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Credit Risk Assessment of Online Shops Based on Fuzzy Consistent Matrix

Yao Yao

Institute of Service Engineering, Hangzhou Normal University, 310012, China
Email address: yyaoexist@hotmail.com

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Abstract: Despite the fast development in trading volume, potential credit risk hindered the development of e-commerce in emerging economies. This paper studies the credit rating industry and its application in e-commerce firstly. Then fuzzy consistent matrix, which makes conform to the consistency of human decision making as its special property of center-division transitivity, is applied to construct a comprehensive credit risk assessment system. Fuzzy consistent matrix helps to integrate incomparable credit risk indicators into one unified criteria. Finally, credit risk ranking is provided for online shops.

Keywords: Credit rating, online shop, fuzzy consistent matrix

1 Introduction

With increasing availability of computers and accessibility of the internet, E-commerce become a booming industry, not only in developing countries but also in emerging economy. Despite the fast development in trading volume, lack of regulation and potential default risk hinder standardization of the industry and the perfection of e-commerce market structure, especially in emerging economy.

The credit risk issue in online shopping is not sufficiently addressed. Asymmetric information problem is more serious in on-line shopping than other forms of commercial activities. Credit rating system, which was originally used in credit risk assessment in financial and banking industry, can be introduced into e-commerce industry.

A comprehensive evaluation indicator system would be necessary in credit rating. There are many credit risk indicators, which differ tremendously and incomparable. Fuzzy consistent matrix, a scientific method to deal with multiple objective decision making process, would be applicable in constructing the comprehensive evaluation indicator system.

This paper will discuss credit risk assessment of online shops with application of fuzzy consistent matrix. In section 2 I will discuss the selection of the indicators in credit

rating; in section 3 construct the mathematical model; in section 4 give an example; in section 5 give some conclusions.

2 The Indicators of Credit Rating for Online Shops

This section will illustrate credit rating system and its applicability. Reference to well accepted credit rating indicators and considered special characters of e-commerce, a set of scientific indicators of credit risk of online shops will be worked out.

The most outstanding character of credit rating is to put all aspects of credit risk information into one single result which denote a certain credit quality degree, such as AAA denotes high credit quality or low risk (A.Duff, and S.Einig, 2009). Indicators in any credit rating method can be devided into two types, quatitative or qualitative. Character, capacity, management economic factors are considered important indicators in any credit rating system. Regardless of the original application field, the aim of credit rating is a compound measure of credit risk, which applicable in any area, include e-commerce. Hence, credit rating can also be applied in online shopping.

Most online shops fall into the category of small and medium sized corporation. Large proportion of online shops are individual-owned business. Therefore, the credit rating for small firm is more applicable in on-line shop credit rating. Generally speaking small firm has shorter operating history, limited production variety, less experienced management, centralized ownership and ignored human capital investment. All the characters above makes small firm more sensitive to credit risk. However, smaller firms are also more efficient than average, more flexible and adaptive, more motivated to innovation and may have some potentials in certain industry.

In credit rating, economic and industrial enviornment should have higher weighting for small firms. Small firms are more sensitive to the economic enviornment, such as economic cycle, national industrial policy, law modification and geograpghic factors. Simple bussiness structure and limited production of small company imcreased operation risk. The life cycle of industry also has more influence on small company. Without famous brand or solid sales partner, they are more vulnarable in sunsetting industry or highly competitive industry. Moreover, qualitative measures is more important than quantitative measures in credit rating for small and medium sized corporation. Short history, fast change, vast extents of operating status and limited management…all these makes financial data of small company inaccsessible and unreliable. Potential profitabilty and credit quality in the long run is more important.

Information asymmetry problem in e-commerce could be effectively reduced by an independent credit rating amongst different stakeholders (M.H.Millon, and A.V. Thakor, 1984). In emerging economies, most online shops are not obliged to submit financial

report, or give any detailed financial or operational information. The capital, asset, liability, and earnings of most online shops remain unknown to the pubic. Hence, the asymmetric information brings more demand for credit risk rating in e-commerce.

Flexibility is another character of online shops. Online shops dramatically vary in size. Judging an online shop merely on operating time or size can be misleading. Small sized shops can covert easily while economic condition changes, and not necessarily more vulnerable to economic environment than larger ones.

