

The Estimation of the Probability of the Twin Crisis Occurrence

SHEN Peilong^{[a],*}; SUN Lixia^[a]

^[a]Faculty of Finance and Banking, Shanxi University of Finance & Economics, Taiyuan, China.

*Corresponding author.

Supported by The National Natural Science Foundation of China (Grant No. 71173140).

Received 31 April 2012; accepted 6 August 2012

Abstract

This paper calculates the probability of the twin crisis by empirical analysis with models of Logit and Probit. It selects some countries where twin crisis occurred in 1997 as samples, and forecasts within the samples. Then, it selects some countries where twin crisis occurred in 2008, and tests from outside samples. Results show that the model was well fitted and of high accuracy. The empirical results show that when economy growing too fast, a country should prevent the formation of the bubble economy; the excessive expansion of domestic credit will create bubble economy; variables of banking crisis tend to be as simultaneous or warning indicators for the occurrence of currency crisis. Structure of foreign debt must be suitable and the scale of foreign exchange reserves must be moderate.

Key words: Banking crisis; Currency crisis; Twin crisis; Probability measurement

SHEN Peilong, SUN Lixia (2012). The Estimation of the Probability of the Twin Crisis Occurrence. *Studies in Sociology of Science*, 3(3), 15-19. Available from <http://www.cscanada.net/index.php/sss/article/view/j.sss.1923018420120303.Z0533>
DOI: <http://dx.doi.org/10.3968/j.sss.1923018420120303.Z0533>

INTRODUCTION

Since the 1990s, financial crises characterized by the currency crisis and banking crisis existing simultaneously occurred in some countries especially developing

countries, and this crisis is called twin crisis or double crisis. As the currency crisis theory does not consider the vulnerability of the banking sector, banking crisis theory does not involve opening economic factors, they do not well explain the phenomenon of twin crisis.

Asian financial crisis in 1997 was a typical twin crisis which caused the boom of studying twin crisis in academic circle. Kaminsky and Reinhart (1999) thought that in many countries where currency crisis occurred, their foreign exchange market was attacked, and their domestic banking industry was in crisis. Flood and Marion (2004) proposed a model of the joint distribution of banking and currency crises. They made two points. Firstly, banking and currency crises are related, but they are not the same thing. Viewing crises in isolation or as joint events biases the estimates of the likelihood of crises. Secondly, the proliferation of government promises, such as adding a promise to bail out bank depositors and the promise of fixing the exchange rate, reduces the likelihood of keeping any individual promise when the resources devoted to keeping the promises are scarce. Bleaney *et al.* (2008) combined a second-generation model of currency crises with a standard banking model. They proposed a model of the interactions between banking crises and currency crises and thought that a run on the banks may cause a currency crisis, or vice versa. There are multiple equilibrium (with either twin crises or no crisis), depending on depositors' expectations of other depositors' actions. Suspension of deposit convertibility can prevent a speculative attack on the currency. Shen (2000) researched the long-term symbiosis and fortuity between the banking and currency crisis by total volume set of method and believed that the banking and currency crisis is a common sport in the long term, the banking crisis would lead to currency crisis, but the currency crisis would not lead to a banking crisis. Liu (2003) analyzed the probability of banking crisis and currency crisis in symbiosis using the frequency distribution and signal

method and came to the same conclusion: In emerging market countries, the relationship between the banking crisis and currency crisis does exist, the banking crises even tend to impending currency crisis as a synchronous or early warning indicators, but not vice versa.

Since the majority of academic literatures focuses on the symbiosis of the banking and currency crisis and rarely focuses on how to warn and prevent twin crisis, this paper estimates the probability of twin crisis through empirical analysis. It has certain instructive and realistic significance for constructing perfect twin crisis warning system.

1. MODEL OVERVIEW

This paper estimates the probability of twin crisis through Logit model and Probit model.

1.1 Logit Model and Probit Model

Logit model application must meet the following two constraints: The first, assuming a causal relationship between explained variables and explanatory variables; the second, explained variables can only have two choices. The twin crisis this paper considers only has two situations: The occurrence and otherwise. Whether twin crisis occur or not are explained variables, indicated by Y ; various factors affecting the occurrence of twin crisis are explanatory variables, indicated by X :

$$Y = \begin{cases} 1, & \text{occurrence} \\ 0, & \text{otherwise} \end{cases}$$

First considering the linear regression model, the probability of a crisis can be expressed as:

$$P_i = E(Y = 1 | X_i) = \beta_1 + \beta_2 X_i \quad (1)$$

Where X_i is the various influencing factors of twin crisis, and when $Y = 1$, the twin crisis occur. But now consider the following expression:

$$P_i = E(Y = 1 | X_i) = \frac{1}{1 + e^{-(\beta_1 + \beta_2 X_i)}} \quad (2)$$

In order to illustrate easily, the formula (2) can be written as:

$$P_i = \frac{1}{1 + e^{-Z_i}} = \frac{e^{Z_i}}{1 + e^{Z_i}} \quad (3)$$

Where $Z_i = \beta_1 + \beta_2 X_i$, Equation (3) represents a model in the name of logistic distribution function.

