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An Assessment Method for Individual Credit Risk Based on SP Theory

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Abstract: Nowadays, the assessment of individual credit risk has drawn great attention of the financial institutions and many assessment models have been developed. However, although the traditional assessment models can assess the credit risk from different aspects, they require that the credit information of the credit subjects is complete. Therefore, those traditional models cannot be well suitable for the individual credit assessment. In order to solve this problem, a more suitable model should be established. Compared with the previous work, this study presents an integrated model. The new model integrates the existing assessment models by using SP theory. The integrated model based on SP theory will greatly improve the suitability while with less credit information of the credit subjects. Through a specific example, the validity of the model has been verified. From the findings of this study, it shows that the new assessment model has some theoretical value and practical significance for the assessment of individual credit risk.

Key words: SP theory, individual credit, credit risk, assessment model

INTRODUCTION

At present, most of the famous international financial institutions have paid great attention to the assessment of their consumers' credit. For a lot of human and financial resources have been devoted to developing into interrelated researches, establishing assessment models and systems of credit risk, such as the single-variable model, the multifactor Z value model, KMV model and CreditMetrics^{TM} and CreditRisk^{+} model and so on (Wang, 2008; Li, 2003). The traditional assessment models of credit risk can be mainly divided into three categories. The first category is the models based on structure model (Merton, 1974) and simplified model (Jarrow and Turnbull, 1995).Those models have rigorous theoretical foundations but they do not make full use of consumers' historical information. The second category is the intelligent models which are represented by neural network models (Lando, 1998). The intelligent models have strong adaptability but require lots of training simples (Liu *et al*., 2010; Daehyon *et al*., 2013). The last category is the widely used statistical measurement models, such as logistic (Lai *et al*., 2010), SVM model (Zhang and Zhou, 2009; Yang and Zhang, 2012) and a large number of decision-making models and experts systems. Apart from the models mentioned above, a few scholars also discussed the essential problems of credit risk with multi-indicators (Ren *et al*., 2010).

However, all the models above are not perfectly suitable for individual credit risk assessment. In one hand, it's because of the small-scale production, low level of information transparency and small amount of loan of individuals (Wang *et al*., 2011a), especially for individual householders, private owners (Wang and Zhu, 2011).

In the other hand, the financial market in China is imperfect, so it lacks of complete data for individual information. Nevertheless, it is undeniable that each of the traditional assessment models has its own advantage. So, it is possible to integrate the traditional assessment models of individual credit risk through using PS theory.

In this study, series of uncertain numbers are estimated by the combination of the specific traditional assessment model of individual credit risk with macro-environment. In practice, the model with SP theory can be amended according to the actual situation based on the principals of uncertainty.

FRAMEWORK OF INDIVIDUAL CREDIT RISK ASSESSMENT MODEL BY SP THEORY

The SP theory studies a pair of sets which is based on the specific issues that we are going to research in. Because one thing can be always divided into two aspects, so it is the same with SP theory. SP theory can describe the connection degree of that two given sets with the form as:

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$$\mu = a+bi+cj \tag{1}$$

$$i, j\in[-1, 1], (a, b, c>0), \qquad a+b+c = 1$$

(Wang *et al*., 2011b; Li and Zhou, 2011). Generally, the connection degree of a pair of sets can be interpreted as:

$$\mu = a+bi-c \tag{2}$$

$i\in[-1, 1]$ a and c both describes the deterministic parts of the relationship of the pair of sets. Further, a represents the same part of the two sets in the pair, c represents the opposition part of the two sets in the pair and b describes the uncertain parts of the relationship of the pair of sets, i describes the uncertainty trend of credit risk. If $i\in[-1, 0]$, the uncertainty will increase the total risk and if $i\in[0, 1]$, the uncertainty will decrease the total risk. Specifically, a pair of sets is composed of two sets, A and B. This pair of sets is described as H = (A, B), in a given background W. Supposed that there are N characteristics in sets and among them, S characteristics are the same in both A and B, P characteristics are different in A and B. And the other F = N-S-P characteristics are neither same nor different in A and B. Further, define S/N as the same degree in W; define F/N as the different degree in W; define the P/N as the opposite degree in W. Then the connection degree can be represented as:

$$\mu(W) = \frac{S}{N} + \frac{F}{N} i - \frac{P}{N} \tag{3}$$

Let that S/N = a, F/N = b and P/N = c, in that case we get $\mu(W) = a+bi-c$.

