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Evaluation on Financial Industry Security Based on T-S Fuzzy Neural Network

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Abstract: After financial crisis happens, evaluating financial industry security becomes a hot issue. This study proposes a comprehensive evaluation model with five classes and nineteen typical indexes based on T-S Fuzzy Neural Network (FNN). This model is good at identifying fuzziness by the membership in the fuzzy theory which could reflect the relative state of all kinds of indexes in the financial industry security. What's more, security levels of financial industry security can be received after training and testing from nonlinear neural network. And empirical analysis verifies the validity of this model and then reflects the state of China's financial risk is generally increasing. At present, China's finance is in the state of suspicious security with negative trend.

Key words: Financial industry security, evaluation, T-S FNN, suspicious security, negative trend, early warning

INTRODUCTION

At present, most studies about financial industry security focus on financial fragility and risk. However, with time goes by, macroeconomic policies are applied into financial industry security such as foreign loans, extensive borrowing, implicit guarantees, deposit insurance and loan competition. They all increase the scope of financial industry security (Li, 2009). Most researches focus on prediction and early warning methods. Some studies use FR probity regression model, KLR signal monitoring model, STV cross-sectional regression model, DCSD early warning model and so on (Pang *et al*., 2009). Most insist that financial fragility and risk are linear and continuous based on the traditional economic theory. But these theories hardly describe economic development accurately because the traditional economic theory uses statistics and linear methods to establish the system based on static equilibrium theory. This makes us give up the traditional one and transfer to the nonlinear science.

As a sub-system of economy, finance is highly dynamic and obviously nonlinear. Luo and South (2007) built a nonlinear comprehensive evaluation model using catastrophe theory. They mainly talked about the application of this theory in the financial industry security. National macro economy, financial institutions and external finance should be included into the evaluation system of financial industry security of China was put forward by Li *et al.* (2007).

Neural network is a kind of nonlinear simulation technique that could simulate human brain (Diao *et al*., 2012) perform parallel processing and execute distribution storage. It has many advantages such as the ability of self-learning, associative information storage and parameter optimization quickly (Bishop, 1995). But neural network is hard to express knowledge and not good at learning speed. Thus another theory called fuzzy theory is introduced which combines the inaccuracy of indexes and subjective information to make evaluation objectively as much as possible. But it is still a problem to produce and adjust the membership function and fuzzy laws. This study combines neural network and fuzzy theory to build a comprehensive evaluation model to adjust the parameters automatically and determine the structure of network including setting up the fuzzy laws. In this way, the impact of subjective factors can be decreased and the network could get stability and generalization.

MATERIALS AND METHODS

Choosing indexes: According to the actual state of China's financial industry, a new index system is designed to judge the extent of China's financial risk based on the current research results. The system has nineteen indexes. Five levels, namely safe, essential safe, subsafe, suspiciously safe and not safe are put forward. These levels all have their own significance. The actual state of China's financial industry and alert value recognized by the international to make different levels of index security are combined (Shen and Wang, 2010). Evaluation system of China's financial industry security is shown in Table 1.

Data: Data of China's financial industry from 1998 to 2011 are chosen, which was posted on or calculated by China Statistical Yearbook and China Financial Yearbook.

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Table 1: Evaluation index system and its threshold values of China's financial industry security

First-level subsystem	Second-level system	Evaluation index	Safe I	Essential safe II	Subsafe III	Suspiciously safe IV	Not safe V
The security of national macroeconomic A		GDP growth	12	10	8.0	4	0
		Inflation rate	-2	3	4.0	6	8
		Unemployment rate	0	2	3.0	5	7
		M2/GDP	0	1	1.5	2	3
		Financial deficit/GDP	0	1	2.0	4	7
The security of financial institutions B	The security of bank institutions B1	Bank NPL ratio	0	7	15.0	25	40
		Capital adequacy ratio	14	12	8.0	5	0
		Demand deposit proportion	0	20	30.0	40	50
		Medium and long-term loan proportion	0	20	40.0	60	80
		Combined loss ratio	0	15	25.0	40	60
	The security of insurance institutions B2	Insurance penetration	12	8	4.0	2	0
		Stock float capitalization/GDP	0	8	15.0	30	50
	The security of security institutions B3	Stock price-earnings ratio	0	20	40.0	60	80
		Current account surplus/GDP	0	2	5.0	8	12
The security of external finance C		Liability ratio	0	8	15.0	25	40
		Debt service ratio	0	8	15.0	25	40
		Export debt ratio	0	30	50.0	70	100
		Short-term external debt ratio	0	20	40.0	60	80
		Appreciation rate of RMB against U.S. dollar	0	2	3.0	5	7

