
\]

\[
T = (d_1\ d_2\ d_3) \odot (D_1\ D_2\ D_3)^T
\]

where \( \odot \) is the composition operator. It can be selected according to the specific application. Frequently used operators include \( (\odot, \cdot), (\land, \lor), (\times, +) \).

The computing of ECSI deals with many indices and many factors. In most of cases, linguistic terms are used in the model of ECSI. Therefore, in the proposed method, the aggregation of linguistic terms using fuzzy composition constitutes the main computing in the evaluation of ECSI.

### 3.3. A method for calculating ECSI \(_1\)

ECSI \(_1\) is composed of the customers’ expectation and cognition in e-commerce. Moreover, the relation between perception and cognition is bijective. In order to calculate ECSI \(_1\) using the Eq. (1), the indices of Table 1 and the five levels quantity table, we introduce an expectation matrix denoted as \( \hat{U} \), and

\[
\hat{U} = \begin{pmatrix}
    u_{11} & u_{12} & u_{13} & u_{14} & u_{15} \\
    u_{21} & u_{22} & u_{23} & u_{24} & u_{25} \\
    \ldots & \ldots & \ldots & \ldots & \ldots \\
    u_{71} & u_{72} & u_{73} & u_{74} & u_{75}
\end{pmatrix}
\]

(7)

where \( u_{ij} \) is the membership degree of the \( i \)-th expectation index \( A_i \) subordinating to the \( j \)-th linguistic terms and \( u_{ij} \in [0,1] \).

When introducing the weights of the expectation indices \( a_i \)'s \( (i = 1, \ldots, 7) \), we obtain the following weighted expectation matrix:

\[
\hat{U}' = \begin{pmatrix}
    a_1 u_{11} & a_1 u_{12} & a_1 u_{13} & a_1 u_{14} & a_1 u_{15} \\
    a_2 u_{21} & a_2 u_{22} & a_2 u_{23} & a_2 u_{24} & a_2 u_{25} \\
    \ldots & \ldots & \ldots & \ldots & \ldots \\
    a_7 u_{71} & a_7 u_{72} & a_7 u_{73} & a_7 u_{74} & a_7 u_{75}
\end{pmatrix}
\]

(8)

In the same way, we can obtain the cognition matrix denoted as \( \hat{V} \)

\[
\hat{V} = \begin{pmatrix}
    v_{11} & v_{12} & v_{13} & v_{14} & v_{15} \\
    v_{21} & v_{22} & v_{23} & v_{24} & v_{25} \\
    \ldots & \ldots & \ldots & \ldots & \ldots \\
    v_{71} & v_{72} & v_{73} & v_{74} & v_{75}
\end{pmatrix}
\]

(9)
where \( v_{ij} \) is the membership degree of the \( i \)-th cognition index \( B_i \) subordinating to the \( j \)-th linguistic terms and \( v_{ij} \in [0,1] \).

When introducing the weights of the cognition indices \( b_i \)'s (\( i = 1, \ldots, 7 \)), we obtain the following weighted cognition matrix:

\[
\tilde{V}' = \begin{pmatrix}
b_1 v_{11} & b_1 v_{12} & b_1 v_{13} & b_1 v_{14} & b_1 v_{15} \\
b_2 v_{21} & b_2 v_{22} & b_2 v_{23} & b_2 v_{24} & b_2 v_{25} \\
\vdots & \vdots & \vdots & \vdots & \vdots \\
b_7 v_{71} & b_7 v_{72} & b_7 v_{73} & b_7 v_{74} & b_7 v_{75}
\end{pmatrix}
\] (10)

Let \( \tilde{G} = R(\tilde{V}'/\tilde{U}') \) be a synthetic matrix taking into account the comparison between the expectation matrix and the cognition matrix. We obtain

\[
\tilde{G} = \begin{pmatrix}
g_{11} & g_{12} & g_{13} & g_{14} & g_{15} \\
g_{21} & g_{22} & g_{23} & g_{24} & g_{25} \\
\vdots & \vdots & \vdots & \vdots & \vdots \\
g_{71} & g_{72} & g_{73} & g_{74} & g_{75}
\end{pmatrix}
\] (11)

In (11), the \( g_{ij} \) can be determined using the following method.

1) For the linguistic terms of very satisfactory, satisfactory, and general (\( j = 1, 2, 3 \)), if the value of cognition is less than that of expectation, i.e. \( b_i v_{ij} < a_i u_{ij} \), then \( g_{ij} = 0 \), it means that customers are not satisfied with the current e-commerce action. If \( b_i v_{ij} = a_i u_{ij} \), then \( g_{ij} = b_i v_{ij} \).

