Adaptive Neurofuzzy Inference System in the Application of the Financial Crisis Forecast

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***Abstract*—The financial crisis must be faced in the competitive financial market risks, the root causes of the improper handling of the financial leverage of the banks. Therefore, how to control financial risk is one of the Bank is committed to academic. At present, all financial institutions to use more traditional financial analysis as well as external ratings to measure its risk, but this method is easy because of the subjective will of the individual risk assessment of the status of the bias. This study is the use of Adaptive Network-Based Fuzzy Inference System(ANFIS) prediction of the crisis of corporate finance.**

In this study, factor analysis of the screening variables, the use of ANFIS as a research method, based Artificial Neural Networks, and Artificial Neural Networks (ANN), compared to view the features and accuracy of both the pros and cons. The results showed that: ANN accuracy rate of 89.49% on ANFIS correct rate of 93.94% on ANFIS correct rate was significantly higher than that of ANN, said the feasibility and effectiveness of the ANFIS prediction of corporate financial crisis is good compared to ANN.

***Index Terms*—Adaptive neuro fuzzy inference system, neural networks, the financial crisis.**

I. Introduction

In recent years, with the vigorous development of financial markets, the importance of credit risk measurement and management more and more financial institutions attach importance to. For the bank, the greater the likelihood of default because the credit risk is the company's operating performance indicators, so the better the performance, the smaller the possibility of breach of contract on behalf of the company, contrary. Therefore, the bank risk management, as well as the ability to assess the operating performance of companies, so that the banks of the pros and cons of risk management to become a stable profit source.

Basel Capital, Accord, by the Basel Committee on Banking Supervision, which the specification order to fund the financial institution's risk of tube management, and provide the fund financial monitoring management unit should follow the standard . Mentioned, the banks must strengthen their credit risk measurement techniques, and estimates of bank credit risk will affect the line should be put aside how much equity capital. Each bank or financial institution established in accordance with their own conditions, credit risk management mechanism, thus achieving control risk, to create a stable profit.

Review the relevant literature, the estimates for the financial crisis and misguide the focus on the univariate analysis (Beaver[1], 1966), multivariate discriminant analysis (Altman[2], 1968), logit model (Ohlson and James, 1980; Platt, and Platt, 1990; Tseng, and Lin,2005; Zavgren[3], 1985), Probit model (Zmijewski, 1984), in subsequent studies more widely adopted. However, these analysis methods is both rigorous assumptions, such as the distribution of independent variables assumed that the covariance matrix of independent variables assume the error term distribution assumptions, and so on. Unless the data satisfy the assumptions, otherwise the estimated correctness remains to be the provider correct (Eisenbeis[4], 1977; Ohlson and James, 1980; Press and Wilson, 1978). Until Computational Intelligence for this problem a possible solution to the way. Odom is and Sharda (1990) first use the class neural network (based Artificial Neural Networks of ANN) applied to credit risk estimation, which has to capture the fault tolerance, Adaptive and self-learning, etc. , so is widely used in various fields. However, the neural network there are still over-equipped fitness and can not explain the causal relationship between the variables shortcomings, so there are still restrictions in the estimation process.

Fuzzy theory more approximate human reasoning can be used to describe the actual problem and allow the inaccuracies that exist in the data sets and uncertainties. The neural network has to learn from past data and induction of. However, the fuzzy theory for the construction of the difficulties of the rule base and neural network for the relationship between the problem variables can not explain. Therefore, Jang[5], (1993), fuzzy theory and neural network two algorithms, the proposed adaptive neural fuzzy inference system (Adaptive Network-Based Fuzzy Inference System, ANFIS), which is the fuzzy theory based on the neural network road to its full model for the processing capabilities of the system uncertainty and imprecision to adjust the parameters of the model. Its architecture is based on fuzzy inference system of Fuzzy Inference System (FIS) for the network model based on combined with the characteristics of self-organizing neural network. ANFIS is a fuzzy theory, fuzzy rule base mode architecture, not only can the original rules one by one converted to fuzzy rules, the expert's experience and knowledge can also be converted to the rules of inference, to compensate for the description of information system deficiencies .

