ABSTRACT
Trust investigation in B2C E-commerce is usually based on analyzing relative compositions of B2C E-commerce, and mainly focuses on direct perceived trust of consumers. But in real B2C E-commerce, recommended trust of mature consumer is an important channel to enhance trust for a new consumer. A recommended trust evaluation method in B2C E-commerce is proposed based on fuzzy analytic hierarchy process. Firstly, compositions that affect online trust in B2C electronic-commerce are analyzed comprehensively. An individual trust evaluation system is established. Furthermore, for a new consumer, using trust evaluations of multiple mature consumers that he/she is familiar with, the study adopts fuzzy analytic hierarchy process to build composite recommended trust evaluation method. Finally, the proposed recommended trust evaluation method is applied to evaluate recommended trust of real B2C online shopping. It simulates the process of trust evaluating of a new consumer and illustrates the validity of proposed recommended trust evaluation method.

Keywords:
B2C electronic commerce, recommended trust, trust evaluation, analytic hierarchy process, fuzzy evaluation

1. INTRODUCTION
In china, internet has enjoyed a rapid growth in customer base, yet according to the survey
conducted by China Internet Network Information Center (CNNIC) in June 2009, only 25.5 percent of internet users purchase online in China [1]. The over-internet-distrust will impede the popularity of Internet usage. As a form of social relationship in human society, trust is an effective mechanism in reducing complexity and uncertainty of social environment [2]. Due to E-commerce’s high uncertainty, high degree of information asymmetry, anonymity, lack of control and potential opportunism when compared with traditional business activities, online trust has become one of the crucial elements that determine the development of online transactions and E-commerce [3-4]. Therefore, a lot of researchers in E-commerce related fields from home and abroad has been focusing on study of online trust. Currently, learning from Psychology, Sociology, Management, Science, Economics, Marketing and other disciplines, the major study method of online trust is to combine the particularity of E-commerce System to build online trust theory based on general trust, to analyze related elements that affect trust and making hypothesis and empirical research. Business-to-Customer (B2C) is a major mode of E-commerce, and the research about trust of B2C has been attached significant importance to in related studies. At present, the research mainly focuses on analyzing one aspect of relevant B2C E-commerce components—consumers’ direct perceived trust and initial trust [6-11]. Nevertheless, recommendation from mature consumers still plays an extremely crucial role in enhancing trust of new consumers, no matter in real Internet promotion or E-commerce development. This impact is further strengthened in China, a country whose cultural tradition emphasizes on social relationships and face to face transactions, yet with an unsound trust system.

Based on fuzzy analytic hierarchy process, the dissertation proposes a recommended trust evaluation method in B2C E-commerce. First of all, on the basis of current research results, through analyzing thoroughly about factors affecting online trust in B2C E-commerce system from a perspective of consumers, goods, online companies and their websites, technology as well as human environment and so forth, the consumers’ individual trust evaluation system is established. As for a new consumer, using trust evaluations of multiple mature consumers that he/she is familiar with, the study adopts fuzzy analytic hierarchy process to build composite recommended trust evaluation method. At last, the proposed recommended trust evaluation method is applied to evaluate recommended trust of some real B2C online shopping. It simulates the process of trust evaluation of a new consumer and illustrates the validity of the proposed recommended trust evaluation method. Compared with statistical theory based on online trust evaluation methods [7-9],[11], the proposed one in this article has three advantages as follows: to begin with, the new method is more in line with actual E-commerce transactions in its simulation of the recommended trust evaluation to new individual consumers. Moreover, the new method is more consumer-targeted than statistical methods in that it effectively integrates distinctive trust evaluations of individual consumers. Last but not least, the new one enables a reasonable conversion between language and scoring evaluation, thus gaining objective language assessment.