Credit rating is a compound measurement. In front of tons of indicator data information from all aspects, professionals need to make evaluation based on their own experience. There are large numbers of online shops emerging everyday. Credit rating system needs to assess various sorts of "soft" information into integrity (Butler and Rodger, 2003). The objectivity and accuracy of credit rating is hard to derive. Fuzzy consistent matrix can help bring objectivity to integrate "soft information", and guarantee optimal result in rational decision-making on credit rating.

The credit rating result is usually updating according to the operational or economic condition. (A.Duff, and S.Einig, 2009) When credit risk decreased, the ratings will update to a better result and vice versa. However, with neither entry nor exit barrier, short duration of online shops make accurate forecasting or timely adjusting of credit rating relatively difficult. Most credit information of online shops is only good for ex post rather than ex ante analysis.

Credit rating is important for not only customers but also business owners. Credit rating information can be useful for different stakeholders, include parties of both buyers and sellers, as well as regulation organizations (A.W.A.Boot, T.T.Milbourn, and A. Schmeits, 2006). Standardized credit rating system could brought stablity and development into the online market, credit rating could remove hesitation of potential customers, lead sellers to be more credible and operate more prudently.

The credit rating method actually used in practice based only on anonymous customer comment online, which is neither objective nor scientific. Considering commonly used indicators in credit rating as a source of reference, combine credit rating of small and medium sized company and the character of online shops, I select six indicators to simplify the problem, include both qualitative and quantitative measures. There are mainly five determinants of credit risk, each with some indicators: character (customer comment on quality), capacity (operating time, sales volume), management (inventory turnover, delivery service), and environment (economic and industrial perspective).

3 Mathematical Model

There are many different types of indicators in credit rating, which are not comparable and difficult to integrate into one unified indicator. Fuzzy consistent matrix is applicable in multi-objective decision (M.Yao, B.Shen, and J. Luo, 2005). Particularly,

the special properties of center-division transitivity makes fuzzy consistent matrix conform to the consistency of human decision-making. Therefore, fuzzy consistent matrix can be applied effectively in widespread fields.

Suppose there are n objectives (O_k), each has a weight of $w_k (k = 1, \cdots, n)$. There are *m* solutions $A_i (i = 1, \cdots, m)$, the optimization process based on fuzzy consistent matrix is as following:

3.1. Construct the Fuzzy Preferential Relation Matrix (FRM):

We can derive n fuzzy preferential relation matrices $B_k = (b_{ij}^k)_{m\times m}, (k = 1, \cdots, n)$ in which $b_{ij}^k = 1.0$ if under O_k, A_i is preferable to A_j; $b_{ij}^k = 0.5$ if A_i is equally preferable as A_j; if A_j is preferable to A_i, then $b_{ij}^k = 0.0$;

3.2. Transform The FRM into Fuzzy Consistent Matrices: $R^k = (r_{ij}^k)_{m\times m}$

in which $$r_{ij}^k = (r_i - r_j)/2m + 0.5 \tag{3.1}$$

$$r_i = \sum_{j=1}^{m} b_{ij}^k \tag{3.2}$$

3.3. Calculate Relative Importance Degree Under Single Objective:

Calculate relative preferential degree s_i^k of A_i under O_k with root method,

$$s_i^k = \overline{s_i} \Big/ \sum_{j=1}^{m} \overline{s_i} \tag{3.3}$$

in which $$\overline{s_i} = (\sum_{j=1}^{m} r_{ij}^k)^{1/m} \tag{3.4}$$

3.4. Calculate the Total Relative Preferential Degree under Multi Objectives:

$$T_i = \sum_{k=1}^{n} w_k s_i^k \tag{3.5}$$

If $T_1 \geq T_2 \geq \cdots \geq T_m$, then the order of preference would be $A_1 \geq A_2 \geq \cdots \geq A_m$

4 Applications, a Simulated Example

Credit risk rating is a multi-objective decision making process. There are many problems, include incomparability amongst indicators and difficulty in quantification. The indicators and the system could be either positive or negative related. Fuzzy consistent matrix would help isolate the subjectivity in the integration of indicators, and achieve relatively reasonable credit rating result.

