A Fuzzy Comprehensive Evaluation Method on Firms' Credit Sale Risk*

Guoqiang Liu¹, Zongfang Zhou¹, Xinmin Song¹, and Yong Shi²

¹ School of Management, University of Electronic Science & Technology of China,
P.R. China, 610054

zhouzff@uestc.edu.cn

² College of Information Science & Technology, University of Nebraska at Omaha, Omaha,
NE 68182, U.S.A

itdmeditor@yahoo.com.cn

Abstract. This paper utilizes the fuzzy comprehensive evaluation method (FCEM) to evaluate firm's credit sale risk, and provide the credit line and time limit of a credit sale according to the grades of firm's credit sale risk. Finally, we also present an example to validate the feasibility of this method. The result will greatly benefit in enhancing the firm's credit sale risk management.

Keywords: Credit sale risk, FCEM, credit sale grades.

1 Introduction

Market economy, characterized with openness and competition, will no doubt lead to the formation of buyers' market, and then Chinese market will be a highly developed credit market, which brings risks and costs to the firms as well as benefits. The credit sale is adding the risk of bad debts, additional financing cost, managing cost, which may lower the firms' capacity of earning profits.

Firms in our country have little consciousness of credit. Lack of scientific risk management system and perfect credit sale management measurements within the business has made great bad debts losses to the firms. Some even said that credit sales are going to die but no credit sales are waiting to die. So, enhance the credit management system and establish the evaluation grade system of client credit has been a burning question of all the firms.

Client's credit risk is credit sale risk, that is, the client unable to or unwilling to repay the credit sale on schedule. Because it should consider many aspects and involves a great deal of quantitative and qualitative indicators to make an analysis of customer's credit risk, including three phases of a trade. The present research on firms' credit risk mostly concentrates on the whole assessment of firm's credit ^{[6][7][8]}, and mainly adopts the accounting method. They seldom carry on a systemic study on credit sale risk ^[7], not to say to combine client's credit level with the credit line and credit time limit.

* National Natural Science Foundation of China (No. 70671017).

This paper uses the fuzzy comprehensive evaluation method to give a quantitative analysis of clients' credit risk and to evaluate the clients' risk degree, and the credit line the firms may offer, and then determine the credit time limit. The result will be an important reference for the firms' credit sale policy-making.

2 Indictors of the Firms' Credit Sale Risk

The firms mostly gets the information of clients through the front line staff, however, it's hard for them to get clients' financial information. According to the characteristics of clients' credit risk, this paper builds the indictor system of accessing firms' client credit risk on the basis of the credit grade indictor of the firms and the characteristic of clients' credit (Fig. 1). In my opinion, in order to avoid overly affecting the formulation of firms' credit policy by a client's past credit sales situation, only the credit situation during some period T need to be evaluated by firms (Time T can be confirmed by the industry environment of the firms).

Firm's client credit sale risk U should include the following indictors: previous transaction U_1 , business status U_2 , management and profit level U_3 , developing potential U_4 , financial analysis U_5 .

(1) Previous transaction U_1 includes: ordering quantity U_{11} , repayment and payment attitude U_{12} , goodwill U_{13} .

(2) Business status U_2 includes: leader's quality U_{21} , employ's quality U_{22} , technical level U_{23} , product sales income U_{24} , gross profit U_{25} , capitalization U_{26} , business environment U_{27} .

(3) Management and profit level U_3 includes: market share U_{31} , major business and funds status U_{32} , total profit growth rate U_{33} , products sale growth rate U_{34} , capital preserves value growth rate U_{35} .

(4) Developing potential U_4 includes: market prospect U_{41} , major products potential U_{42} , industry position U_{43} .

(5) Financial analysis U_5 includes: liability and net assets ratio U_{51} , short-term liability and net asset ratio U_{52} , quick ratio U_{53} , working capital U_{54} , receivable accounts turnover U_{55} .

3 The Application of FCEM

3.1 Evaluation of the indictor weights

This paper uses AHP method to determine the weight of firms' client credit sale risk, and the calculation procedure is as follows:

(1) Use scale 1-9 to construct Judgment Matrix A

Element a_{ij} in matrix A refers to the relative importance of U_{ij} pairwise. An expert panel generally constructs the judgment matrix. Certainly firms may also choose experienced sellers, financial personnel.