Easily confirmed, as the change from $-\infty$ to $+\infty$, P_i is changing from 0 to 1, and P_i on Z_i (and thus on X_i) are nonlinear relationship, so that it meets above two requirements. But it seems to meet these requirements, it results in estimation. Equation (2) can be clearly seen, P_i on X_i is not only nonlinear relationship, but also for various β are nonlinear. This means that we can not use well-known OLS procedure to estimate the parameters.

If the probability of a crisis P_i is given by Equation (3),

then the probability of the crisis which do not occur $1 - P_i$ is:

$$1 - P_i = \frac{1}{1 + e^{Z_i}} \quad (4)$$

Therefore, we can get:

$$\frac{P_i}{1 - P_i} = \frac{1 + e^{Z_i}}{1 + e^{-Z_i}} = e^{Z_i} \quad (5)$$

Now, $P_i/(1 - P_i)$ is the odds ratio of occurring twin crisis -- the probability ratio of occurrence to not occurrence? For example, if $P_i = 0.8$, the odds ratio is four.

Now, if obtaining the natural logarithm of Equation (5), we can get a very interesting result:

$$L_i = \ln\left(\frac{P_i}{1 - P_i}\right) = Z_i = \beta_1 + \beta_2 X_i \quad (6)$$

The logarithm of odds ratio L_i is not only linear to X_i , but also to parameters from the view of estimation. L is called logit. Such a model like Equation (6) is named the logit model.

Probit model describes the relationship between Interpretation vector and Binary dependent variable through normal distribution. Its cumulative distribution function of random variable is different from the Logit model, and it can be expressed as:

$$P(Y_i = 1 | X_i) = \phi(X_i \beta) \quad (7)$$

1.2 Estimation of Logit Model and Probit Model

In addition to the linear probability model, binary choice models generally use the maximum likelihood estimation. Set of each observed values of binary dependent variable come from the Bernoulli distribution, the probability of each observed values are one is expressed as $F(X_i \beta)$, and satisfies the conditions of independent of each other, then the likelihood function as:

$$L = \prod_{y_i=0} [1 - F(x_i \beta)] \prod_{y_i=1} F(x_i \beta) \quad (8)$$

That is,

$$L = \prod_{i=1}^N [F(x_i \beta)]^{y_i} [1 - F(x_i \beta)]^{1-y_i} \quad (9)$$

Log-likelihood function is:

$$\ln L = \sum_{i=1}^N \{y_i \ln F(x_i \beta) + (1 - y_i) \ln [1 - F(x_i \beta)]\} \quad (10)$$

The first order conditions of Log-likelihood function is:

$$\frac{\partial \ln L}{\partial \beta} = \sum_{i=1}^N \left[\frac{y_i f_i}{F_i} + (1 - y_i) \frac{-f_i}{(1 - F_i)} \right] x_i = 0 \quad (11)$$

The estimated coefficient of binary choice model can not be interpreted as the marginal effect on the dependent variable, can only be judged from sign. If positive, it indicates that the greater the explanatory variables,

the bigger the probability of the dependent variable to take one; if negative, it indicates that the smaller of the corresponding probability.

2. THE SELECTION OF SAMPLES AND INDICATORS

On the view of historical period of the previous financial crisis, the 1997 Asian financial crisis and the global financial crisis in 2008 is an ideal study object in this paper.

2.1 The Selection of Samples

This paper selects fifty-one Asian countries where twin crisis occurred in 1997, including countries suffering severe crisis and less severe crisis. We select countries where typical twin crisis occurred: Thailand, Malaysia, Philippines, Indonesia, Korea, Japan and so on; countries we select where twin crisis did not occur come from Asia, Africa, Latin America and so on and they are emerging market countries or other developing countries, of which the situations of economic development are similar each other. This is convenient for learning and comparing among these countries. Ultimately, it is good for developing mutually.

2.2 The Selection of Indicators

This paper selects three kinds of indicators via considering the integrity and availability of data and the actual conditions of sample countries. They are Macro-level indicators, level indicators of currency and bank level indicators. All sample data are from the World Bank database.

First, Macro-level indicators: GDP growth rate (X1), Inflation rate (X2), Real interest rates (X3), Official exchange rate (X4); Second, level indicators of currency: M2/foreign exchange reserves (X5), Current account balance/GDP (X6), Short-term debt/foreign reserves (X7), Short-term debt/total external debt (X8), Money growth (X9); Third, Bank level indicators: Domestic credit/GDP (X10), Deposit and lending spreads (X11), Bank of liquid assets/assets (X12).