Therefore, the main motivation of this study is to hope that the method of combining the application of neural network and fuzzy theory-of ANFIS to credit risk estimation. That is to use the rules in the rule base of fuzzy theory to describe the complex relationships between the variables, re-use the learning ability of neural network "to adjust the membership functions and rule base, with the general financial variables and non-financial variables, the establishment of a a new set of financial distress prediction model to enhance the efficiency of credit risk models, to reduce bank losses, and to provide decision-making

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reference. The purpose of this study is the use of the ANFIS model to the prediction of corporate financial crisis, compared with the predictions of the ANN model, the correct rate of the test ANFIS model is better than the ANN model to provide agency managers in the banking risk in the estimate of risk more correct model selection.

This study is divided into five parts, the first part is the introduction, the second part of the literature review, the third part is a description of the theoretical model, the fourth part of the empirical results and analysis, the final section conclusions and recommendations.

II. Literature Review

Regression analysis can be divided into Probit Logit two models, the model can solve the general linear probability model estimates of conditional probabilities may fall outside the range of (0,1), Logit and Probit model thus generated. Probit model with the main difference of the Logit model is that the former assumes that the residuals of the cumulative distribution for the cumulative standard normal distribution, the latter is based on the assumption that the cumulative distribution of the residuals compared with the cumulative Logit allocation. Logit model applies not only to the dependent variable is a qualitative change in the number of regression models, this model using the cumulative density function will be converted to the real value of the explanatory variables the probability value, and solve the linear Probit model of the estimated parameters, to produce for explanatory variables to estimate the predicted values fall outside the (0,1), and the use of maximum likelihood function extremum Fang Wu, calculating the various estimators, these estimators are consistent the form of asymptotically efficient and asymptotically normally distribution. However, the merits of the regression model, has yet to come up Collins and Green (1982), Ingram and Frazier[6], (1982), Gentry, Newboed and Whitford (1985), Gessner[7], et al (1988) pointed out that the Logit model is better than discriminant analysis and almost Logit and Probit model results.

Neural network model to simulate human or biological nervous system to external shock response, for the study of human thinking mode, through the repeated process of learning, with the output variables may inquire from the input variables (such as financial ratios, market information, etc.) , through the hidden layer to the output variable to the variation of the minimum requirements, different weights to give each input variable, then the nonlinear conversion to produce the output variables so that the results between 0 and 1, judge whether the firm financial crises. Neural network model was first proposed by Odom is and Sharda (1990) applied to the financial crisis prediction, followed by Tam and Kiang[8], (1992), Salchenberger Cinar and Lash, (1992), the Coats and Fant (1993), Wilson and Sharda (1994) , Altman, Marco and Varetto (1994), Boritz and Kennedy (1995), Kerling (1996), Davalos, Gritta and Chow (1999), Piramuthu[9] (1999), Jo, Han and Lee (1997), Wanous[10], Boussabaine and Lewis (2003) and other scholars applied to the financial crisis forecast article.

In recent years in different areas of ANFIS There are many examples of successful application, such as: bank credit early warning system (Malhotra, and Malhotra, 2002), the diagnosis of disease (Güler and Übeyli[11], 2004, 2005; Kazeminezhad, Etemad-Shahidi, and Mousavi[12],, 2005; Yeh and Cheng, 2005), the reservoir real-time operating system (Chang and Chang, 2006), Water Resources Research (Nayak,, Sudheer, Rangan, In and Ramasastri, 2004), ocean Engineering (Kazeminezhad et al., 2005), motor control (Aguilar, Melin, and Castillo, 2003; Ali Akcayol, 2004; Melin and Castillo, 2004; Melin and Castillo, 2005), industrial manufacturing (Hasiloglu, Yilmaz,, Comakli, and Ekmekci[13], 2004; Li, Wu, Tsai, and Chang,2006; LO, 2003; Lo, and Lin,, 2005; LU, Yeh, of Li, Wu, and Liu,, 2003), electric power system (Ellithy and Al-Naamany, 2000) and options evaluation (Lee Waugh wall and Ke group, 2006).