As we can see from the discussions above, the key point to establishing the assessment model of individual credit risk by SP theory is the determination of the same degree, the different degree and the opposite degree. The following four principals to determine the three degrees can be obeyed:

- Confirm the different definitions of the three degrees in different traditional models
- Make full use of the already known results of the traditional models
- Reflect the characteristics of the traditional models
- Focus on the background of specific issues

FRAMEWORK OF CART MODEL BY PS THEORY

The model of Classification and Regression Trees (CART) classifies the grades of index to assess the credit risk. The Fig. 1 gives an example of CART model. In this model, B_1, B_2 and B_3 are the nodes of bankruptcy. NB_4 and NB_5 are the nodes of safety.

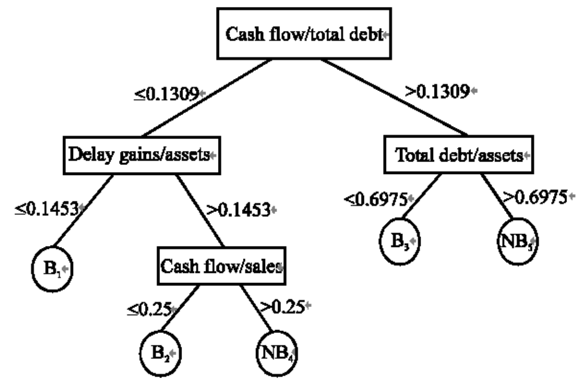

Fig. 1: Assessment model of CART

According to the Fig. 1, the individual credit risk can be classified into five types in this study. The connection degree of the pair of sets H = (bank, individual) is $\mu = a+bi-c$. $\mu_A>0$ is credible consistency, it illustrates the lower credit risk; $\mu_A<0$ is credible reverse, it illustrates the higher credit risk.

According to the Fig. 1, the connection degree can be represented as:

- Individual credit risk-free:

$$\mu_A = \frac{6}{10} + \frac{4}{10} i \tag{4}$$

- Low individual credit risk:

$$\mu_A = \frac{5}{10} + \frac{4}{10} i - \frac{1}{10} \tag{5}$$

- Special attention individual credit risk:

$$\mu_A = \frac{4}{10} + \frac{4}{10} i - \frac{2}{10} \tag{6}$$

- High individual credit risk:

$$\mu_A = \frac{1}{10} + \frac{4}{10} i - \frac{5}{10} \tag{7}$$

- Inevitable loss:

$$\mu_A = \frac{4}{10} i - \frac{6}{10} \tag{8}$$

We assume that the individual credit risk rating is divided into 5 grades: AA_AAB_ABA_ABB and C. The connection degree from the highest grades AA to the lowest grades C of the pair of sets H = (bank, individual) can be represented as:

$$\mu_D = \begin{cases} \frac{7}{10} + \frac{2}{10}i - \frac{1}{10} \\ \frac{6}{10} + \frac{3}{10}i - \frac{1}{10} \\ \frac{5}{10} + \frac{3}{10}i - \frac{2}{10} \\ \frac{4}{10} + \frac{3}{10}i - \frac{3}{10} \\ \frac{6}{10}i - \frac{4}{10`} \end{cases} \tag{9}$$

$\mu_D>0$ is credible consistency, it illustrates the lower individual credit risk; $\mu_D<0$ is credible reverse, it illustrates the higher individual credit risk.

SP MODEL OF INDIVIDUAL CREDIT RISK

Suppose there are m experts to assess the individual credit risk including n traditional credit risk assessment models. For the model h_k, there are A_k experts approving it. And there are C_k experts opposing it. So, there are $B_k = m-A_k-C_k$ experts absent from voting.