2. TRUST INFLUENCING FACTORS IN B2C E-COMMERCE

In this section, the indicators system for influencing factors of individual trust evaluation is built based on analyzing relative compositions of B2C E-commerce system by summarization of
literature. Many scholars have defined the conception of trust from different disciplines angle, for instance, in Psychology, trust is considered as a part of personal qualities, namely the belief, expectations and feelings developed during individual psychological process; whereas experts in management believe that trust is a form of organizational control used to reduce uncertainly as well as transaction cost \(^2\). Trust is essentially personal relationships according to Mayer \(^12\). McKnight differentiates trust belief from trust intention \(^13\). Online trust is one’s belief, expectations as well as feelings to trust another under the existence of uncertainties in E-commerce circumstances. Therefore, the study defines trust as: in certain social and technological environment, consumers’ perceived intuition that finally forms subjective belief, expectations and feelings towards trading counterparty, its website and environment to reduce transaction risks and uncertainties, which are caused by information asymmetry, trading vituality and time span in B2C E-commerce. As a result, trust in B2C E-commerce is affected by consumers, goods, online companies and their websites as well as environment, etc. From those elements, the indicators system for trust influencing factors is further established.

### 2.1 CONSUMER-RELATED FACTORS

In B2C online transactions, consumers make analysis, judgment and evaluation about online business and its website, product attributes, as well as perceived information of environment on the basis of existing experience and knowledge. This is a subjective process in which consumers react to trading counterparty and environment, thus closely related to individual subjective factors. Empirical studies have shown that the following elements have something to do with consumers’ perceived trust \([3, 8-9, 23]\). A1: Experience of using Internet. A2: Experience of trading online. A3: Attitude towards risk, namely preference, which usually involves three types: risk preference, risk neutral and risk aversion. People who belong to risk preference are more likely to accept online transaction. A4: Trust propensity, the willingness to trust an individual develops through long-term growth in society, which reveals consumers’ trust trend towards general things, Internet trust trend included.

### 2.2 GOODS-RELATED FACTORS

In B2C online transactions, consumers purchase goods through online transactions, which results in a close tie between the product attributes and consumers’ perceived trust and risks. Empirical studies have illustrated that the elements related to consumers’ perceived trust \([4,14]\) are as follows: B1: Types of goods. Generally speaking, search goods have a lower perceived risk than experience goods. B2: Brand of goods. A good brand can reduce consumers’ perceived risks. B3: Price of goods. Under the premise of the law of value, the lower the price, the more attractive it is to consumers. On the contrary, the either too high or too low price deviating from the law of value will lead to consumer distrust. B4: The instruction of goods. Appropriate instructions will improve consumers’ purchase intention; while rough or exaggerated descriptions will easily cause distrust to a certain consumer.

### 2.3 WEBSITE-RELATED FACTORS

In B2C online transactions, Consumers get information about goods and online companies through Internet. E-commerce website layout design, navigation, site content design, transaction
implementation methods, the security protection icon, relevant links and applications related to computer technologies are all channels of transmitting trust. Empirical researches have revealed that following factors are related to consumers’ perceived trust \(^{[4, 14-15]}\): 

C1: Website reputation and popularity. C2: Website security, which includes transaction security, privacy protection and third-party certification. C3: Good navigation system, namely the ease of use of the website. C4: Transaction implementation convenience. C5: Website style, consisted of layout design, image and content design, namely the usefulness of the website.

**2.4 ONLINE COMPANY-RELATED FACTORS**

In B2C online transactions, the real subject to which consumers face is online company, so the online company’s own characteristics are closely related to consumers’ trust. Empirical studies have proved elements that have an impact on consumers’ perceived trust are \(^{[7, 16-17]}\): D1: Online company’s reputation and popularity. D2: Online company’s history and business scale. D3: Online company’s willingness to make customized products for consumers. D4: Consumers’ familiarity to the online company.

**2.5 ENVIRONMENT-RELATED FACTORS**

The factors that influence trust in B2C E-commerce comprise both technology and social environment. As the information transmission medium, the security of data transmission and transaction privacy are prerequisites of online transaction \(^{[5]}\). Social environment, information technology, relevant laws and regulations, as well as trust management are effective means to lower B2C E-commerce information asymmetry \(^{[6, 18-20]}\). Following human environment related factors have an influence on consumers’ perceived trust: E1: Social cultural factors. E2: Legal environment factors. E3: Commercial operational environment factors. Following technology environment related factors have an impact on consumers’ perceived trust: E4: Network technology maturity. E5: Information access facility. E6: Network system stability. E7: Website authority safety certification.