Six indicators (objectives) are selected to assess credit risk of online shops, include: customer comment (O_1), operating history (O_2), sales volume (O_3), inventory turnover (O_4), delivery service (O_5), economic and industrial perspective (O_6). Suppose there are five online shops to be assessed.

4.1. Construct Fuzzy Preferential Relation Matrices:

Fuzzy preferential relation matrices of five shops under six different indicators can be constructed by using the method described before in section 3.1. B_1 to B_6 indicate Fuzzy preferential relation matrices under objectives O_1 to O_6 respectively in sequence.

$$B_1 = \begin{bmatrix} 0.5 & 1 & 0 & 0 & 1 \\ 0 & 0.5 & 0.5 & 1 & 0 \\ 1 & 0.5 & 0.5 & 0 & 0 \\ 1 & 0 & 1 & 0.5 & 0 \\ 0 & 1 & 1 & 1 & 0.5 \end{bmatrix} \quad B_2 = \begin{bmatrix} 0.5 & 0 & 0 & 0 & 1 \\ 1 & 0.5 & 0 & 1 & 0 \\ 1 & 1 & 0.5 & 0 & 0.5 \\ 1 & 0 & 1 & 0.5 & 1 \\ 0 & 1 & 0.5 & 0 & 0.5 \end{bmatrix} \quad B_3 = \begin{bmatrix} 0.5 & 0 & 1 & 0 & 1 \\ 1 & 0.5 & 1 & 0 & 1 \\ 0 & 0 & 0.5 & 0 & 0.5 \\ 1 & 1 & 1 & 0.5 & 0.5 \\ 0 & 0 & 0.5 & 0.5 & 0.5 \end{bmatrix}$$

$$B_4 = \begin{bmatrix} 0.5 & 0.5 & 0.5 & 1 & 1 \\ 0.5 & 0.5 & 1 & 1 & 1 \\ 0.5 & 0 & 0.5 & 1 & 0 \\ 0 & 0 & 0 & 0.5 & 0 \\ 0 & 0 & 1 & 1 & 0.5 \end{bmatrix} \quad B_5 = \begin{bmatrix} 0.5 & 1 & 1 & 0 & 0 \\ 0 & 0.5 & 0.5 & 0.5 & 1 \\ 0 & 0.5 & 0.5 & 1 & 0.5 \\ 1 & 0.5 & 0 & 0.5 & 0 \\ 1 & 0 & 0.5 & 1 & 0.5 \end{bmatrix} \quad B_6 = \begin{bmatrix} 0.5 & 0.5 & 1 & 1 & 0 \\ 0.5 & 0.5 & 0 & 1 & 0 \\ 0 & 1 & 0.5 & 0 & 1 \\ 0 & 0 & 1 & 0.5 & 0 \\ 1 & 1 & 0 & 1 & 0.5 \end{bmatrix}$$

4.2. Construct Fuzzy Consistent Matrices:

Using equation (3.1) and (3.2) in section 3.2, FRMs in section 4.1 can be transferred into fuzzy consistent matrices as following:

$$R_1 = \begin{bmatrix} 0.5 & 0.55 & 0.55 & 0.5 & 0.4 \\ 0.45 & 0.5 & 0.5 & 0.45 & 0.35 \\ 0.45 & 0.5 & 0.5 & 0.45 & 0.35 \\ 0.5 & 0.55 & 0.55 & 0.5 & 0.4 \\ 0.6 & 0.65 & 0.65 & 0.6 & 0.5 \end{bmatrix} \quad R_2 = \begin{bmatrix} 0.5 & 0.4 & 0.35 & 0.3 & 0.45 \\ 0.6 & 0.5 & 0.45 & 0.4 & 0.55 \\ 0.65 & 0.55 & 0.5 & 0.45 & 0.6 \\ 0.7 & 0.6 & 0.65 & 0.5 & 0.65 \\ 0.55 & 0.65 & 0.4 & 0.35 & 0.5 \end{bmatrix}$$