T-S fuzzy model: T-S fuzzy system has a good ability of self-adaptability to refresh automatically and adjust the membership function continuously (Shi and Wang, 2010). Under the law of R^i, "if-then" can be used to define the T-S fuzzy system as follows.

If:

$$x_i \text{ is } A_1^i, x_2 \text{ is } A_2^i, \cdots, x_k \text{ is } A_k^i$$

Then:

$$y_i = p_0^i + p_1^i x_1 + \cdots + p_k^i x_k \quad (1)$$

where, A_j^i is the fuzzy set, $p_j^i (j = 1, 2, \cdots, k)$ is the parameter, y_i is the output according to the fuzzy laws. The input of system that means "if" is fuzzy and the output that means "then" is determined. This fuzzy inference represents that output is the linear combination of inputs.

First, input is supposed as $x = [x_1, x_2, ..., x_k]$, the membership of every input variable x_j is calculated according to the fuzzy laws:

$$\mu_{A_j^i} = \exp(-(x_j - c_j^i)^2 / b_j^i) \quad j = 1, 2, \cdots, k; i = 1, 2, \cdots, n \quad (2)$$

Then fuzzy computing of every membership can be implemented by regarding the fuzzy operators as the multiplicative operators:

$$\omega^i = \mu_{A_j^1}(x_1) * \mu_{A_j^2}(x_2) * \cdots * \mu_{A_j^k}(x_k) \quad i = 1, 2, \cdots, n \quad (3)$$

Finally, the output y_i is calculated according to the result of fuzzy computing:

$$y_i = \sum_{i=1}^{n} \omega^i (p_0^i + p_1^i x_1 + \cdots + p_k^i x_k) / \sum_{i=1}^{n} \omega^i \quad (4)$$

T-S fuzzy neural network: There are four layers called input layer, fuzzy layer, fuzzy inference layer and output layer. The input layer links to the input vector x_i, in which the number of nodes is the same to the input vector dimension. In the fuzzy layer fuzzy membership μ is received through the fuzzy processing according to the membership function 2. And in the fuzzy inference layer, multiplicative Eq. 3 helps to get ω. Finally the output in the output layer can be gotten by the Eq. 4.

The FNN learning algorithm is as follows:

- **Error calculation:**

$$e = \frac{1}{2}(y_d - y_c)^2 \quad (5)$$

where, y_d is the desired network output, y_c is the actual network output and e is the error of these two outputs.

- **Coefficient correction:**

$$p_j^i(k) = p_j^i(k-1) - \alpha \frac{\partial e}{\partial p_j^i} \quad (6)$$

$$\frac{\partial e}{\partial p_j^i} = (y_d - y_c)\omega^i / \sum_{i=1}^{m} \omega^i \cdot x_j \quad (7)$$

where, p_j^i is the neural network coefficient, α is the network learning rate, x_j is the network input parameter, ω^i is the multiplicative result of input parameter membership.

- **Parameter correction:**

$$c_j^i(k) = c_j^i(k-1) - \beta\frac{\partial e}{\partial c_j^i} \tag{8}$$

$$b_j^i(k) = b_j^i(k-1) - \beta\frac{\partial e}{\partial b_j^i} \tag{9}$$

where, c_j^i and b_j^i are the center and wideness of the membership function, respectively.