Before the purchase intention is formed, a consumer needs to build purchase trust by integrating every relevant factor in the transaction process. A recommended trust evaluation method in B2C E-commerce is proposed on the basis of fuzzy analytic hierarchy process.

**3. RECOMMENDED TRUST EVALUATION BASED ON FUZZY ANALYTIC HIERARCHY PROCESS**

First, from the two levels of factors related to trust in B2C E-commerce, the hierarchy indicators system for individual trust influencing factors is built. Let mature consumers to score on trust factors of some online purchase, involving score evaluation of every factor in the two levels and pairwise judgment matrix between every two determinants; then using fuzzy Delphi group decision-making method to determine the weight of each influencing factor. Finally, the recommended trust evaluation of a new consumer in B2C E-commerce can be gained from the fuzzy gravity center method.

**3.1 HIERARCHY INDICATORS SYSTEM FOR INDIVIDUAL TRUST INFLUENCING FACTORS**
FACTORS

Through analysis of elements that affect trust in B2C E-commerce in Chapter 2, the two-level indicators system for trust influencing factors in B2C E-commerce is established as follows: Consumer-related factors (A), including A1, A2, A3 and A4; Goods-related factors (B), including B1, B2, B3 and B4; Website-related factors, including C1, C2, C3, C4 and C5; Online company-related factors, including D1, D2, D3 and D4; Environment-related factors, including E1, E2, E3, E4, E5, E6 and E7.

3.2 SUB-FACTORS SCORING RULE

24 sub-factors in five aspects of online trust are scored and evaluated by mature consumers. The scoring rule is: from 0 to 100, the degree to which the specific factor perceives trust is strengthened. The followings explain the relationship between the value of each factor and trust. Consumer-related factors: the higher value of A1 indicates more experience in surfing the Internet, and the evaluation of online trust is more reliable, to a new consumer, the degree of trust is also higher; A2 is similar to A1; the greater value of A3 is, the greater degree of trust towards online transaction; A4 is similar to A3. Goods-related factors: the higher value of B1 indicates consumers are more prone to trust the goods; B2, B3, B4 is similar to B1. Website-related factors: the greater value of C1 means that consumers are more likely to trust the website; C2, C3, C4, C5 are similar to C1. Online company-related factors: the greater value of D1 means that consumers are more likely to trust the company; D2, D3, D4 are similar to D1. Environment-related factors: the greater value of E1 shows that consumers are more prone to trust the culture environment; E2, E3, E4, E5, E6, E7 are similar to E1.

3.3 WEIGHT OF MAIN FACTORS AND SUB-FACTORS

The dissertation adopts Fuzzy Delphi Analytic Hierarchy Process Method [21] to determine the weight of main factors and sub-factors of trust. Based on the Delphi group survey, the method uses triangular fuzz number to synthesize the pairwise judgment matrix made by each consumer, thus getting the fuzzy pairwise judgment matrix of consumer group, then determining the fuzzy weight vector of consumer group’s fuzzy judgment, last, determining final weight of each sub-factor by single criterion weight decision analysis, the detailed process is described in literature [21]. Assume the weight matrix of main factors A, B, …E is $W_{15}$, the weight matrix of sub-factors are $W_{14}$, $W_{14}$, $W_{15}$, $W_{15}$ and $W_{17}$ respectively.

3.4 EVALUATION SET AND SINGLE FACTOR EVALUATION MATRIX

In order to transform scoring evaluation into trust language evaluation, suppose any sub-factor F’s possible existing trust level is $G = \{G_1, G_2, G_3, G_4, G_5\}$, if the score of factor $F < 60$, it means totally distrust ($G_1$); $60 \leq F < 70$, it means basic trust ($G_2$); $70 \leq F < 80$, it means semi-trust ($G_3$); $80 \leq F < 90$, it means great confidence in the factor ($G_4$); $90 \leq F < 100$, it means full trust ($G_5$).
Hypothesez n mature consumers score on $A_i$—one of main factor A’s sub-factors—according to trust level stated above, score values are recorded as $\{a_1, a_2, ..., a_n\}$. If the indicators on trust level $G$ are $\{a_{i1}, a_{i2}, ..., a_{im}\}$, then the membership of the certain trust factor on trust level $G$ is:

$$p_i = \frac{a_{i1} + a_{i2} + ... + a_{im}}{a_1 + a_2 + ... + a_n} \quad (1)$$

$p_i$ is the membership on trust level of $G_i$—a trust evaluation of a sub-factor of $A_i (i = 1, 2, ..., 5)$. Thus we can get evaluation matrix of sub-factor $A_i$.