Therefore, Jang, (1993), fuzzy theory and neural network two algorithms, the proposed adaptive neural fuzzy inference system (Adaptive Network-Based Fuzzy Inference System, ANFIS), which is the fuzzy theory based on the neural network road to its full model for the processing capabilities of the system uncertainty (uncertainty) and imprecision (imprecisely) to adjust the parameters of the model. Therefore, the correct rate of the ANFIS model used in this study to the prediction of corporate financial crisis, compared with the predictions of the ANN model, test the ANFIS model is better than the ANN model to agency managers in the banking risk in the estimate of risk do more correct model selection.

III. Theoretical Model Shows

A. Backpropagation Network Learning Algorithm

Backpropagation neural network is based on the steepest drop method (by Gradient Steepest Descent Method).Using this principle as a basic principle, the concept of application of the error function to minimize learning in neural network. The back-propagation network learning is to adjust the network weights, the training example input vector calculated by the network, you can output and expectations similar to the output vector. According to the neuron model, the n layer *j*-th unit output value Y_j^n the following formula:

$$Y_j^n = f(net_j^n) \tag{1}$$

$net_j^n = \sum_i Y_i^{n-1} w_{ij} - \theta_j$, $f(\ )$: Transfer function, w_{ij}: The *i*-th input unit and the *j*-th hidden the strength of the link between the unit, θ_j: Bias of the n-th hidden unit.

Because the network to learn: the weighted value of the correction network link, the network error function reaches a minimum, the following equation:

$$E = \frac{1}{2}\sum_j (T_j - Y_j)^2 \tag{2}$$

T_j : The actual output value of the *j*-th data,

$j = 1,2,\ldots,N$. Y_j : Predict the output value of the j-th data, $j = 1,2,\ldots,N$, Because the error function is a function of the weighted value of the network link, so in order to make the error function reaches a minimum, available Gradient Steepest Descent Method to the error function to minimize.

B. Adaptive Neuro-Fuzzy Inference System

Characteristics of the adaptive neural fuzzy inference system close to the neural fuzzy system, significant results (Melin and Castillo, 2004; Melin and Castillo, 2005) model of the nonlinear function. Adaptive Neuro-Fuzzy Inference System in the membership function parameters to focus on extracting information from the description of system performance. The ANFIS through the adjustment of system parameters of the specified error standard, and the data to focus on learning characteristics (Jang, 1993). Today, ANFIS has been used in classification and data analysis (Lo, 2003). Used in this paper is the adaptive network fuzzy inference system (ANFIS), mainly based on ANFIS fuzzy inference system mode the main, the use of fuzzy If-Then rules to deal with the semantic analysis of human knowledge and the logic description of the process, give full play uncertainty for the system's imprecision of language processing capabilities. Sugeno fuzzy model, in the If-Then rules and fuzzy reasoning to the same level of membership function or transfer function using a similar function to construct the the ANFIS main architecture; in the learning and adjustment of parameters, it is the combination of feed forward neural network supervised learning method, all the parameters of the fuzzy inference system can get the appropriate adjustments, so that the model has self-learning and organizational capacity.

Neuro-Fuzzy, a variety of different network architectures according to different cutting of the input space, in this paper uses a fuzzy inference system for adaptive network architecture, the architecture of this network in Figure 1, basically the first hidden layer neural perform the computation of the membership function value (that is compatible with the degree of calculation), the neural implementation and (AND) operation "in order to obtain the fuzzy rules the start of the former the Kam Ministry of strength, then layer class neurons in the implementation of the (OR) operator, in order to start strength the union of all fuzzy rules, before Kam Ministry, and finally in the output layer neurons will be the implementation of defuzzification operation, in order to provide a specific output value. Neural function and computation of each layer are described below:

Compatibility of the degree of "operations, the first layer: the first layer of neurons to perform input and fuzzy sets are calculated as follows:

$$O_{1,i} = \mu_{A_i}(x), \quad for \quad i = 1,2$$

$$O_{1,i} = \mu_{B_{i-2}}(y), \quad for \quad i = 3,4 \qquad (3)$$

Where *x* or *y* is the input of the *i*-th processing unit, A_i or B_{i-2} is the fuzzy set represented by the processing unit. Means that $O_{1,i}$ stands for input variable *x* or *y* on the fuzzy set $A(= A_1, A_2, B_1, B_2)$ is attributable to the degree of fuzzy set membership function of A , you can use any appropriate parameterized membership functions, these membership functions are usually referred to as "the former Kam Ministry of parameters.