2) For the linguistic terms of very satisfactory, satisfactory, and general, if the value of cognition is more than that of expectation, i.e. \( b_i v_{ij} = a_i u_{ij} \), then \( g_{ij} \) can be determined using one of the three following norms according to the nature of the specific application:
   - Optimistic norm \( g_{ij} = b_i v_{ij} \)
   - Conservative norm \( g_{ij} = a_i u_{ij} \)
   - Compromise norm \( g_{ij} = \gamma a_i u_{ij} + (1 - \gamma) b_i v_{ij}, 0 \leq \gamma \leq 1 \)

3) For the linguistic terms of unsatisfactory and very unsatisfactory, if the value of cognition is more than that of expectation, i.e. \( b_i v_{ij} > a_i u_{ij} \), then \( g_{ij} = 0 \). If \( b_i v_{ij} = a_i u_{ij} \), then \( g_{ij} = b_i v_{ij} \).

4) For the linguistic terms of unsatisfactory and very unsatisfactory, if the value of cognition is less than that of expectation, i.e. \( b_i v_{ij} < a_i u_{ij} \), then \( g_{ij} \) can be determined by one of the three following norms according to the specific application:
   - Optimistic norm \( g_{ij} = a_i u_{ij} \)
   - Conservative norm \( g_{ij} = b_i v_{ij} \)
   - Compromise norm: \( g_{ij} = \gamma a_i u_{ij} + (1 - \gamma) b_i v_{ij}, 0 \leq \gamma \leq 1 \)

The index ECSI\(_1\) can be directly calculated from the matrix \( \tilde{G} \).

\[
ECSI_1 = \tilde{P} \circ \tilde{G}
\]

\[
\tilde{P} = (p_1 \; p_2 \; p_3 \; p_4 \; p_5 \; p_6 \; p_7)
\] (12)

where \( p_i \) (\( i \in \{1, \ldots, 7\} \)) are the weights linearly combining the corresponding expectation indices and cognition indices, i.e. \( p_i = (\lambda a_i + (1 - \lambda) b_i) \), \( 0 \leq \lambda \leq 1 \).

### 3.4. A method for calculating ECSI\(_2\)

ECSI\(_2\) is composed of the customers’ loyal behavior and grumble behavior. However, in practice, the relation between these two behaviors is not bijective.

In the evaluation of the customers’ loyal behavior and grumble behavior, the corresponding indices also include both numerical values and linguistic values. In order to unify all these indices for calculating the aggregated index
ECSI₂, we transform numerical indices into linguistic terms. For example, when calculating the index of the number of suggestions for improvement, we set up several rules as follows: more than five times per month corresponds to very satisfactory, four to five times per month corresponds to satisfactory, three times per month corresponds to general, one to two per month corresponds to unsatisfactory and zero per month corresponds to very unsatisfactory respectively.

In ECSI₂, customers’ grumble evaluation deals with negative indices. In this case, we cannot directly calculate them as we do it for positive indices in loyal behavior. When calculating negative indices, we put forward a method for order adjustment, i.e. very satisfactory is permuted with very unsatisfactory, satisfactory is permuted with unsatisfactory and so on. After this adjustment, the customers’ grumble indices can be calculated using the same method as that with which we calculate the customers’ loyal indices. In the same time, according to the result of ECSI₂, we select the linguistic term corresponding to the biggest membership degree and then determine the customers’ behavior in e-commerce with respect to the five linguistic values: very satisfactory, satisfactory, general, unsatisfactory and very unsatisfactory.

3.5. A method for calculating ECSI

After obtaining two evaluation vectors ECSI₁ and ECSI₂, we calculate the membership degrees of ECSI using the composition operation given by the Eq. (3), corresponding to the five linguistic evaluation terms respectively. The evaluation result of ECSI is the most suitable evaluation term corresponding to the biggest membership degree.

4. Main steps of measurement and its notices of ECSI

In CSI, the main steps of measurement are given as follows [7,8].

Step 1 Determining evaluation’s indices and quantifying them.
Step 2 Determining evaluation targets.
Step 3 Choosing samples to be evaluated.
Step 4 Designing the questionnaire.
Step 5 Implementing investigation.
Step 6 Processing data.
Step 7 Calculating CSI and analyzing it.
Step 8 Compiling the report of CSI.
Step 9 Presenting the suggestion for improving the service quality.

The main steps of processing are very similar between ECSI and CSI. However, the following specificities on e-commerce should be taken into account in the processing of ECSI.

First, ECSI is faced with an open environment and strongly related to a big scale investigation. It is necessary to establish an Internet based method for investigation and analysis of customers’ reactions.

Second, there exist a number of choices for generating the quantity evaluation table, such as five levels quantity table, seven levels quantity table. The specific linguistic evaluation terms should be selected according to the nature of the specific application.

Third, the method for data processing should be reasonable and efficient.

Finally, results of evaluation with ECSI can be used to improve the level of service or reduce the risk in e-commerce.