$$R_A = [p_1, p_2, p_3, p_4, p_5] \quad (2)$$

The single factor evaluation matrix of main factor A is derived from the integration of each sub-factor evaluation matrix of main factor A.

$$R_A = [R_{A_1}, R_{A_2}, R_{A_3}, R_{A_4}]^T \quad (3)$$

The evaluation matrix of all main trust factors can be merged into the single factor evaluation matrix.

$$R = [R_A, R_B, R_C, R_D, R_E]^T \quad (4)$$

### 3.5 COMPREHENSIVE EVALUATION OF SUB-FACTORS

Presume the weight matrix of sub-trust-factors of main factors A are $W_{1x4}^{(A)}$ respectively. Evaluation matrix of A is $R_A$. The comprehensive evaluation of main factor A’s sub-factor is:

$$P_A = W_{1x4}^{(A)} \circ R_A \quad (5)$$

There are various options about compose operation $\circ$, the research chooses $(+, *)$ operation. If the sum of each element of $P_A$ doesn’t equal 1, then the normalization process of $P_A$ is necessary, namely dividing the sum of each element of $P_A$ to obtain comprehensive evaluation of main factor A’s sub-factors. Similarly, comprehensive evaluation of other main factors’ sub-factors can be calculated as well.

### 3.6 COMPREHENSIVE FUZZY EVALUATION

Suppose comprehensive evaluations of all main trust factors A, B...E’s sub-factors are $P_A, P_B, P_C, P_D, P_E$. The weight matrix of main trust factors A, B...E are $W_{1x5}^{(i)}$, then the comprehensive fuzzy evaluation is:

$$P = W_{1x5}^{(i)} \circ [P_A, P_B, P_C, P_D, P_E] \quad (6)$$

The compose operation is the same with (5). Similarly, the normalization process of $P_A$ can be completed.

### 3.7 INTERPRETATION OF EVALUATION
The value gained from formula (6) is the membership of comprehensive recommended trust on each trust level. Fuzzy set center of gravity is an inherent property of fuzzy sets, which reveals the region in which the membership of fuzzy sets concentrate. Fuzzy set center of gravity can be utilized to characterize expert evaluation [22]. By adopting the fuzzy center method of defuzzification, we can get comprehensive recommended trust language evaluation. Suppose the domain trust level \{G_1, G_2, G_3, G_4, G_5\} shows is \{x_1, x_2, x_3, x_4, x_5\}, the comprehensive evaluation is \(P\), then the comprehensive recommended trust evaluation is:

\[
f = P^* [x_1, x_2, x_3, x_4, x_5]^T
\]

If the value of \(f\) is the closest to \(G_i (i = 1, 2, ..., 5)\), then it is the trust evaluation of corresponding level.

4. CASE STUDY

The study evaluates on a recommended trust of an actual online purchase to illustrate the rationality of recommended trust evaluation model. The experiment scenario is: someone is preparing to purchase some cosmetics online. Due to her unfamiliarity with online purchasing, she needs to make online purchasing related trust analysis before the purchase intention is generated. She develops online trust mainly through friends’ recommendation. Six friends with whom she is familiar and having online purchasing experience score on trust factors and fill out pairwise judgment matrix between sub-factors (Please contact the author if original data are needed).

4.1 SINGLE ELEMENT EVALUATION MATRIX

By making analysis of the score evaluation sheet, the membership of sub-factors’ trust level can be calculated according to formula (1), shown as Table 1.

