CHEMICAL ENGINEERING TRANSACTIONS
VOL. 46, 2015

A publication of AIDIC
The Italian Association of Chemical Engineering
Online at www. aidic. it/cet

Guest Editors: Peiyu Ren, Yanchang Li, Huiping Song

ISBN 978-88-95608-37-2; **ISSN** 2283-9216
DOI: 10.3303/CET1546220

Research on Risk Warning of Financial Information System Based on Triangular Fuzzy Method and Support Vector Machine

Jiasheng Zhang

Anhui Sanlian University, Hefei, 230601, China.
ahslzjs@126.com

It is well known that electronic bank whose development speed is so quick represents the future direction of bank industry. Although electronic bank can bring some convenient ways to us, it makes us have to face some realistic problems. In this paper, two aspects are demonstrated as follows: firstly, an improved fuzzy-AHP method is proposed. In real case, it is difficult to provide exact assessments by people. Therefore, triangular membership method is developed to improve acquirement of weights of each risk factor to avoid some qualitative methods such as expert scoring. Then, combining of the characteristic of risk assessment framework of bank information system, the proposed fuzzy-AHP method is applied to obtain weights of each risk factor of bank information system from 2011 to 2013 and further obtain the risk index of each risk factor. Secondly, based on this risk index and using classification properties of support vector machine to predict the risk. Finally, the experiment demonstrates the validity and applicability of the proposed method.

1. Introduction

Clearly, electronic bank whose development speed is so quick represents the future direction of bank industry. Although electronic bank can bring some convenient ways to us, it makes us face some realistic problems. For example, what can we do to guarantee the safety of account information and transaction information? With the development of electronic bank, the most concerned problem is the safety of electronic bank system. Many studies have been done in this field.

In general, identity theft represents the illegality activity that individual simulates others without agreement in order to acquire specific benefits or avoid obligation and responsibility, which will damage others benefits including individuals, group or country (Shu and Chen, 2009). To date, some experts suggest it is needed to increase input in the topic that how to prevent identity theft (Sharp et al., 2004). Based on trust model, Tan et al. (2003) and Dong et al., (2008) analyzed the existing studies of security of electronic bank in China, developed several solutions to deal with security identity framework of electronic bank and further compared these solutions. According to the real demand of enterprise's application system, Keith (2006) and Jon and Sriganesh (2008) proposed the relationship between individual characteristics and the possibility of identity theft. Feng et al., (2008) and Chen (2006) summarized general rules and characteristics of transaction behavior of electronic business and further constructed a model related to money laundering and anti-money laundering. With the high standard under the environment of electronic payment, Cao (2006) demonstrated the definition of electronic transaction protocol and elliptical curve cryptography. Kahn (2008) and Thomas (2009) proposed a model to guarantee the essential information of allocation credit.

The security protocol of electronic payment has been attracted much attentions (Wang et al., 2007; Xu ei al., 2008; Kim et al., 2002). Kungpisdan (2004) proposed a dynamic protocol of electronic payment to guarantee the security of wireless network. Pella (2008) and Pennathur (2013) developed that the development of electronic bank increases the competition in the inter-bank. However, drastic competition may affect the benefits of electronic bank. Cunningham (2005) and Keldon (2006) built a model to identify effect of technology cost, risk premium and new technology on the selection of new technology by consumers.

In this paper, a improved AHP is proposed. In real case, it is difficult to provide exact assessment by people. Therefore, triangular membership method is developed to improve acquirement of weights of each risk factor

Please cite this article as: Zhang J.S., 2015, Research on risk warning of financial information system based on triangular fuzzy method and support vector machine, Chemical Engineering Transactions, 46, 1315-1320 DOI:10.3303/CET1546220

to avoid some qualitative methods such as expert scoring. Then, combining of the characteristic of risk assessment framework of bank information system, the proposed fuzzy-AHP method is applied to obtain weights of each risk factor of bank information system from 2011 to 2013 and further obtain the risk index of each risk factor. Based on this risk index and using classification properties of support vector machine to predict the risk. Finally, the experiment demonstrates the validity and applicability of the proposed method.

