Online Reputation Evaluation of E-commerce Enterprises Based on Fuzzy Theory

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Abstract. With the development of network communication technology, the Internet technology is no longer the main factor restricting the development of e-commerce. While e-commerce facilitates people's daily life, the amount and quantity of transactions have greatly increased, and the risks arising from the virtuality of transactions have also increased dramatically. The author, with the construction of online reputation evaluation index system of e-commerce enterprises, comprehensively evaluates the online reputation of e-commerce enterprises with transactions carried out at their self-built platforms, by means of fuzzy analytic hierarchy process (AHP). Through practical application, this paper provides technical support for online reputation evaluation of e-commerce enterprises.

Keywords: E-Commerce, Online Reputation, Index Weight, Fuzzy Comprehensive Evaluation

1 Introduction
Traditional commercial activities have been greatly impacted, and the e-commerce industry that has arisen along with it is booming. With the expansion of the users of the Internet and the diversity of the ways of use, e-commerce economy is changing people's lives all the time.

At present, Internet technology is no longer the main bottleneck restricting the development of e-commerce, and credit (reputation) is the main factor affecting the successful completion of an e-commerce transaction. Credit is different from that of reputation. Credit mainly refers to that when money and goods are separated, economic transactions between people are still performed as agreed. The credit is reflected in economic behaviors. Reputation is accumulated by several credit behavior processes, which is reflected in behavior results. As can be seen from the above concept, reputation, relative to credit, requires accumulation over time, that is, credit in a certain period of time is reflected as reputation [1]. But in real life, the two are often used interchangeably.

In recent years, scholars have studied e-commerce reputation management and reputation evaluation. For example, in reference [2], the reputation evaluation model proposed is studied. In reference [3], based on the uncertainty of online system interaction, the author proposed a method combining Semi quantitative methods to apply to the reputation evaluation. Ji Shuxian, et al [4] believe that the establishment of online reputation management is beneficial for both parties to know...
the credit status of their trading partners, thus improving the success rate of online transactions.

2 Evaluation index system

2.1 Basic principle

1) All-roundness

E-commerce is the online transaction of physical products through virtual trading on the Internet. Therefore, it is necessary to consider both online and offline factors simultaneously.

2) Timeliness

The index in the system should pay attention to the influence of time accumulation on the index. The development of enterprises is dynamic. Most enterprises will constantly adjust their policies and measures at all levels. The timeliness of data needs to be considered, and the evaluation results also have certain timeliness [5].

3) Core

There are many factors that affect online reputation, and the index system cannot cover all. Therefore, it is important to focus on the core index. The indexes in the index system are differently weighted according to their importance.

2.2 Index System for Online Reputation Evaluation of E-commerce Enterprises

Starting with business operation and business service, and taking into account the existence of malicious bad commercial behaviors such as bad evaluation, the author constructed an index system for e-commerce online reputation evaluation from three aspects: offline enterprise evaluation, online enterprise service and online buyer feedback, as shown in Table 1.

| Name of primary index | Name of secondary index | Index description |
|-----------------------|-------------------------|------------------|
| A: offline enterprise evaluation | A1: enterprise's own quality | Refers to the registered capital, scale, influence in the industry, brand recognition, etc. of an enterprise |
|                        | A2: technological innovation ability | Reflected in an enterprise's technical reserves, product updates, etc. |
|                        | A3: funds and financial position of an enterprise | Refers to the profitability, solvency and capital turnover efficiency of an enterprise. |
|                        | A4: technological content of enterprise products | Mainly refers to an enterprise's product prices. The product price is directly proportional to the technological content of the product. |
|                        | A5: enterprise market share | Refers to the proportion of an enterprise's product sales in the industry. |
|                        | A6: external environment for enterprise development | Refers to the policy support, financial assistance and international situation, etc. for enterprise development. |
| B: online enterprise service | B1: sales of online transactions | Refers to the total sales amount of online transactions within a certain period of time. |
|                        | B2: Sales quantity in a certain period of time | Refers to the total sales volume of online transactions in a certain period of time. |
|                        | B3: shipping logistics | Refers to the delivery time limit, logistics service time limit and service quality of online transactions. |
|                        | B4: online sales consulting service | Refers to customer service provided by online sales personnel. |
|                        | B5: security of funds supervision | Refers to the supervision of online transaction funds by enterprises and the return of funds when a transaction is terminated during the period from the start of online transaction to the unfinished transaction, when customer service funds are paid but goods are not received. |
|                        | B6: commitment and | Refers to a customer's consultation on after-sales service |
2.3 Determination of index weight