<table>
<thead>
<tr>
<th>Sub-factor</th>
<th>(p_1)</th>
<th>(p_2)</th>
<th>(p_3)</th>
<th>(p_4)</th>
<th>(p_5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(A_1)</td>
<td>0.0000</td>
<td>0.1363</td>
<td>0.3040</td>
<td>0.3585</td>
<td>0.2013</td>
</tr>
<tr>
<td>(A_2)</td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.6316</td>
<td>0.1789</td>
<td>0.1901</td>
</tr>
<tr>
<td>(A_3)</td>
<td>0.0000</td>
<td>0.1405</td>
<td>0.1508</td>
<td>0.5186</td>
<td>0.1901</td>
</tr>
<tr>
<td>(A_4)</td>
<td>0.0000</td>
<td>0.1404</td>
<td>0.1617</td>
<td>0.6979</td>
<td>0.0000</td>
</tr>
<tr>
<td>(B_1)</td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.3076</td>
<td>0.6924</td>
</tr>
<tr>
<td>(B_2)</td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.6483</td>
<td>0.3517</td>
</tr>
<tr>
<td>(B_3)</td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.6500</td>
<td>0.3500</td>
</tr>
<tr>
<td>(B_4)</td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.8246</td>
<td>0.1754</td>
</tr>
<tr>
<td>(C_1)</td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.3074</td>
<td>0.3313</td>
<td>0.3613</td>
</tr>
<tr>
<td>(C_2)</td>
<td>0.0000</td>
<td>0.1478</td>
<td>0.4761</td>
<td>0.1783</td>
<td>0.1978</td>
</tr>
</tbody>
</table>
4.2 DETERMINATION OF WEIGHT OF FACTORS

This paper processes the pairwise judgment matrix of main trust factors by the method discussed in 3.3, the group fuzzy pairwise judgments of main trust factors are expressed as below.

\[
\begin{align*}
\mathbf{C}_i & = \begin{bmatrix} 0.0000 & 0.0000 & 0.3002 & 0.5172 & 0.1826 \\ 0.0000 & 0.1423 & 0.3113 & 0.3505 & 0.1959 \\ 0.0000 & 0.0000 & 0.3094 & 0.5061 & 0.1844 \\ 0.0000 & 0.0000 & 0.0000 & 0.3148 & 0.6852 \\ 0.0000 & 0.1488 & 0.6608 & 0.1904 & 0.0000 \\ 0.0000 & 0.0000 & 0.3094 & 0.5061 & 0.1844 \\ 0.0000 & 0.0000 & 0.3002 & 0.5172 & 0.1826 \end{bmatrix} \\
\mathbf{D}_i & = \begin{bmatrix} 0.0000 & 0.0000 & 0.3105 & 0.6895 & 0.0000 \\ 0.0000 & 0.1423 & 0.3261 & 0.5313 & 0.1959 \\ 0.0000 & 0.0000 & 0.3105 & 0.6895 & 0.0000 \\ 0.0000 & 0.0000 & 0.0000 & 0.3148 & 0.6852 \\ 0.0000 & 0.1425 & 0.3261 & 0.5313 & 0.1959 \\ 0.0000 & 0.0000 & 0.0000 & 0.3148 & 0.6852 \end{bmatrix} \\
\mathbf{E}_i & = \begin{bmatrix} 0.0000 & 0.4654 & 0.3410 & 0.1935 & 0.0000 \\ 0.0000 & 0.4534 & 0.5466 & 0.0000 & 0.0000 \\ 0.0000 & 0.6238 & 0.1820 & 0.1942 & 0.0000 \\ 0.0000 & 0.0000 & 0.1549 & 0.6686 & 0.1765 \\ 0.0000 & 0.0000 & 0.0000 & 0.8187 & 0.1813 \\ 0.0000 & 0.0000 & 0.3149 & 0.6851 & 0.0000 \end{bmatrix} \\
\mathbf{F}_i & = \begin{bmatrix} 0.0000 & 0.2854 & 0.3277 & 0.1860 & 0.2008 \end{bmatrix}
\end{align*}
\]