Note that:

$$\mu(m) = WRI$$
$$(W_1,\cdots,W_n)\begin{bmatrix} A_1, B_1, C_1 \\ \cdots\cdots\cdots \\ A_n, B_n, C_n \end{bmatrix}\begin{bmatrix} 1 \\ i \\ -1 \end{bmatrix} \tag{10}$$

Where:

$$\begin{bmatrix} A_1, B_1, C_1 \\ \cdots\cdots\cdots \\ A_n, B_n, C_n \end{bmatrix}\begin{bmatrix} 1 \\ i \\ -1 \end{bmatrix}$$

is called the decision-making matrix, W is weight vector, I is column vector. Taking the equal weight, the $\mu(m)$ can be represented as:

$$\mu(m) = WRI$$
$$(\frac{1}{n},\cdots,\frac{1}{n})\begin{bmatrix} A_1, B_1, C_1 \\ \cdots\cdots\cdots \\ A_n, B_n, C_n \end{bmatrix}\begin{bmatrix} 1 \\ i \\ -1 \end{bmatrix} \tag{11}$$

According to the actual background, the variables can be calculated as below:

$$a = f(A_1,\ldots,A_n) \tag{12}$$

$$b = g(B_1,\ldots,B_n) \tag{13}$$

$$c = h(C_1,\ldots,C_n) \tag{14}$$

The connection degree of bank and the individual is:

$$\mu(m) = a+bi-c \tag{15}$$

Analysis of the relationship of a, b, c can help us gain credit risk of individual.

EXAMPLE

Considering a sample of four models: $h_1,\ldots, h_4$ and assuming that the financial institutions assess the credit risk of individual with the same weight. Then the decision-making matrix can be represented as:

$$\begin{bmatrix} A_1, B_1, C_1 \\ \ldots\ldots \\ A_4, B_4, C_4 \end{bmatrix}\begin{bmatrix} 1 \\ i \\ -1 \end{bmatrix} \tag{16}$$

Further, assuming that the assessment results and connection degree of the four models are respectively as follows:

The first model is:

$$\mu_A = 0.4+0.4i-0.2 \tag{17}$$

The second model is:

$$\mu_R = 0.52+0.48i \tag{18}$$

The third model is:

$$\mu_C = 0.5+0.1i-0.4 \tag{19}$$

The fourth model is:

$$\mu D = 0.5+0.3i-0.2 \tag{20}$$

In this case, the decision-making matrix is:

$$\mu(m) = \begin{vmatrix} 0.40, 0.40, 0.20 \\ 0.52, 0.48, 0.00 \\ 0.50, 0.10, 0.40 \\ 0.50, 0.30, 0.20 \end{vmatrix} \tag{21}$$

Now let us consider the average connection degree:

$$\bar{\mu}(H) = \bar{a} + \bar{b}i - \bar{c} \tag{22}$$

Where:

$$\bar{a} = \frac{1}{n}\sum_{k=1}^{n} A_k = (0.4 + 0.52 + 0.5 + 0.5)/4 = 0.48 \tag{23}$$

$$\bar{b} = \frac{1}{n}\sum_{k=1}^{n} B_k = (0.4 + 0.48 + 0.1 + 0.3)/4 = 0.295 \tag{24}$$

$$\bar{c} = \frac{1}{n}\sum_{k=1}^{n} C_k = (0.2 + 0.4 + 0.2)/4 = 0.2 \tag{25}$$

In the worst situation, if $\bar{a} < \bar{b}i + \bar{c}$ is satisfied, i.e., 0.2+0.295i>0.48, namely i >0.95.But the range of i is [-1,1]. So the condition $\bar{a} < \bar{b}i + \bar{c}$ is hard to satisfy. The credit risk of this individual is low.

Further, we assume

$$a_{min} = \min(a_1, \ldots a_4) = 0.4 \tag{26}$$

$$C_{max} = \min(c_1, \ldots c_4) = 0.4 \tag{27}$$

$$B = 1 - a_{min} - c_{max} = 0.2 \tag{28}$$

So:

$$\mu(H) = 0.2i \tag{29}$$

From the Eq. 29, the credit risk of the individual is highly dependent on i. So, the assessment of credit risk of this individual should pay more attention to the external macro-environment.

Summarizing the conclusions above, the credit risk of this individual is low.

CONCLUSION

This study has pointed out the insufficient of the traditional credit risk assessment models based on the characteristics of the individuals. As an attempt, this paper introduces SP theory to integrate the traditional credit risk assessment models as a new credit risk assessment model Generally, the individual credit risk assessment method with SP theory has the following advantages: (1) Consider the credit risk of individual in different aspects in order to gain more accurate conclusions, (2) Smaller amount of calculation is needed and it has greater flexibility and (3) Capture the actual characteristics of individual through the assessment of individual credit risk.

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