2.3.1 Building Hierarchy Model

According to Table 1, Establishment of online reputation evaluation hierarchy model with enterprise as the main body, in Fig1.

![Online Reputation Evaluation of E-commerce Enterprises](image)

**Fig1.** Establishment of online reputation evaluation hierarchy model with enterprise as the main body

2.3.2 Analytic Hierarchy Process

In order to facilitate the quantitative determination of the weight of each evaluation index, the author uses Satty's 1 ~ 9 scaling procedure to express the relative importance of each evaluation index [6, 7].

2.3.3 Determination of Weight of Evaluation Index by Judgment Matrix

Select 10 experts to assign values to the evaluation indexes according to the 1-9 scale method, and finally get the weights of each index as shown in Table 2-5.

**Table 2** The weight of the first level index relative to the overall goal

|   | A   | B   | C   | Weight |
|---|-----|-----|-----|--------|
| A | 1   | 1/2 | 6   | 0.3681 |
| B | 2   | 1   | 5   | 0.5498 |
|  | A   | B   | C   | Weight |
| C | 1/6 | 1/5 | 1   | 0.0821 |

Note: \( \lambda_{max} = 3.0858; \) CR=0.0825
Table 3 The relative weight of each secondary index in the off-line evaluation of enterprises

|   | A   | A1 | A2 | A3 | A4 | A5 | A6 | Weight |
|---|-----|----|----|----|----|----|----|--------|
| A1| 1   | 6  | 2  | 5  | 4  | 7  |    | 0.4233 |
| A2| 1/6 | 1  | 1/4| 1/2| 1/3| 2  |    | 0.0589 |
| A3| 1/2 | 4  | 1  | 4  | 1/2| 3  |    | 0.1933 |
| A4| 1/5 | 2  | 1/4| 1  | 1/2| 3  |    | 0.0894 |
| A5| 1/4 | 3  | 2  | 2  | 1  | 4  |    | 0.1916 |
| A6| 1/7 | 1/2| 1/3| 1/3| 1/4| 1  |    | 0.0435 |

Note: $\lambda_{\text{max}} = 6.3353$; CR=0.0532

Table 4 The relative weight of each secondary index in enterprise online service

|   | B   | B1 | B2 | B3 | B4 | B5 | B6 | Weight |
|---|-----|----|----|----|----|----|----|--------|
| B1| 1   | 2  | 7  | 4  | 5  | 7  |    | 0.4060 |
| B2| 1/2 | 1  | 5  | 4  | 5  | 6  |    | 0.3021 |
| B3| 1/7 | 1/5| 1  | 1/3| 1/2| 2  |    | 0.0523 |
| B4| 1/4 | 14 | 3  | 1  | 2  | 4  |    | 0.1228 |
| B5| 1/5 | 1/5| 2  | 1/2| 1  | 3  |    | 0.0801 |
| B6| 1/7 | 1/6| 1/2| 1/4| 1/3| 1  |    | 0.0368 |

Note: $\lambda_{\text{max}} = 6.2194$; CR=0.0348

Table 5 Relative weight of secondary indicators in buyer’s online feedback

|   | C   | C1 | C2 | C3 | Weight |
|---|-----|----|----|----|--------|
| C1| 1   | 3  | 6  |    | 0.6548 |
| C2| 1/3 | 1  | 3  |    | 0.2499 |
| C3| 1/6 | 1/3| 1  |    | 0.0953 |

Note: $\lambda_{\text{max}} = 3.0183$; CR=0.0176

From table 3 to table 5, it can be seen that if the consistency ratio CR of each judgment matrix is less than 0.1, the weight distribution of each evaluation index is reasonable.