Then the group standardized fuzzy weight vector can be obtained:
The author uses the triangular fuzzy number in literature [21] to calculate weights. The decision weights depend on the decision-making environment parameters and decision-making optimistic coefficient. Assume the decision-making environment parameters and decision-making optimistic coefficient are 0.5 and 0.8 respectively, through calculation and normalization, the weight vector of main trust factors A, B, …E can be expressed as below:

\[ W^{(i)} = [0.2031 \ 0.2003 \ 0.2095 \ 0.1939 \ 0.1932] \]  

Likewise, the weight vectors of sub-trust-factors are:

\[ W^{(A)}_{14} = [0.2483 \ 0.2503 \ 0.2567 \ 0.2447] \]  
\[ W^{(B)}_{14} = [0.2618 \ 0.2383 \ 0.2535 \ 0.2464] \]  
\[ W^{(C)}_{14} = [0.2603 \ 0.2438 \ 0.2564 \ 0.2395] \]  
\[ W^{(D)}_{14} = [0.1346 \ 0.1398 \ 0.1385 \ 0.1448 \ 0.1475 \ 0.1521 \ 0.1428] \]  

4.3 COMPREHENSIVE FUZZY EVALUATION AND LANGUAGE EVALUATION EXPLANATION

From Figure 1, formula (5) and (11-15) we can get the comprehensive evaluation of sub-factors:

\[ P_A = [0.000 \ 0.1043 \ 0.3119 \ 0.4377 \ 0.1462] \]  
\[ P_B = [0.000 \ 0.000 \ 0.000 \ 0.6030 \ 0.3970] \]  
\[ P_C = [0.000 \ 0.0577 \ 0.3403 \ 0.3788 \ 0.2231] \]  
\[ P_D = [0.000 \ 0.0723 \ 0.3232 \ 0.4261 \ 0.1784] \]  
\[ P_E = [0.000 \ 0.2532 \ 0.2646 \ 0.4013 \ 0.0810] \]  

From formula (6) and (15-19) we can get the comprehensive fuzzy evaluation:

\[ P = [0.000 \ 0.0962 \ 0.2484 \ 0.4492 \ 0.2062] \]  

Suppose the domain trust level \{G_1, G_2, G_3, G_4, G_5\} shows is \{30, 65, 75, 85, 95\}, from formula (7) and (21) we can know that the comprehensive evaluation fuzzy center of gravity indicates is 82.6529, which is the closest to \(G_4\); thereby, the great confidence in the certain factor can be concluded.

5. CONCLUSION
Trust is the key success factor of online transaction and E-commerce. The current researches about trust in B2C E-commerce mainly focus on analyzing relative compositions of B2C E-commerce and direct perceived trust of consumers, the study method is to establish online trust theory, analyze the assumptions of related influencing elements of trust and make empirical research. But in actual B2C E-commerce, recommended trust of mature consumers is an important channel to increase trust of a new consumer. Based on fuzzy analytic hierarchy process, the article presents a recommended trust evaluation method in B2C E-commerce. Firstly, elements that affect online trust in B2C electronic-commerce are analyzed comprehensively, and an individual trust evaluation system is established. As for a new consumer, utilizing the evaluation of sub-factor of trust scored by mature consumers he/she is familiar with, we can determine the pairwise judgment matrix between sub-factors. The membership of trust level can be inferred from the score evaluation of sub-factors; the weight of each sub-factor can be inferred from the pairwise judgment matrix. From the membership shown in Figure 1 and weight of sub-factors, we can get the comprehensive fuzzy recommended trust evaluation. Eventually, by adopting the fuzzy center method of defuzzification, we can get comprehensive recommended trust language evaluation. The proposed recommended trust evaluation method is applied to evaluate recommended trust of some real B2C online shopping. It simulates the process of trust evaluation of a new consumer and illustrates the validity of the proposed recommended trust evaluation method. Compared with statistical theory based on online trust evaluation methods, the proposed one in this article has three advantages. The new method is more in line with actual E-commerce transactions in its simulation of the recommended trust evaluation to new individual consumers; the new method effectively integrates distinctive trust evaluations of individual consumers; the new one enables a reasonable conversion between language and scoring evaluation, thus gaining objective language assessment.

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