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EARLY WARNING SYSTEM OF FINANCIAL RISK IN CHINA'S FOREIGN INVESTMENT[3]

In this paper we identify the components of financial risk in China's foreign investment, and construct an index system of the risk. Then we set up an early warning system of the risk based on the artificial neural network (ANN). We also predict the financial risk of China's foreign investment in 2009 with the early-warning system to test the system.

Keywords: *foreign investment; financial risk; risk index system; early warning; artificial neural network (ANN); principal component analysis (PCA); China.*

JEL Classification: *F21, F37, E44.*

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СИСТЕМА РАННЬОГО ЗАПОБІГАННЯ ФІНАНСОВИМ РИЗИКАМ У КИТАЙСЬКИХ ІНОЗЕМНИХ ІНВЕСТИЦІЯХ

У статті визначено компоненти фінансових ризиків у китайських іноземних інвестиціях і наведено систему індексування ризиків. Запропоновано систему раннього запобігання ризикам на основі штучної нейронної мережі, а також зроблено прогноз фінансових ризиків у китайських іноземних інвестиціях за 2009 р. для тестування розробленої системи.

Ключові слова: *іноземні інвестиції; фінансові ризики; система індексування ризиків; раннє запобігання; штучна нейронна мережа; метод головних компонент, Китай.*

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СИСТЕМА РАННЕГО ПРЕДУПРЕЖДЕНИЯ ФИНАНСОВЫХ РИСКОВ В КИТАЙСКИХ ИНОСТРАННЫХ ИНВЕСТИЦИЯХ

В статье определены компоненты финансовых рисков в китайских иностранных инвестициях и приводится система индексирования рисков. Предложена система раннего предупреждения рисков на основе искусственной нейронной сети, а также сделан прогноз финансовых рисков в китайских иностранных инвестициях за 2009 г. для тестирования разработанной системы.

Ключевые слова: *иностранные инвестиции; финансовые риски; система индексирования рисков; раннее предупреждение; искусственная нейронная сеть; метод главных компонент, Китай.*

1. Introduction. In recent years, amid China's fast pace of economic development, China's outward foreign investment increased rapidly. Although by the end of 2008 the financial crisis was affecting the entire world, it may have put Chinese companies in a better position to buy up ailing Western companies (Chen and Young, 2010). China's outward FDI has doubled almost every year since 2003. Outward FDI in 2008 is nearly 20 times of that in 2003 (Ministry of Commerce, PRC, 2010). In 2010, China's total non-financial overseas direct investment reached 68.8 bln. USD,

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[3] Acknowledge: This study is supported by Ministry of Social Science, Project No. 09JZD0017.

ranking fifth in the world. Compared with domestic investment, foreign investment has its unique risks, which can be divided into regional risks, financial risks and management ones. In this paper, financial risk is defined as the possibility of foreign capital price volatility caused by the fluctuating exchange rate, interest rate, international credit etc. Financial risk has caused large losses in China's foreign investments especially in cross-border mergers & acquisitions (M&A). For example, both China Investment Company's acquisition of Black Stone and Ping An Insurance's acquisition of Fortis Inc. in 2007 resulted in failures due to the shrunk of asset price after the completion of the deal. As cross-border M&A is playing a more important role in China's foreign investment (Gu, 2011), financial risks in foreign investments needs to be widely considered.

In this paper we develop an early warning model of financial risk for China's foreign investment from the macroperspective, aiming to predict the financial risk level of China's foreign investment and to provide financial risk information for Chinese investors. Early warning of risks is an important part of risk management. Timely and accurate early warning information helps investors identify risks as early as possible, making risk management more efficient.

From the macroaspect, literature on early warning system for financial risks mainly concentrates on forecasting the currency crises, debt crises and macro-financial risks (Ciarlone et al., 2006, Fratzscher, 2003). By to the type of approach, prediction models can be divided into linear and nonlinear ones. Frankel and Rose (1996) first developed the linear method. Using a probit model, they estimate the probability of currency crises for more than 100 developing countries from 1971 to 1992. Kaminsky et al. (1998) also proposed the non-parametric signal approach which involves monitoring the evolution of a number of economic indicators. When an indicator exceeds a particular threshold, this is interpreted as a signal that a crisis could occur in the following 24 months. After the turn of the 21st century, more approaches have been proposed on the study of early warning systems of financial risks, including the artificial neural network (ANN), regime switching approach, VaR approach and so on. Under the ANN, Nag and Mitra (1999) built a currency crisis early warning system and compared it with the signal approach; Fioramanti (2008) built a warning system of sovereign debt crises of developing countries and compared it with the probit model. Both studies show that the ANN model performs better than others for prediction of financial risks. Brockett et al. (2006) also demonstrate that ANN method performs better than other approaches in risk prediction. Considering the focus of our model is on the accuracy of early warning, this paper will be following the ANN research ideas.