2.4 Fuzzy Comprehensive Evaluation of Online Reputation Evaluation of E-commerce Enterprises by AHP

2.4.1 Determination of Evaluation Object

The evaluation object of this paper is the e-commerce enterprise whose sales mode is the direct sales through a self-built sales platform.

2.4.2 Establishment of Evaluation Factor Set

According to the specific indicators in Table 1 and figure 1, set the first level factor set of e-commerce enterprise online reputation evaluation system $U={(\text{offline enterprise evaluation, online enterprise service and online buyer feedback})}$. The Level 2 factor set is $U_1={(\text{enterprise’s own quality, technological innovation ability, enterprise financial status, enterprise product technological content, enterprise market share and external environment for enterprise development})}$, $U_2={(\text{sales from online transactions, sales volume within a certain period of time, delivery logistics, online sales consulting service, fund supervision safety and after-sales service commitment and fulfillment})}$, and $U_3={(\text{evaluation released by the buyer, recent trading funds of the buyer and evaluation received by the buyer})}$.

At present, S&P credit rating standard is an internationally recognized credit rating standard. In this paper, e-commerce enterprises online reputation is divided into four levels, $V={(A, B, C, D)}$. 

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Note: $\lambda_{\text{max}}$ is the maximum eigenvalue of a matrix, and CR (Consistency Ratio) is a measure of consistency in judgment matrices used in the Analytic Hierarchy Process (AHP) method. CR is calculated as CR = (Consistency Index) / (Random Index). A CR value less than 0.1 indicates a reasonable level of consistency in the judgments made.

For a 3x3 matrix, the CR is calculated as CR = CI/RI, where CI is the Consistency Index and RI is the Random Index for a 3x3 matrix, which is approximately 0.58.

For a 4x4 matrix, the CR is calculated as CR = CI/RI, where CI is the Consistency Index and RI is the Random Index for a 4x4 matrix, which is approximately 0.90.
3 Application Examples

Background: In 2019, the e-commerce industry has developed rapidly. In this external environment, an e-commerce enterprise mainly sells electrical household appliances such as electric water heaters, gas water heaters, water purifiers, air purifiers and wall-mounted boilers through its self-built sales platform.

3.1 Determination of Weight Set
According to table 1 to table 5, the weights of each index layer are as follows.

\[ W = \begin{bmatrix} 0.3681 & 0.5498 & 0.0821 \\ 0.4233 & 0.0589 & 0.1933 & 0.0894 & 0.1916 & 0.0435 \\ 0.4060 & 0.3021 & 0.0523 & 0.1228 & 0.0801 & 0.0368 \\ 0.6548 & 0.2499 & 0.0953 \end{bmatrix} \]

3.2 Determination of Fuzzy Comprehensive Evaluation Index
In this paper, 10 technical experts in management, operation, brand and quality are invited to score each index. Based on the level evaluation frequency of each expert on different factors, the fuzzy evaluation matrix of each index factor is obtained.