2. Some Basic Concepts

Membership function is demonstrated as follows:
Definition 1. Suppose fuzzy object *X* is the set of object *x*, then the fuzzy set *A* in *X* can be represented in the following:

$$A=\{((x,\ f_A(x))\big|x\in X\} \tag{1}$$

Then $f_A(x)$ can be named as membership function of *A*.

The popular used membership function includes triangular function, trapezoidal function and Gaussian function. Hereinto, triangular degree function is determined by three parameters which are supposed as {*m*, *n*, *h*}. This triangular degree function can be represented as:

$$h(x)=H(x,m,n,h)=\geq\begin{cases}0 & x\leq m\\ (x-m)/(n-m) & m\leq x\leq n\\ (h-m)/(h-n) & n\leq x\leq h\\ 0 & h\leq x\end{cases} \tag{2}$$

Trapezoidal membership function is determined by {m, n, h, q}, which can be showed as

$$h(x)=H(x,m,n,h,q)=\geq\begin{cases}0 & x\leq m\\ (x-m)/(n-m) & m\leq x\leq n\\ 1 & n\leq x\leq h\\ (h-m)/(h-n) & h\leq x\leq 1\\ 0 & q\leq x\end{cases} \tag{3}$$

Gaussian membership function can be showed as

$$h(x)=H(x,m,\delta)=e^{-1/2((x-m)/\delta)2} \tag{4}$$

3. Triangular Fuzzy AHP Method

Given a triangular fuzzy judgment matrix $A=\left(\tilde{a}_{ij}\right)_{n\times n}$ where $a_{ij}=\left(l_{ij},m_{ij},u_{ij}\right)=\tilde{a}_{ji}^{-1}=\left(1/u_{ji},1/m_{ji},1/l_{ji}\right)$, $i=1,\ldots,n$ and $i\neq j$, the process of this method is showed in the following.

Step 1, each row of judgment matrix is added.

$$RS_i=\sum\nolimits_{j=1}^{n}a_{ij}=\left(\sum\nolimits_{j=1}^{n}l_{ij},\sum\nolimits_{j=1}^{n}m_{ij},\sum\nolimits_{j=1}^{n}u_{ij},\right) \tag{5}$$

Step 2, arithmetic average of row vector is calculated to obtain the synthesized value of the i_{th} element.

$$S_i=\frac{RS_i}{\sum\nolimits_{j=1}^{n}RS_j}=\left(\frac{\sum\nolimits_{j=1}^{n}l_{ij}}{\sum\nolimits_{k=1}^{n}\sum\nolimits_{j=1}^{n}u_{kj}},\frac{\sum\nolimits_{j=1}^{n}m_{ij}}{\sum\nolimits_{k=1}^{n}\sum\nolimits_{j=1}^{n}m_{kj}},\frac{\sum\nolimits_{j=1}^{n}u_{ij}}{\sum\nolimits_{k=1}^{n}\sum\nolimits_{j=1}^{n}u_{kj}}\right),\ i=1,\ldots,n \tag{6}$$

Step 3, the possibility degree between two fuzzy numbers is defined as follows.

$$V\left(M_1 \geq M_2\right) = 1, m_1 \geq m_2$$
$$V\left(M_1 \geq M_2\right) = hgt\left(M_1 \cap M_2\right) = \mu_{M_1}\left(d\right) = \frac{l_1 - u_2}{\left(m_2 - u_2\right) - \left(m_1 - l_1\right)} \tag{7}$$

where *d* is the point of intersection between M_1 and M_2 in axis of *x*- demonstrated in Figure 1.