The second layer: second layer neurons labeled Π, the implementation of the fuzzy rules of calculation of the "Starting Strength", is calculated as follows:

$$O_{2,i} = w_i = \mu_{A_i}(x) \cdot \mu_{B_i}(y), \quad i = 1,2 \qquad (4)$$

In the third layer: the third layer neurons labeled N, execution will start the strength of regularization of the operator, calculated as follows:

$$O_{3,i} = \overline{w}_i = \frac{w_i}{w_1 + w_2}, \quad i = 1,2 \qquad (5)$$

The fourth layer: it is performed in the fourth layer of neurons, each fuzzy rule Kam Ministry after the execution of the number of the operator, is calculated as follows:

$$O_{4,i} = \overline{w}_i f_i = \overline{w}_i (p_i x + q_i y + r_i), \quad i = 1, 2 \qquad (6)$$

The fifth layer: the fifth layer, only a single class of neurons, labeled Σ, calculate the sum of the previous layer neuron output value of the class, as the final output value of the network:

$$O_{5,i} = \sum_i \overline{w}_i f_i = \frac{\sum_i w_i f_i}{\sum_i w_i} \qquad (7)$$

IV. Empirical Process and Results Analysis

A. Source Description and Basic Descriptive Statistics Analysis

Selected by the Institute of default listed company from 2003 to 2007, the full delivery of shares, corresponding to a breach of the company, with two companies of similar scale within the same industry, in the deleted information is not complete company, select the 51 breach of contract,with 102 normal, whichever is breach of contract before the fourth quarter of financial statements information, breach of contract and paired normal company listed in the Appendix.

In this study, selected variables, including current ratio, quick ratio, cash flow ratio, net income to total assets ratio, net income to equity, inventory turnover, accounts receivable turnover, debt ratio and debt to equity ratio . The study variables basic descriptive statistics shown in Table I.

B. Factor Analysis

Factor analysis does not consider the impact of the dependent variable, and only collected a number of independent variables in the extraction of common factors and try to find common features from a large number of independent variables. The purpose of this analysis is to represent the original data structure in fewer dimensions,

and can save most of the information provided in the original data structure, also solve the problem all variables were linear.

In this study, the effective sample, delete the variables of low explanatory power, that is, keeping the factor loadings greater than 0.6 and above variables; in the extraction of factors using principal component method, and using orthogonal shaft $Vari_{max}$ method to rotate; and extract the Eigen values factors greater than 1. Extraction of four factors as liquidity, profitability, asset management and financial structure. Each aspect of this study, factor analysis results summarized in Table II.

TABLE I: DESCRIBED IN TABLES

Variable(%)	Mean	Standard deviation	Minimum	Maximum
Current ratio	167.90	136.54	5.28	1405.60
Quick Ratio	91.25	123.18	0.17	1101.05
Cash flow ratio	11.52	41.32	-92.28	368.09
Net profit after tax to total assets ratio	-0.02	0.11	-1.03	0.21
Net profit after tax to equity	-0.05	0.55	-4.70	10.88
Inventory turnover rate	6.57	10.57	0.00	84.57
Accounts receivable turnover ratio	12.95	41.36	0.20	492.18
Gearing ratio	48.04	16.10	4.78	107.76
Debt to equity ratio	1.18	1.29	-13.89	11.09

TABLE II: RESULTS OF FACTOR ANALYSIS

Factors named	Representation of variables	Factor loadings	Eigen value	Cumulative explained variance
Mobility	X1: Current Ratio	0.926	2.283	65.37%
	X2: speed ratio	0.936		
	X3: cash flow ratio	0.696		
Profitability	X4: Net Income to total assets ratio	0.745	1.646	43.65%
	X5: net profit after tax to equity	0.829		
Asset Management	X6:inventory turnover rate	0.861	1.483	60.13%
	X7:Accounts receivable turnover ratio	0.888		
Financial structure	X8: debt ratio	0.821	1.287	74.43%
	X9: liabilities to equity	0.795		

C. The ANFIS Financial Crisis Forecast Modeling Process

Liquidity, profitability, asset management and financial structure in this article the ANFIS financial crisis prediction model input variables, output value of a financial crisis or no financial crisis, the model (6):

$$P_{ANFIS} = F(x_1, x_2, x_3, x_4) \quad (8)$$

Where: P_{ANFIS} forecast for the ANFIS model, x_1 is the mobility, x_2 , profitability, x_3 , asset management, x_4 financial structure.