Offline enterprise evaluation R1: 

\[ R1 = \begin{bmatrix} 0.6 & 0.3 & 0.1 & 0 \\ 0.5 & 0.2 & 0.2 & 0.1 \\ 0.4 & 0.3 & 0.2 & 0.1 \\ 0.2 & 0.4 & 0.3 & 0.1 \\ 0.5 & 0.2 & 0.2 & 0.1 \\ 0.1 & 0.4 & 0.4 & 0.1 \end{bmatrix} \]

Online enterprise service R2: 

\[ R2 = \begin{bmatrix} 0.4 & 0.4 & 0.2 & 0 \\ 0.3 & 0.4 & 0.3 & 0 \\ 0.2 & 0.5 & 0.2 & 0.1 \\ 0.4 & 0.4 & 0.1 & 0.1 \\ 0.2 & 0.3 & 0.4 & 0.1 \\ 0.2 & 0.4 & 0.3 & 0.1 \end{bmatrix} \]

Online buyer feedback R3: 

\[ R3 = \begin{bmatrix} 0.1 & 0.4 & 0.4 & 0.1 \\ 0.1 & 0.4 & 0.4 & 0.1 \\ 0.1 & 0.5 & 0.2 & 0.2 \end{bmatrix} \]

Table 6 Risk Grading Quantification and Feature Description

| Online reputation level | Online reputation feature description |
|-------------------------|---------------------------------------|
| A                       | The enterprise has good online service, high product quality, huge operation and development potential, and high buyer satisfaction. |
| B                       | The enterprise has good online service, high product quality, stable operation and development, and good buyer satisfaction. |
| C                       | The enterprise has relatively good online service, average product quality, unstable operation and development, and poor buyer experience. |
| D                       | The enterprise has poor online service, poor product quality, unstable operation and development, and poor buyer consumption experience. |

1) B1 = [0.4788 0.2882 0.1753 0.0577]
2) B2 = [0.3360 0.3973 0.2376 0.0292]
3) B3 = [0.1000 0.4095 0.3809 0.1095]
4) R:

\[ R3 = \begin{bmatrix} 0.4788 & 0.2882 & 0.1753 & 0.0577 \\ 0.3360 & 0.3973 & 0.2376 & 0.0292 \\ 0.1000 & 0.4095 & 0.3809 & 0.1095 \end{bmatrix} \]

B = [0.3692 0.3581 0.2264 0.0463]
The results of fuzzy comprehensive evaluation index show that the membership degrees of Levels A, B, C and D online reputation of the e-commerce enterprise are 36.92%, 35.81%, 22.64% and 4.63% respectively. According to the maximum membership, the online reputation level of the enterprise is Level A.

4 Conclusion
In recent years, the consumers have shown distrust in the development of e-commerce enterprises, which is mainly reflected in poor experience after buying. At the same time, due to the large number of e-commerce enterprises, it is difficult for consumers to make a choice. The online reputation evaluation of e-commerce enterprises helps to improve the business environment and urge enterprises to improve product quality and service. With the help of the constructed online reputation evaluation model of e-commerce enterprises, this paper comprehensively evaluates the online reputation of an enterprise by FAHP. The facts prove that this method has good operability.

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References
[1]. Chen X Y. Research on Initial Reputation Score Determination Method and Reputation Score Aggregation Model in Online Reputation Management System [D]. 2013.
[2]. Sang A, Ismail R, Boyd C. A survey of trust and reputation systems for online service provision [J]. Decision Support Systems, 2007, 43(2):618-644.
[3]. Zhang Y, Wang S G, Xu Y T. Online credit evaluation system based on analytic hierarchy process and set pair analysis [C] International Symposium on Computational Intelligence and Design. Tokyo: IEEE, 2008: 453-456.
[4]. Ji Sh X, Hu P and Cheng F. Research on Credit Calculation Model in Online Reputation Management System [J]. Forecasting, 2008(04):61-67.
[5]. Wang Y J. Research on Credit Evaluation Methods of Online Trading Enterprises [D]. 2007.
[6]. Yu L, Wang J L, Li Ch X, et al. Health Assessment of Shahu Lake Wetland in Ningxia Based on DPSIR and AHP [J]. Journal of Southwest University: Natural Science Edition, 2014.36(2):124-130.
[7]. Yin T. Construction of Evaluation Index System of Road Transportation Emergency Capacity by AHP [J]. Journal of Southwest China Normal University: Natural Science Edition, 2012,37(11):107-111.