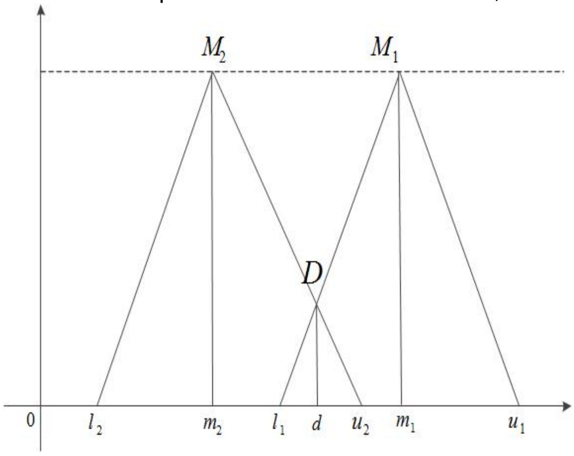

Figure 1 Triangular fuzzy numbers

4. The Determination of Weights

The first layer of index framework called the risk of bank information system is divided into five indexes in the second layer including technical risk of electronic bank denoted as w_1, operation risk of electronic bank denoted as w_2, internal risk of electronic bank denoted as w_3, legal risk of electronic bank denoted as w_4 and other risk of electronic bank denoted as w_5. Each risk in the second layer can be divided into two indexes in the third layer containing reputation risk, liquidity risk, operation risk, price risk, compliance risk, interest risk, exchange rate risk, transaction risk, legal risk and strategic risk. Because of the limitation of the content, we only provide the computation method of the risk weigh in the second layer, and others are the same.
The judgment matrix is demonstrated as

$$B = \begin{bmatrix} 1.000 & 1.327 & 1.583 & 1.871 & 2.114 \\ 0.831 & 1.000 & 1.318 & 1.619 & 1.916 \\ 0.618 & 0.719 & 1.000 & 1.344 & 1.627 \\ 0.672 & 0.658 & 0.769 & 1.000 & 1.358 \\ 0.444 & 0.571 & 0.637 & 0.782 & 1.000 \end{bmatrix}.$$

Suppose that $\lambda_{\max}$ is the maximal eigenvector and *W* is corresponding eigenvector of $\lambda_{\max}$. It can be obtained that $\lambda_{\max}$ =5.0023 and $W = (w_1, w_2, w_3, w_4, w_5) = (0.6217, 0.5218, 0.4133, 0.3514, 0.2637)$. Then, the eigenvector is normalized. Suppose $w_i^{(j)}$ is the *i* sub-vector of the *j* layer index, where *j* =1, 2, 3; *i* = 1, 2, 3, 4, 5.

Based on the normalization, $w_i^{(j)} = w_i \Big/ \sum_{i=1}^{n} w_i \; (j = 1, 2, 3; i = 1, 2, 3, 4, 5)$. The eigenvector corresponding to the maximal eigenvector $W = (w_1, w_2, w_3, w_4, w_5) = (0.5972, 0.5016, 0.4216, 0.3543, 0.2975)$ is brought into to obtain a new weight vector $W^{(1)} = (w_1^{(1)}, w_2^{(1)}, w_3^{(1)}, w_4^{(1)}, w_5^{(1)}) = (0.2862, 0.2402, 0.1903, 0.1618, 0.1214)$.

After obtaining this new weight vector, consistency check is implemented. *CI* is the index of consistency check and the order of the judgment matrix is *n*. *CI* is showed as $CI = \frac{\lambda_{\max} - n}{n-1}$. The order of the second layer of index framework is 5, so *n* = 5. Then, $\lambda_{\max} = 5.0081$ and $n = 5$ are brought into the equation to acquire that $CI = \frac{\lambda_{\max} - n}{n-1} = \frac{5.0023 - 5}{5-1} = 0.0013$.

Meanwhile, *RI* is average random consistent index. As $n = 5$, we can obtain that $RI = 1.12$.

Then, based on *CI* and *RI*, it can be acquired that $CR = \frac{CI}{RI} = \frac{0.0013}{1.12} = 0.0012 < 0.1$. Because $CR = 0.0012 < 0.1$, consistency check is done.

5. Prediction by Support Vector Machine

The ideal of SVR is demonstrated as follows. Firstly, suppose $x \in R^n$ and $y \in R$, where R^n denotes output space. Then, through nonlinear transformation, input space of *x* can be mapped into a high dimensional feature space. Finally, in this space, linear function can be used to fit the sample data and guarantee to obtain good generalization ability.