RESULTS AND DISCUSSION

According to the dimension of training sample the number of input and output nodes can be determined and fuzzy membership function. And because of nineteen dimensional input data and one dimensional output, the structure of this network should be 19-38-1. Namely there are 38 membership functions. If twenty coefficients p_0~p_{19} are chosen, fuzzy membership center "c" and wideness "b" randomly can be gotten.

Producing samples: When FNN is used to evaluate the security of financial industry, the grading standards of financial industry as the training sample to train the network should be adopted. However, there hasn't been publicly recognized data so far. So it is reasonable to use the grading standards as the standard index value to produce training sample and testing sample with the method called linear interpolation. There are 360 training samples. Class I to Class II: 90; Class II to Class III: 90; Class III to Class IV: 90; Class IV to Class V: 90. And then the same way is used to get forty testing data to test the network which has been trained. And desiring goals of the training samples and testing samples between different levels should be corresponding to the value among 1~2, 2~3, 3~4 and 4~5 as the ratio above. Before training, normalization processing should be executed to eliminate the dimension difference among the different parameters.

Evaluation: According to the steps and features of input and output in the FNN, the network structure is set. There are 19 input nodes, one output node and twenty sets of coefficients p_0~p_{19}. During the training, if given a input x_i, the prediction of network y_c will be received. And then the prediction y_c and the desired output y_d are compared. It could adjust the parameters p_0~p_{19} and the value of b and c. Repeating the same procedure 1000 times, the result is shown in Fig. 1.

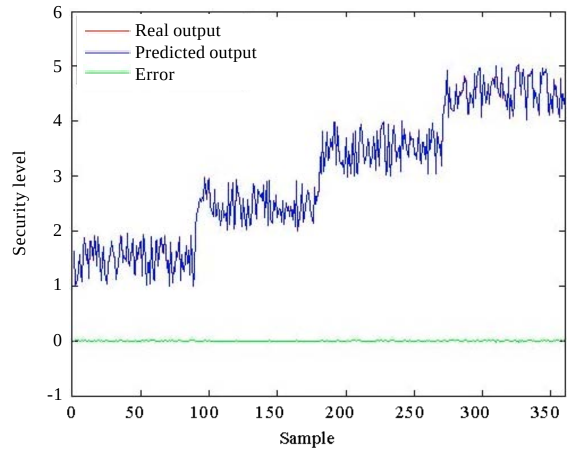

Fig. 1: Predicting result of training samples

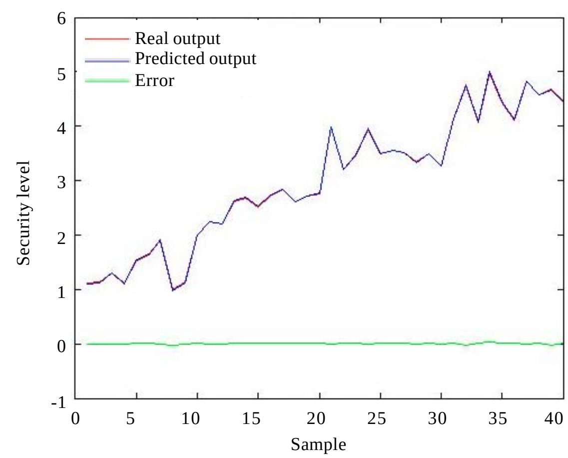

Fig. 2: Predicting result of testing samples

From Fig. 1, the prediction result is good can be concluded because the errors between the desired outputs and actual outputs are small. Then predicting by using the testing samples, result is shown in Fig. 2.

From Fig. 2, the result is also good because the prediction error is only 0.097%. It shows us that this network has a good generalization capability and the actual data of China can be used to get the evaluation. According to the regulation of determining the security level, the result of evaluation is shown in Fig. 3. And the standardized result is shown in Fig. 4.