More specifically, this paper first identifies the factors of financial risk in China's foreign investment and constructs a risk index system. Then, based on the risk index system and ANN, we develop an early warning system of financial risk of China's foreign investment and we predict the financial risk of China's foreign investment in 2009 to test the system.

This paper is structured as follows: Section 2 identifies the factors of financial risk in China's foreign investment and builds the risk index system. Section 3 contains the construction of the early warning system. We also train and test the models in this part. Section 4 concludes the paper.

2. Financial risk factor identification of China's foreign investment.

2.1. Factor identification. In this part, we identify the factors composing the financial risk of China's foreign investment. The analysis is based on the Global Financial Stability Map (GFSM) in the Global Financial Stability Report 2009 (GFSR2009) released by the IMF in October 2009. This report classifies global financial risk into 6 dimensions: monetary and financial conditions, risk appetite, macroeconomic risks, emerging market risks, credit risks and market and liquidity risks. On the other hand, since China's foreign investment is affected by both China's domestic condition and foreign factors, we also added domestic-related factors and removed the factors not significantly related to China's foreign investment in the GFSM. Thus, we identity the components of the financial risk in China's foreign investment, which is an adjustment to the Global Financial Stability Map regarding the domestic-related factors. We classify the financial risk of China's foreign investment into 5 dimensions: liquidity and market risk, macroeconomic risk, credit risk, price risk and home country risk.

The first 3 risks are defined according to the GFSM. Liquidity risk means the potential for instability in pricing and funding risks that could result in broader spillovers and/or mark-to-market losses. Macroeconomic risk is from the macroeconomic shocks with the potential to trigger a sharp market correction, given existing conditions at capital markets. Credit risk means changes in, and perceptions of, credit quality that have the potential for creating losses resulting in stress to systemically important fnancial institutions. The price risk is defined as the losses caused by price volatility which is directly connect to the monetary policy of Chinese government. Home country risk is about the factors directly related to the conditions of foreign investment of a home country. For each dimension, we chose 2 or 3 indicators to measure the risks mentioned above. The decision of the variables is based on the earlier studies. Table 1 describes the indicators of each dimension and the data sources.

2.2 Structure of risk index system. Based on the risk identification analysis, we established a financial risk index system of China's foreign investment using factor analysis. Through factor analysis, on the one hand, we reconfirmed the classification of the indicators mentioned above; on the other hand, we quantified the factors composing the financial risk. Then we got a measurable financial risk index system of China's foreign investment.

We used the 12 indicators during 1994 to 2008 as the sample data to conduct factor analysis. Before that, we normalized the data of each indicator into the closed interval of [0, 1] to make the indicators comparable. For each indicator, closer to 1 indicates more liquidity, greater returns, and less risk - and vice versa.

Then we used the normalized data for the factor analysis with SPSS 16. Following the method of principal component analysis to extract factors and quartimax rotation to adjust the factors, we got 12 factors from 12 indicators. The number of factors is decided by the eigenvalue criterion: a factor whose eigenvalue is more than 1 will be kept. This criterion can confirm that each factor contains at least 1 indicator. Finally, we extract 4 factors (F1, F2, F3 and F4) from 12 indicators, whose cumulative variance explaining rate is 76.9%.