Step 1. In feature space, linear estimation function is defined as

$$y = f(x, \omega) = \omega^T \phi(x) + b \tag{8}$$

Step 2. For nonlinear regression problem, non-negative relaxation variables ξ and ξ^* are introduced to solve the optimization problem which can be showed as

$$\min \frac{1}{2}\|\omega\|^2 + C \cdot \sum_{i=1}^{N} (\xi_i + \xi_i^*) \tag{9}$$

$$\text{S.t.} \begin{cases} y_i - \omega \cdot \phi(x_i) - b \le \varepsilon + \xi_i \\ -y_i + \omega \cdot \phi(x_i) + b \le \varepsilon + \xi_i^* \quad i = 1, 2, \cdots, N \\ \xi_i > 0, \xi_i^* > 0, C > 0 \end{cases} \tag{10}$$

where penalty factor $C > 0$ is a preset constant. The more the value of *C* is, the more the penalty degree is.

Step 3. Based on Eq. (11) and through selecting component $\overline{a_k}$ in open interval $(0, C)$, bias term *b* can be obtained as

$$b = y_k - \sum_{i=1}^{N} (a_i^* - a_i) K(x_i, x_k) - \varepsilon \tag{11}$$

Step 4. Finally, the nonlinear regression function in high dimension space is developed as

$$y = f(x) = \omega\phi(x) + b = \sum_{i=1}^{N} (a_i^* - a_i) K(x_i, x) + b \tag{12}$$

In Eq(13), $K(x_i, x) = (\phi(x_i) \cdot \phi(x))$ is the kernel function, $\phi(x)$ and $\phi(x_i)$ are the image of mapping of the points *x* and x_i in sample space.

6. Simulation Experiment

Membership degree is brought into assessment matrix to achieve intelligent operating instead of man-made. Using the method which adds degree of safety of assessment range can avoid the problems in assessment range in original fuzzy comprehensive evaluation which is too absolute. The assessment range of each element in the proposed method is more suitable for real cases and overcome the drawback of the existing methods.

Combining with the weight *W* determined by the mentioned triangular fuzzy method, we define the assessment set is $V=\{V_1,V_2,V_3,V_4,V_5\}=\{90,80,70,60,50\}$. Then, it can be obtained the value or score of risk index from multiplying weights with assessment set of the second layer of index framework. Using support vector machine, we can predict the risk of bank information system during the first half year in 2014 (14A), the second half year in 2014 (14B) and the first half year in 2015 (15A). 14A1. 14B1 and 15B1 denotes the real risk index during the first half year in 2014, the second half year in 2014 and the first half year in 2015, respectively. The comparison result is demonstrated in Figure 2.

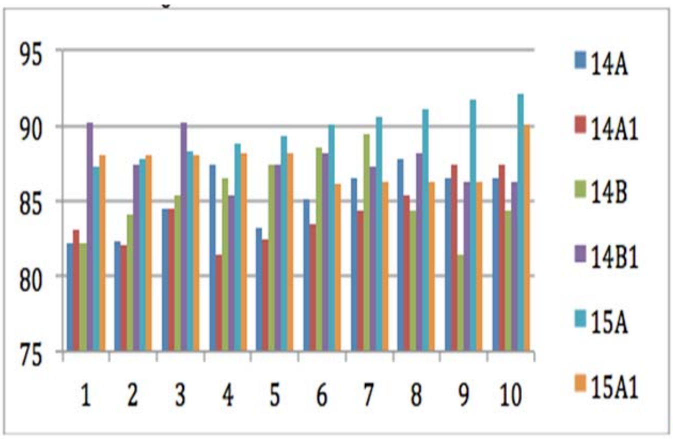

Figure 2: The prediction results

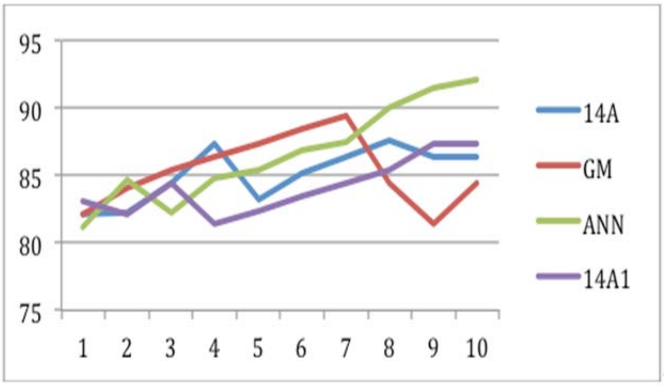

Figure 3: The forecast comparison chart

Figure 2 shows the changeable of 10 elements of risk index during 2014-2015. Hereinto, the whole is in the trend of increasing and prediction value is response to real value. It is demonstrated that the different result calculated by grey prediction method (GM) and neural network method (ANN) in Figure 3. Clearly, the prediction result is satisfied. To sum up, risk index of financial industry is related to modern technology in those years, especially operation risk of system and internal control risk.