Fig. 1. Indicator system of client's credit sale risk

Table 1. Scale 1–9

Scale	Meaning
1	Indicates two indicators are of equal importance;
3	Indicates the former indicator is weakly more important than the latter one;
5	Indicates the former indicator is strongly more important than the latter one;
7	Indicates the former indicator is very strongly more important than the latter one;
9	Indicates the former indicator is absolutely more important than the latter one;
2, 4, 6, 8	Intermediate values;
Reciprocal	If the importance ratio of indicator i to j is a_{ij} , then this ratio of indicator j to i is $a_{ji} = 1/a_{ij}$;

(2) Using maximum eigenvalue to calculate the weight:

$$A\omega = \lambda_{\max}\omega \tag{1}$$

Where $\lambda_{\max}$ is the maximum eigenvalue in matrix A , ω is corresponding characteristic vector. It can be regarded as the weight vector behind the normalization of ω .

(3) Consistency test

Consistency test is used to validate whether the judgment matrix has a consistency. If not, we have to adjust the matrix by the steps follows:

I. Consistency index:

$$C.I. = \frac{\lambda_{\max} - n}{n - 1} \quad (2)$$

II. Finding the corresponding average random consistency : $R.I.$

III. Consistency ratio:

$$C.R. = \frac{C.I.}{R.I.} \quad (3)$$

If $C.R. < 0.1$, it is acceptable that the matrix is consistent; otherwise, the judgment matrix would need some modification.

(4) Calculate combined weights

Relative weight of the indicator should be calculated from one level to another. Supposing the weight of the second level indicator to the indicator of client's credit risk was $\omega = (\omega_1, \omega_2, \dots, \omega_k)^T$, and the weight of the third level indicator to the second level was $\omega_i = (\omega_{i1}, \omega_{i2}, \dots, \omega_{in})^T$, $i = 1, 2, \dots, k$. Then the combined weight of the third level indicator to client's credit risk should be $V = (v_1, v_2, \dots, v_n)^T$, and $v_i = \sum_{j=1}^k \omega_j \omega_{ij}$, $i = 1, 2, \dots, n$.

3.2 Clients' Credit Sale Risk Grades

Client's credit sale risk is related directly to the firms' credit sale policy to this client. This paper grouped client's credit sale risk into six rates, each with corresponding credit line.

(1) Membership degree of quantitative index

There are so many kinds of membership functions that the judgment of its belongingness is very subjective.

Whereas in the practical situation, belonging to which membership function can be decided, according to the specific situation of firms' clients. We will apply membership function: $\mu v_i(u) = e^{-a(u-c)^b}$. In this formula, there are some instructions: u stands for the actual value of the indicator; $\mu v_i(u)$ means the

Table 2. Firms’ client credit sale risk and corresponding credit line

Rat e	Definition	Annotation / note
1	For the client with very good credit, firms could provide the most affordable credit risk.	$a > b > c > d$ Firms could adjust rate and credit indicator accordingly, plus with some measures if necessary.
2	For the client with better credit, firms could provide credit provide under a%.	
3	For the client with average credit, firms could provide credit risk under b%.	
4	For the client with bad credit, firms could provide credit risk under c%.	
5	For the client with worse credit, firms could provide credit risk under d%.	
6	For the client with most terrible credit, firms would provide no credit risk. Only can be conducted the transaction by cash.	

membership degree of u to v_i , $a > 0, b$ is plus even number, a and b are unallocated constants, and c is the constant when it is applied to membership degree of v_i level $\mu v_i(u) = 1$.

(2) Membership degree of qualitative indicator

When choosing senior marketing personnel, financial personnel and business management personnel, we should classify all the evaluative elements into groups according to the already designated evaluation standard. And then calculate the frequency M_{ij} of each evaluate elements divided by level v_i . At last the membership degree would become clear:

$$\mu_{ij} = M_{ij} / n \tag{4}$$

From above membership function we can make out the degree r_{ijt} of U_i ’s indicator u_{ij} devised by the evaluation number t , the U_i ’s fuzzy comprehensive evaluation matrix:

$$R_i = \begin{bmatrix} r_{i11} & r_{i12} & \cdots & r_{i1m} \\ r_{i21} & r_{i22} & \cdots & r_{i2m} \\ \cdots & \cdots & \cdots & \cdots \\ r_{in1} & r_{in2} & \cdots & r_{inn} \end{bmatrix} \tag{5}$$

In this matrix, i is the quota’s number of each categorical element, that is, $U_1, U_2, \dots, U_5$; where n : the number of each evaluation indicator in U_i ; m : the evaluation number of vector’s evaluation set. By the formula $U_i = \omega_i \bullet R_i$, we can get the fuzzy comprehensive evaluation set of all indicators in

level U and $U_i = (b_{i1}, b_{i2}, \dots, b_{im})$, ω_i stands for proportion vector of each U_i evaluation indicator, b_{it} is get from $M(\bullet, \oplus)$ operator, that is,

$$b_{it} = \omega_{i1} \bullet r_{i1t} \oplus \omega_{i2} \bullet r_{i2t} \oplus \dots \oplus \omega_{in} \bullet r_{int} \quad (6)$$

This operator has to take all the elements' weight into consideration, which fulfill firms' need of taking the whole synthesized indicator of client's credit risk into consideration.