From the results above, although the economy of China is increasing generally from 1998 to 2011, the risk trend faced by financial industry of China is going up at the same time. In 2007, the worst security evaluation happened to the financial industry in recent years and at

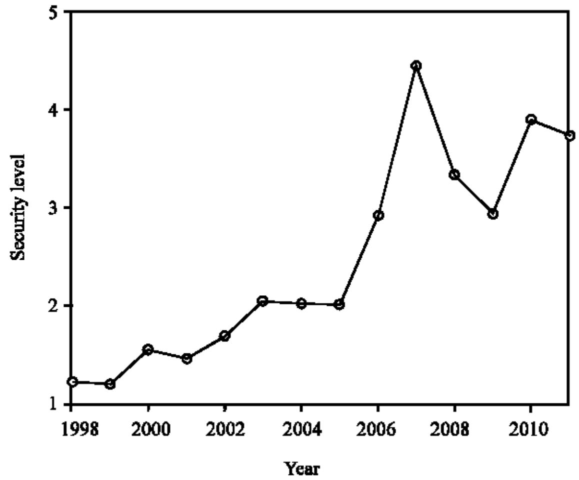

Fig. 3: Evaluating result of China's finance industrial security

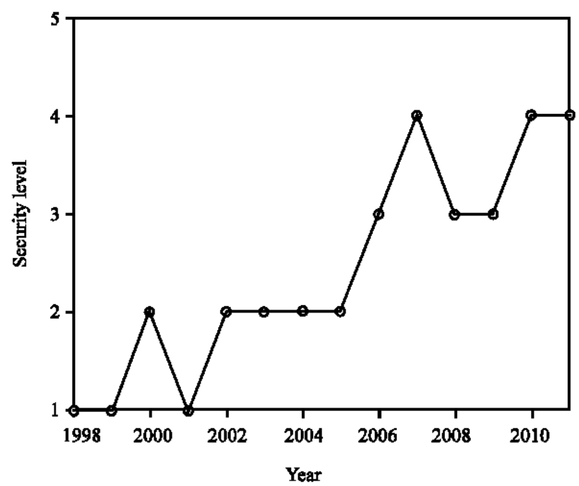

Fig. 4: Standardized evaluating result of China's finance industrial security

the same time the global financial crisis happened exactly. And now the security of financial industry is not positive.

The result has a same conclusion that before financial crisis in 2008 China's financial industrial security is better than other years as Zhang (2010). But this paper's result reflects China's condition better.

CONCLUSION

In this study, the five security levels are put forward at first. And then choose nineteen representative indexes to establish a comprehensive evaluation model based on T-S FNN by combining the fuzzy theory and neural network theory. Linear interpolation method is used to produce training and testing samples. In this way, the accuracy of network is increased by training and predicting. After empirical research, the results show that the risk faced by financial industry of China is generally increasing from 1998 to 2011.

And in 2007 the worst happened to the financial industry. At present, the financial industry is still suspiciously safe and the trend is not positive. Finally, the evaluation can be a good director for the development and a good warning sign of financial industry.

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REFERENCES

Bishop, C.M., 1995. Neural Network for Pattern Recognition. Oxford Clarendon Press, UK., ISBN:13- 9780198538646, pp: 5-28.

Diao, M.N., X.H. Wen and Y.G. Liu, 2012. Integrated assessment on sea water quality based on the fuzzy neural network. Mar. Sci. Bull., 31: 228-232.

Li, Y., L.W. Chen and B. Han, 2007. China's financial industry security evaluation system and applied research. Value Eng., Vol. 26. 10.3969/j.issn.1006-4311.2007.10.049

Li, M.G., 2009. China's Financial Industry Security Report. Jiaotong University Press, Beijing, China.

Luo, H.Y. and X. South, 2007. The applied research of catastrophe theory in the evaluation of financial security. Finance Hainan, (In Chinese). 10.3969/j.issn.1003-9031.2007.03.013

Pang, H., S. Li and Y.D. Jia, 2009. Financial Security Warning Mechanisms and Risk Controlling. Science Press, New York.

Shen, Y. and X.X. Wang, 2010. Study on the Security Warning in the Process of Financial Liberalization in China. Science Press, New York.

Shi, F. and X.C. Wang, 2010. Matlab Neural Network Analysis of 30 Cases. University of Aeronautics and Astronautics Press, Beijing.

Zhang, Z.H., 2010. Financial security warning indicator system construction and empirical research. Bus. Econ., 7: 78-79.