Table 1. **Indicators of Financial Risk of China's Foreign Investment**

Dimension	Code	Indicator	Explanation of Indicator	Data sources	Area
Liquidity risk	*S1*	G-3 excess liquidity	Difference between broad money growth and estimates for money demand of G3 country	GFSR2009 by IMF	Global
	S2	G-3 Bank Lending Conditions	Long-term loan of G3 country	GFSR2009 by IMF	
Macroeconomic risk	*S3*	Global average GDP	Growth rate of Global average GDP	WEO Database	
	S4	OECD Leading Indicator	Indicator recognizes the turning points between expansions and lowdowns of economic activity released by OECD	OECD Database	
Credit risk	*S5*	Delinquency Rate on Consumer and Mortgage Loans	Delinquency rates on a wide range of other credit, including residential, commercial mortgages and credit card loans.	Mortgage Bankers Association	
	S6	Households Financial Obligation Ratio	Total amount of financial obligations scaled by disposable income for the US households.	GFSR2009 by IMF	
	S7	World Implied Equity Premia	Get through a three-stage dividend discount model	GFSR2009 by IMF	
Price risk	*S8*	Short-term interest rate spread between China and the US	Both interest rates choose 3 month benchmark interest rate	OECD Database	Home country and overseas
	S9	Effective exchange rate of RMB		BIS Database	
	S10	Global inflation rate	CPI includes both fuel and non-fuel price indices	WEO Database	Global
Home country risk	*S11*	Income of China's foreign investment	Includes income from FDI, reinvestment, securities investment and etc.	China's international balance sheet	Home Country
	S12	Scale of China's foreign investment	Growth rate of China's foreign investment scale	China's international balance sheet	

The component matrix (Table 2) shows the indicators' contribution to the factors. Bonded indicators affect the corresponded factors most. Combining Tables 2 and 1, we can find the implication of 4 factors. F1, mainly affected by S1, S2, S5, S6, S7 which are the indicators of liquidity risk and credit risk, can be seen as the global financial condition risk. F2 is mainly affected by S3, S4, S11 and S10. S3 and S4 are both indicators of macroeconomic risk and S10 is the global CPI. Therefore, F2 reflects the global macroeconomic conditions. F3 is mainly affected by S9, S11 and S12, all of which are the indicators of China's own condition. The last, F4, is mainly affected by S9 and S8, indicating market risk. The result of the factor analysis is consistent with the classification of the indicators mentioned in chapter 2.1.

Table 2. **Component Matrix**

	F1	*F2*	*F3*	*F4*
S7	**0.8682**	0.0234	0.122	-0.081
S2	**-0.834**	-0.335	-0.015	-0.379
S5	**0.7827**	0.2043	-0.039	0.459
S1	**-0.764**	-0.051	-0.193	0.15
S6	**0.7358**	-0.405	0.253	-0.161
S3	-0.031	**0.9629**	-0.015	-0.09
S4	0.3395	**0.8162**	0.154	-0.154
S11	0.0199	**0.6368**	**-0.524**	0.234
S9	0.1131	-0.006	**0.724**	**0.55**
S12	-0.206	-0.02	**-0.716**	0.071
S10	0.373	**0.691**	-0.023	-0.276
S8	-0.003	-0.104	-0.144	**0.755**

We quantified the 4 factors through the factors' scores which can be calculated through the regression method in factor analysis. For each factor, the higher the score is, the lower the risk is. Moreover, we can get the factor that reflects the overall financial risk by calculating the weighted sum of the 4 factors' score, in which the proportion of each factor's variance explaining rate is taken as its weight. The overall factor which is denoted by F_t is calculated as follows:

$$F_t = \lambda_1 / \sum \lambda_i \times F1 + \lambda_2 / \sum \lambda_i \times F2 + \lambda_3 / \sum \lambda_i \times F3 + \lambda_4 / \sum \lambda_i \times F4$$

and represents the variance explaining rate of the corresponding factor.

Table 3. **Financial Risk Index System**

Level 1	Level 2
Global financial condition risk (F1)	G-3 excess liquidity (S1)
	G-3 Bank Lending Conditions (S2)
	Delinquency Rate on loans (S5)
	Households Financial Obligation (S6)
	World Implied Equity Premia (S7)
Global macroeconomic risk (F2)	Global average GDP (S3)
	OECD Leading Indicator (S4)
	Global inflation rate (S10)
Home country risk (F3)	Income of China's foreign investment (S11)
	Scale of China's foreign investment (S12)
	Short-term interest rate spread (S8)
Market risk (F4)	RMB effective exchange rate (S9)

According to the factor analysis, we conclude that financial risk of China's foreign investment is composed of 4 factors: global financial condition risk, global macroeconomic risk, home country risk and market risk. We also calculate the overall financial risk. Hence, we got an index system of financial risk for China's foreign investment. As shown in Table 3, the index system has two levels. The first level contains 4 factors extracted and quantified through the factor analysis. The second level contains 12 indicators as in Table 1.