$$R_3 = \begin{bmatrix} 0.5 & 0.4 & 0.45 & 0.35 & 0.6 \\ 0.6 & 0.5 & 0.25 & 0.45 & 0.7 \\ 0.55 & 0.75 & 0.5 & 0.2 & 0.45 \\ 0.65 & 0.55 & 0.8 & 0.5 & 0.75 \\ 0.4 & 0.3 & 0.55 & 0.25 & 0.5 \end{bmatrix} \quad R_4 = \begin{bmatrix} 0.5 & 0.45 & 0.65 & 0.8 & 0.6 \\ 0.55 & 0.5 & 0.7 & 0.85 & 0.65 \\ 0.35 & 0.3 & 0.5 & 0.65 & 0.45 \\ 0.2 & 0.15 & 0.35 & 0.5 & 0.3 \\ 0.4 & 0.35 & 0.55 & 0.7 & 0.5 \end{bmatrix}$$

$$R_5 = \begin{bmatrix} 0.5 & 0.5 & 0.5 & 0.55 & 0.45 \\ 0.5 & 0.5 & 0.5 & 0.55 & 0.45 \\ 0.5 & 0.5 & 0.5 & 0.55 & 0.45 \\ 0.45 & 0.45 & 0.45 & 0.5 & 0.4 \\ 0.55 & 0.55 & 0.55 & 0.6 & 0.5 \end{bmatrix} \quad R_6 = \begin{bmatrix} 0.5 & 0.6 & 0.55 & 0.65 & 0.45 \\ 0.4 & 0.5 & 0.45 & 0.55 & 0.35 \\ 0.45 & 0.55 & 0.5 & 0.6 & 0.4 \\ 0.35 & 0.45 & 0.6 & 0.5 & 0.3 \\ 0.55 & 0.65 & 0.6 & 0.7 & 0.5 \end{bmatrix}$$

4.3. Calculate Relative Preferential Degree:

The relative preferential degree under all indicators can be calculated by equation (3.3) and (3.4) in section 3.3. The result of relative preferential degree under all indicators is in Table 4.1.

Table 4.1: Relative preferential degree.

Indicators	Shop A	Shop B	Shop C	Shop D	Shop E
Customer comment	0.194	0.200	0.200	0.194	0.212
Operating history	0.191	0.199	0.203	0.208	0.199
Sales volume	0.197	0.200	0.200	0.211	0.192
Inventory turnover	0.209	0.212	0.197	0.182	0.201
Delivery service	0.200	0.200	0.200	0.196	0.204
Economic perspective	0.203	0.195	0.200	0.195	0.207

4.4. Calculate the Total Relative Preferential Degree under Multi Indicators:

Considering the influential power of different indicators on credit risk, the weighing of each indicator is as following: w_1=0.2, w_2=0.1, w_3=0.2, w_4=0.15, w_5=0.15, w_6=0.2.

The total relative importance can be calculated by equation (5), the result is as following: T_1=0.1993, T_2=0.2007, T_3=0.1999, T_4=0.1975, T_5=0.2029

That is $T_5>T_2>T_3>T_1>T_4$.

Hence, the order of the five shops from high to low creditworthiness is shop 5, shop 2, shop 3, shop1 and shop 4. Shop 5 has highest credibility, while shop 4 has the lowest credibility.

5 Conclusions

At present credit risk problem of online shops is not sufficiently regulated in emerging economies. Based on fuzzy consistent matrix, this paper constructed a comprehensive evaluation indicator system in Credit rating. There are many indicators to assess credit risk of online shops. However, the integration of different indicators is a complicated problem. Fuzzy consistent matrix, a scientific method to deal with multiple objective decision making process, is used to unify the indicators and construct a credit risk assessment system of online shops.

Credit risk is difficult to be measured in quantity, and the financial information of online shops is hard to collect. Therefore, application of fuzzy consistent matrix can help solve the problem, construct a credit rating system combine many qualitative measures and some quantitative measures, on an ordinal rather than numeral basis.

In the future, third-party specialized institutions are supposed to provide fair, scientific, objective assessment. The property of discretion brought uncertainty in credit risk evaluation. Fuzzy consistent matrix method gives some perspective to address this

problem. Moreover, other measures, such as imposing compulsory financial report of online shops, would be necessary to improve credit worthiness of e-commerce along with credit rating.

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Yao Yao received the MS degree in international money and banking from University of Birmingham in 2007. She is currently a teacher in the Institute of Service Engineering, Hangzhou Normal University. Her research interests are in the areas of knowledge service, financial engineering and computing, and international finance.