7. Conclusions

Firstly, combining of the characteristic of risk assessment framework of bank information system, the proposed fuzzy-AHP method is applied to obtain weights of each risk factor of bank information system from 2011 to 2013 and further obtain the risk index of each risk factor. Secondly, based on this risk index and using classification properties of support vector machine to predict the risk. Finally, the experiment demonstrates the validity and applicability of the proposed method and the proposed method can promote the development of business in the internet bank.

References

Bauer K., Hein S.E., 2006, The effect of heterogeneous risk on the early adoption of Internet banking technologies, Journal of banking & finanee, 30(6): 1713-1725.

Cao. H P, 2006, Certification authority in online banking based on secure electronic transaction. Computer System and Application, 6: 58-60.

Chen. B, 2006, The design of safe system in the enterprise bank based on CA with the double strong factors, J. Wuhan Inst. Chen. Tech., 28(3): 68-70.

Cunningham L.F., Gerlaeh J., Harper M.D., 2005, Perceived risk and e-banking services: Ananalys is from the perspective of the consumer. Journal of Financial Services Marketing, 10(2): 165-178.

Feng. Y, Yan. C, Yang. D M, Zhang. J J, 2008, Detection and supervision for money laundering in e-commerce based on third party online payment, Systems Engineering Theory and Practice, 12:60-69.

Jon T.S. Quah M.S., 2008, Real-time credit card fraud detection using computational intelligence [J]. Expert Systems with Applications, 35(4): 1721-1732.

Kahn C.M., Roberds W., 2008, Credit and identity theft. Journal of Monetary Economies, 55: 251-264.

keith B.A., 2006, Who Are the Victims of Identity Theft? The Effect of Demographics [J]. Journal of public policy & marketing, 25(2): 160-171.

Kim M.A., Lee H.K., Kim S.W., 2002, Implementation of anonymity-based e-payment system for m-commerce [C]. ICCCAS. 02, Chengdu, China, 363-366.

Kungpisdan S., Srinivasan B., Le P.D., 2004, A secure account-based mobile payment protocol. ITCC04, Las Vegas, USA, 35-39.

Laukkanen P., Sinkkonen S., Laukkanen T., 2008, Consumer resistance to internet banking: postpones, opponents and rejecters [J]. The International Journal of Bank Marketing, 26(6): 440-455.

Pennathur A., 2001, Clicks and bricks: E-risk management for banks in the age of the Internet. Journal of Banking and Finance 25, 2103-2123.

Sharp T, Shreve-Neiger A., Fremouw W., Kane J., Hutton S., 2004, Exploring the Psyehological and Somatic Impact of Identity. Theft. Journal of Forensic Seienee, 49: 1-6.

Shu X., Chen K.Y., 2009, On identity theft prevention and control of the legal system. Journal of Zhejiang Wanli University, 22(4): 73-79.

Tan R.H., Liu H.B., Wang D., 2003, A selection of framework design about certificate authentication of internet banks, Journal of Financial Research, 12: 105-112.

Wang D.X., Du Y.S., Shen J., 2007, Anonymity-revocable divisible multi-bank e-cash payment scheme, Computer Engineering, 33(16): 126-127.

Wendels T.H., Mhlmann T., Versen T., 2009, Determinants of banks risk exposure to new account fraud. Evidence from Germany. Journal of Banking & Finance, 33(2): 347-357.

Xu G.S., Gu L.Z., Yang Y.X., Li Z.X., New transferable electronic cash scheme, Journal of Communications, 2008, 29(5): 1-5.

Zhang H.N., Dong L.L., Yan X.H., 2008, The research of PKI-based identify authentication in online bank, Computer Security, 7: 61-63.