3. Building of the early warning system.

3.1 Model structuring, training and testing. Our interest in artificial neural networks (ANNs), whose functioning resemble the logic of human brain, comes from the fact that it can be used in an intensive data process to approximate functions that

are highly nonlinear. We chose the back-propagation (BP) network to build the early-warning model. The BP network is one of the most widely used ANNs, which has been proven able to implement any complex nonlinear mapping through the learning process. During the learning process, the network makes adjustments to the weights of the associated input variables using various kinds of training functions in order to make the output consistent with the predetermined goal. Thus, a trained network can complete the mapping between the input and goal variables.

In this paper, we build an early warning model based on the BP network using the tool in MATLAB7.0. As concluded in Part 2, the financial risk of China's foreign investment is composed of 4 factors, and adding the overall financial risk, we established a total of 5 early warning models: M1, M2, M3, M4, M5, each model corresponding to one risk. In each model, we took the normalized data of the 12 indicators of the second class risk index system mentioned in Part 2 as the input data and set the one lagged year's risk level as the goal. Risk level of each year of each kind of risk is decided based on the value of the risk's factor scores. Specifically, each factor's score is divided into 4 levels: safe (I), basic safe(II), alert (III) and dangerous (IV) in accordance with factors scores. We assigned the value to 4 risk levels as (0001), (0010), (0100) and (1000) in order to get the quantified goal value. The higher the score is, the safer the risk level is. The network shows the relationship between the input variables and the risk level of the next year. Therefore, if given the input data of a certain year, the trained network will work out the possible next year's risk level, achieving the purpose of risk early warning.

In order to decide the architecture, training algorithm and parameters of the network, various trials were conducted and finally the best performing network was found. The network chosen is a two-layer network with 8 units in the hidden layer and 4 units in the output layer. The performance function is the mean squared error (MSE), the algorithm of the training process is Levemberg-Marquardt, the transfer function of the hidden layer is LOGSIG and the transfer function of the output layer is TANSIG. All the functions above are the most frequently used in the BP network. The number of the units of the hidden layer is tried by order of size and that of the output layer is decided according to the number of output variables.

We use the data of 1994-2008 to train and test the network. The data is divided into 3 groups: the training group, the testing group and the forecast group. The input data of 1994 and 1996-2007 and the output data of risk level of 1995 and 1997-2008 belong to the training group, the input data of 1995 and the output data of 1996 are taken as the testing group, and the input data of 2008 is used to forecast the risk level for 2009. Network training is a process of many trials of training parameters until the output is consistent with the goal. We set initial weights to be random and there are 3 parameters, learning rate(lr), goal and epochs, needing to be decided in the training process. In our work, lr of the trained network is chosen as 0.01. Goal and epochs varies with the models in Table 4. The networks with those parameters, having an output completely consistent with the goal with a small enough error, are the ones to say finish training.

Then we use data of the testing group to test the trained network. After putting in the normalized data of 1995, we get a simulated output value. If it is consistent with the goal, the network passes the test. As shown in Table 5, the outputs of all the models are almost the same as the goals, which indicates that all the models have passed the test.

Table 4. **Goal & Epochs**

Model	epochs	goal
M1	200	1.00E-12
M2	110	1.00E-10
M3	190	1.00E-10
M4	200	1.00E-10
Mt	150	1.00E-09

Table 5. **Testing Result**

Model	Output				Goal
M1	0.0000	0.5131	0.0000	1.0000	0001
M2	0.0000	0.9999	0.0000	0.0000	0100
M3	0.0000	0.0000	0.9747	0.0134	0010
M4	0.9989	0.0000	0.0000	0.0005	1000
Mt	0.0000	0.0000	0.0061	0.9995	0001

3.2 Forecast result. We input the normalized data of the 12 indicators of 2008 to forecast the risk level of 2009. Table 6 shows the forecast result based on the output of the models and the risk level evaluated in Part 3.1.