Adopt the trapezoidal membership functions in each fuzzy rule of the former Kam Ministry has a membership function, the choice of membership functions, triangular membership functions, trapezoidal membership functions, Gaussian function membership function, program input test betterconvergence value. Each input variable access to three attribution degree of value (low, medium, high).

ANFIS model for each class of neurons, use the synaptic vector, as the transmission of the message, the link network. In this study, four input variables, each input variable to each of the three membership function values, so the fuzzy rules. After the use of neural network learning function, depending on the characteristics of self-learning module allocation decisions for each fuzzy rule weights, the output value of ANFIS model of the fuzzy rule base.

D. ANFIS and ANN Model Results Analysis

In this study, ANFIS and ANN models to predict financial crises, the model input four variables, respectively, liquidity, profitability, asset management and financial structure. From Table 3 that ANN correct rate of 0.8949, the type I error of 0.1333, the type II error is 0.1061; 0.8197 of the correct rate of the test sample, the type I error of 0.2273, the type II error is 0.1538. Table 3 shows that, on ANFIS training samples of the correct rate of 0.9394, type I error of 0.0625 and 0.0455 of a type II error; 0.9180 of the correct rate of the test sample, the type I error of 0.0909, the type II error is 0.0769. Used in this study the performance of the ANFIS forecasting the financial crisis much better than the ANN model, so the use of ANFIS to predict the company's financial crisis, the occurrence of certain feasibility.

TABLE III: ON ANFIS AND ANN MODELS ANALYSIS

	Model	Total correct rate	Error of Type I	Error of Type II
Training samplesa	ANN	0.8949 (443/495) b	0.1333 (22/165)	0.1061 (30/330)
	ANFIS	0.9394 (465/495)	0.0625 (10/165)	0.0455 (15/330)
Testing samplesa	ANN	0.8197 (100/122)c	0.2273 (10/44)d	0.1538 (12/78)e
	ANFIS	0.9180 (112/122)	0.0909 (4/44)	0.0769 (6/78)

(a) Presupposes a number of fuzzy rules based on the training sample set with a pre-set some kind of membership function of fuzzy input signal to give a certain fuzzy weight

coefficient, and logical operations and network training, the actual output signal. Compared to the error of the output signal and the desired output, and the test sample, the test to achieve the purpose of online learning.

(b) (443/495): the former - 443, said the correct number of categories, the latter - 495 representing the number of samples.

(c) Testing the total sample of 122 pens, 100 pen correctly predicted in the test sample.

(d) 44 is the financial crisis, the molecules can not correctly measure the items of the financial crisis, the forecast non-financial crisis, the company.

(e) Denominator, namely the 78-pen is not a financial crisis, the company, the molecule is not correct rate measured by the items of non-financial crisis, the forecast for the financial crisis companies. 122 = 78 +44; 100 = 122-10-12.

V. Conclusions and Recommendations

Recently, in the face of repeated financial crises, investors are hoping to have a fair and accurate reference, therefore, the credit ratings are increasingly being taken seriously, the credit rating classification AFINS model and ANN model. The study results show that, on ANFIS forecasting performance of the financial crisis much better than the ANN model, so the use of ANFIS to predict the company's financial crisis, the occurrence of certain feasibility.

In the past, when the bank financing between the company is facing financial crisis, not have a full guarantee of the debt, it is only the company's passive pumping the money supply behavior. Now, with the build of the new Basel II, financial institutions have to adjust their financial structure and amplification of risk departments, in order to construct suitable for their own ratings model. Between the finance company through the provision of collateral to enhance the credit rating, making the bank can take the initiative to select the exact financing objects in order to reduce the risk of banks' own lending.

In this paper there is still a lot of direction for further research, such as research methods in the variable can consider the macroeconomic variables, the state variables, expert opinions, etc., of different factors, to do more in-depth study.

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