3.3 The Credit Sale Time Limit

Credit sale time limit usually means the period from the time when clients buy the commodity to the time of payment. Too long a period will cause some indefinite elements and the corresponding cost. Too short a period would cause clients lose interest, thus lose its function. Therefore, firms should set an appropriate credit sale time limit for each would-be client.

Supposing all the clients would pay credit loan on time, and according to Capital-Time-Value Principle and the fact that credit profit will always be larger than credit cost, together with credit line, firms will get the credit sale time limit to its clients.

$$[\text{credit loan} / (1+R)^{CT} - \text{sales cost} - \text{credit sales cost}] / \text{total cost} \geq R \quad (7)$$

In this formula, credit sale cost includes bad debts cost (credit loan $\times$ bad debts rate), opportunity cost ((profit rate + loan interest) $\times$ CT) and management cost (the additional fee of receivable account). R stands for standard financial rate of return; CT shows the credit sale time limit.

If clients want to extend credit sale time limit, firms can use the same method to test whether the cost is equal to or larger than firm's interest rate. If the answer is positive, then the request is acceptable; otherwise, it would be refused.

4 Illustration

Suppose there is a company, its credit management department is evaluating a client's credit risk. Consulting its senior marketing personnel and management personnel, the company works out a comparative evaluation matrix. Each indicator's weight would be clear by power method:

Indicator weights of U : (0.4185, 0.0973, 0.1599, 0.0618, 0.2625);
 Indicator weights of U_1 : (0.1007, 0.6738, 0.2255);
 Indicator weights of U_2 : (0.0667, 0.0260, 0.1099, 0.3648, 0.1958, 0.0410);
 Indicator weights of U_3 : (0.1441, 0.4699, 0.0792, 0.2619, 0.0448);
 Indicator weights of U_4 : (0.1172, 0.6144, 0.2684);
 Indicator weights of U_5 : (0.0901, 0.3466, 0.1668, 0.3466, 0.0500).

According to the membership function with a normal distribution and suggestions from senior marketing personnel, financial personnel and management personnel, client's membership degree to each level should be:

$$U = (0.0885, 0.1178, 0.2730, 0.2124, 0.2008, 0.1075)$$

The conclusion is that the credit sale risk of this firm's clients belongs to the third rate and the credit line is 15% at the most. Through the formula (7), we can get that the time limit available to the client is no more than 23 days.

5 Conclusion

This paper illustrates a systematic research of an firms' credit sale policy and evaluation on its client's credit risk. There are three parts of this process: evaluating clients' credit risk by the fuzzy comprehensive evaluation method, working out clients' credit line with the consideration of clients' credit rate, and calculating the time limit of credit sale. Besides, the evaluation system also includes recovering the money, result evaluation of credit department, etc., we will devote ourselves to these researches in the future.

References

1. Wang Lianfen, Xu Shubai, Theory of Analytic Hierarchy Process (in Chinese), RENMIN University of China Press, 1990.
2. Yang Lunbiao, Gao Yingyi, Fuzzy Mathematics Theory and Application (in Chinese), South China University of Technology Press, 2003.
3. Peng Zuzeng, Sun Wenyu, Fuzzy Mathematics and its Application (in Chinese), Wuhan University Press, 2002.
4. Zhou Zongfang, Tang Xiaowo, The Research on Ordering Structure of Credit[J].Journal of Systems Science and Information, 2004,3(2) :531-534
5. Zhou Zongfang, Tang Xiaowo. Research on Targets Evaluation for Customers Credit[J].Journal of Systems Science and Information, 2003,4(1) :635-638
6. Zhou Wenxin, Wang Jiancheng, The Fuzzy Comprehensive Evaluation Method of the Credit Level of Firms Rating (in Chinese) [J], Systems Engineering, vol19 no4, pp72-75, July 2001.
7. Lin Hanchuan, Xia Minren, Firms Rating Theory and Practice (in Chinese), University of International Business and Economics Press, pp133-160, 2003.
8. Pu Xiaolei, Han Jiaping, Firms Credit Management paragon, China International Business and Economics Press (China Commerce and Trade Press), 2001.