Table 6. **Forecast Result**

Model	Forecast Output				Risk Level
M1	0.9995	0.0390	0.0000	0.0000	IV
M2	0.9999	0.0000	0.0000	0.0000	IV
M3	0.0000	0.0013	1.0000	0.0008	II
M4	0.0000	1.0000	0.0000	0.0000	III
Mt	0.9999	0.0000	0.1820	0.0008	IV

Table 7. **Risk Level Comparison**

Year	Global Financial Condition	Global Macroeconomic	Home Country Condition	Market risk	Overall Financial Risk
2007	III	I	II	IV	I
2008	IV	III	II	IV	IV
2009	IV	IV	II	III	IV

To analyze the risk warning result of 2009, we compare it with the risk level of the previous 2 years as shown in Table 7.

(1) Global financial conditions. The risk level of global financial conditions in 2009 is dangerous (IV), the same as that in 2008. Since the outbreak of the subprime crisis in 2007, the global financial condition risk level went worse, from alert in 2007 to dangerous in 2008 and the worsening tendency will continue to 2009. In fact, the impact of the financial crisis did continue to 2009.

(2) Global macroeconomic risk. Global macroeconomic risk level will go from alert in 2008 to danger in 2009. Macroeconomic conditions usually lag behind financial conditions and in fact the global macroeconomic condition became worse in 2009, proving that our risk warning is in agreement with the reality and that the forecast is reliable.

(3) Home country conditions. Home country conditions of 2009 maintained the level of the previous 2 years of basic safety. In this paper, home country condition mainly includes the scale and changes in income of China's foreign investment. Since

2005, the scale of China's foreign investment growth has accelerated significantly and investment income also increased; with government encouragement, currently a large number of companies are "going global". From the perspective of home country conditions, the current conditions provide a good opportunity to invest overseas.

(4) Market risk. Market risk in 2009 will be on alert, less than that in 2008 but still in a high risk level. In 2008, the volatile exchange rate of the RMB against the USD impacted the market. In our work, we forecast that the risk will continue to exist but will be a little reduced in 2009,which is consistent with the real conditions. In fact, the exchange rate of the RMB against the USD became more stable than in 2008, however the devaluation of USD made the effective exchange rate of RMB appreciate.

(5) Overall financial risk. In 2009, the overall financial risks of foreign investment maintained the risk level in 2008. According to the factor analysis, the factors F1-F4 differed in the contribution to the overall financial risk factor F_t, in decreasing order: F1 contributing 33.4%, F2 accounting for 22%, F3 taken 12.9% and F4 occupying 9.37%. This shows that foreign investment is mainly affected by international finance and macroeconomic conditions. In 2009, international financial and macroeconomic risks were at a dangerous level, so even though the risk of home country is on basic safe level, the overall risk level of foreign investment stayed at a high level.

4. Conclusion. Main conclusions of this paper are as follows:

First, we identified the financial risks in China's foreign investment composited of liquidity and market risk, macroeconomic risk, credit risk, price risk and home country risk. Second, we structured an index system of financial risk for China's foreign investment. The index system included two levels. The first level includes 4 factors integrated from the 5 aspects of financial risk mentioned above. The second level included 12 indicators. Third, we built an early warning system of financial risk for China's foreign investment based on the index system through ANN. This early warning model divided the risk into 4 levels: dangerous, alerting, basic safe and safe, and the models are trained and tested successfully. Finally, we used the early warning models to predict the financial risk in 2009 to test the models. Forecasting results are consistent with the condition of 2009 which is satisfactory.

The drawback of ANNs is that they do not offer an immediate intuition for policy implication. However, Chinese investors can still get inspiration from the warning result. First, they should pay more attention to the risk in international conditions which is the main factor of financial risk in China's foreign investment. Second, the warning results show that home country conditions are good for foreign investment currently, so investors may still gain in foreign investment if they can effectively avoid the risk at the global market.

Considering the financial risk of China's foreign investment varies by countries and industries, further study might focus on analysis of the early warning of financial risk of China's foreign investment by industry or by country.

Last but not least, neither public nor private institutions should entrust their prediction in a single automatic procedure. As a result, the early warning models in this work should be used together with traditional methods used in actual investment.

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Стаття надійшла до редакції 05.06.2013.