5. Application

According to Tables 1 and 2, we suppose that we have obtained the following results for customers’ evaluation of book sale using Internet. This type of e-commerce is very successful so far. We use the method presented in this paper to calculate the customer’s satisfaction. The corresponding data are given as follows.
\[ \tilde{U} = \begin{pmatrix} 0.8 & 0.2 & 0 & 0 & 0 \\ 0.9 & 0.1 & 0 & 0 & 0 \\ 0 & 0.3 & 0.7 & 0 & 0 \\ 0 & 0.3 & 0.7 & 0 & 0 \\ 0.2 & 0.8 & 0 & 0 & 0 \\ 0.2 & 0.8 & 0 & 0 & 0 \\ 0 & 0.8 & 0.2 & 0 & 0 \end{pmatrix}, \quad \tilde{V} = \begin{pmatrix} 0.9 & 0.1 & 0 & 0 & 0 \\ 0.8 & 0.2 & 0 & 0 & 0 \\ 0.6 & 0.4 & 0 & 0 & 0 \\ 0.6 & 0.4 & 0 & 0 & 0 \\ 0 & 0.8 & 0.2 & 0 & 0 \\ 0 & 0.8 & 0.2 & 0 & 0 \\ 0 & 0.2 & 0.8 & 0 & 0 \end{pmatrix} \]

\[ \tilde{S} = \begin{pmatrix} 1 & 0 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 \end{pmatrix}, \quad \tilde{T} = \begin{pmatrix} 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 \end{pmatrix} \]

\[ a_i = b_i = 1, \quad i = 1, 2, \ldots, 7. \quad P = (0.1 \quad 0.2 \quad 0.2 \quad 0.1 \quad 0.1 \quad 0.1 \quad 0.1). \]

\[ C = (0.25 \quad 0.25 \quad 0.25 \quad 0.25). \quad D = (0.3 \quad 0.4 \quad 0.3). \quad w_s = 0.4, \quad w_T = 0.6, \quad w_1 = 0.4, \quad w_2 = 0.6. \]

If we use the optimistic norm, we obtain \( \tilde{G} \) as follows.

\[ \tilde{G} = \begin{pmatrix} 0.9 & 0 & 0 & 0 & 0 \\ 0.2 & 0 & 0 & 0 & 0 \\ 0.6 & 0.4 & 0 & 0 & 0 \\ 0.6 & 0.4 & 0 & 0 & 0 \\ 0 & 0.8 & 0.2 & 0 & 0 \\ 0 & 0 & 0.8 & 0 & 0 \\ 0 & 0 & 0.8 & 0 & 0 \end{pmatrix} \]

Then, we obtain

\[ ECSI_1 = (0.33 \quad 0.28 \quad 0.18 \quad 0 \quad 0). \quad ECSI_2 = (0.2 \quad 0.2 \quad 0.18 \quad 0.24 \quad 0.18). \]

\[ ECSI = (0.252 \quad 0.232 \quad 0.18 \quad 0.144 \quad 0.108). \quad \Delta = (-0.099 \quad -0.016 \quad 0 \quad 0.24 \quad 0.18). \]

\[ ECSI_f = (0.153 \quad 0.216 \quad 0.18 \quad 0.384 \quad 0.288). \]

According to the principle of the biggest membership degree, the result of customers’ evaluation is then considered to be unsatisfactory.

In same way, if we use conservative norm, the matrix \( \tilde{G} \) is given as follows.

\[ \tilde{G} = \begin{pmatrix} 0.8 & 0 & 0 & 0 & 0 \\ 0.1 & 0 & 0 & 0 & 0 \\ 0.3 & 0 & 0 & 0 & 0 \\ 0.3 & 0 & 0 & 0 & 0 \\ 0.8 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0.2 & 0 & 0 \end{pmatrix} \]
Then, we have

\[
\begin{align*}
\text{ECSI}_1 &= (0.08 \ 0.22 \ 0.01 \ 0 \ 0), \\
\text{ECSI}_2 &= (0.2 \ 0.2 \ 0.18 \ 0.24 \ 0.18), \\
\text{ECSI} &= (0.152 \ 0.208 \ 0.184 \ 0.144 \ 0.108), \\
\Delta &= (0.091 \ -0.021 \ 0.174 \ 0.24 \ 0.18), \\
\text{ECSI}_f &= (0.263 \ 0.187 \ 0.358 \ 0.384 \ 0.288).
\end{align*}
\]

The biggest membership degree of \( \text{ECSI}_f \) is 0.384 and the result of customers’ evaluation is then considered to be unsatisfactory.

### 6. Conclusion

This paper studied the concept of customer satisfaction index in e-commerce from the viewpoint of system control and system analysis. For this purpose, a model for evaluating this index has been proposed. Moreover, this paper put forward a method for calculating this index based on five levels quantity table using fuzzy techniques. The work presented in this paper can provide a theoretic foundation for reducing the risk in advance in e-commerce. The model of ECSI deals with many complex factors at different levels. As most of transactions in e-commerce concern international trade, the cultural backgrounds in different countries should also be taken into account in the characterization of customer satisfaction on Internet. Therefore, in our future work, we will further improve ECSI by integrating additional cultural factors into the existing formalization.

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