3. EMPIRICAL RESULTS AND ANALYSIS

3.1 Estimation of Logit Model

The data of 12 indicators of 51 countries are substituted into the Logit model to empirical test through Eviews 6.0. When introducing official exchange rate (X4), it can not be estimated, so the indicator X4 is removed. Then the remaining variables are substituted into model to test in order and the insignificant explanatory variables are removed, including the inflation rate (X2), M2/foreign exchange reserves (X5), the current account balance/GDP (X6), short-term debt / total external debt (X8), money growth (X9) and the savings and loan spreads (X11). It is retained that the GDP growth rate (X1), the effective interest rate (X3), short-term debt/reserves (X7), domestic credit/GDP (X10), Bank of liquid assets/assets (X12). Then the five significant variables and the probability of financial crisis make Logit model regression again. Estimated results in Table 1.

Table 1
Logit Model Regression

Variable	Coefficient	Std. error	z-statistic	Prob.
X1	0.388479	0.165014	2.354216	0.0186
X3	-0.174093	0.064593	-2.695213	0.0070
X7	0.241669	0.088439	2.732613	0.0063
X10	0.034311	0.008861	3.872295	0.0001
X12	-0.567452	0.159564	-3.556257	0.0004
C	-3.110886	1.316583	-2.362849	0.0181
McFadden R-squared	0.698840	Mean dependent var		0.117647
S.D. dependent var	0.325396	S.E. of regression		0.210719
Akaike info criterion	0.453461	Sum squared resid		1.998106
Schwarz criterion	0.680735	Log likelihood		-5.563253
Hannan-Quinn criter.	0.540309	Restr. log likelihood		-18.47274
LR statistic	25.81897	Avg. log likelihood		-0.109083
Prob(LR statistic)	0.000097			
Obs with Dep=0	45	Total obs		51
Obs with Dep=1	6			

As can be seen from Table 1, X1, X3, X7, X10, X12 are significant at the level of 5%, indicating that these five variables are highly significant, and the stability and credibility of model are good. In particular, domestic-credit/GDP (X10) has a significant impact on the probability of financial crisis. When a country desperate to provide credit, it will inevitably cause bank failures

and even bankruptcy, affecting normal development of monetary aspects and macro-economic levels, leading to twin crisis. According to Table 1, we can draw the expression of Y_i of Logit model is:

$$Y_i = -3.110886 + 0.388479 \times X_1 - 0.174093 \times X_3 + 0.24166 \times X_7 + 0.034311 \times X_{10} - 0.567452 \times X_{12}$$

Therefore, the probability of Logit model for the financial crisis is:

$$P_i = F(Y_i) = \frac{1}{1 + e^{-(-3.110886 - 0.388479 \times X_1 + 0.174093 \times X_3 + 0.241669 \times X_7 + 0.034311 \times X_{10} - 0.567452 \times X_{12})}}$$

3.2 Test of Probit Model

These significant variables can be tested by Probit model.

As is shown in Table 2, the result is the same with that of Logit model:

Table 2
Probit Model Regression

Variable	Coefficient	Std. error	z-statistic	Prob.
X1	0.210316	0.089667	2.345524	0.0190
X3	-0.098728	0.037566	-2.628098	0.0086
X7	0.132146	0.051539	2.563998	0.0103
X10	0.019975	0.004884	4.089992	0.0000
X12	-0.318226	0.092914	-3.424933	0.0006
C	-1.740534	0.713506	-2.439409	0.0147
McFadden R-squared	0.708185	Mean dependent var		0.117647
S.D. dependent var	0.325396	S.E. of regression		0.208448
Akaike info criterion	0.446691	Sum squared resid		1.955283
Schwarz criterion	0.673965	Log likelihood		-5.390622
Hannan-Quinn criter.	0.533539	Restr. log likelihood		-18.47274
LR statistic	26.16423	Avg. log likelihood		-0.105698
Prob(LR statistic)	0.000083			
Obs with Dep=0	45	Total obs		51
Obs with Dep=1	6			

According to Table 2, we can draw the expression of Y_i of Probit model is:

$$Y_i = -1.740534 + 0.210316 \times X_1 - 0.098728 \times X_3 + 0.132146 \times X_7 + 0.019975 \times X_{10} - 0.318226 \times X_{12}$$

So the probability of Probit model for the financial crisis is:

$$P_i = \phi(Y_i) = \phi(-1.740534 - 0.210316 \times X_{15} + 0.098728 \times X + 0.132146 \times X_7 + 0.019975 \times X_{10} - 0.318226 \times X_{12})$$

Where $\phi(y)$ is a normal distribution function, the results can be obtained by checking the normal distribution table.

3.3 Sample Test

This paper makes a starting point for sample test from

International financial crisis which occurred in 2008, selecting the occurrence of twin crisis countries: Vietnam, the Philippines, Indonesia, Malaysia, Bangladesh; selecting countries which did not occur twin crisis: China, Laos, Cambodia, Egypt, Fiji. The data of 5 significant indicators of these 10 countries are substituted into the probability of twin crisis model and the results obtain in Table 3.

Table 3
Probability Calculation Results

Country	Probability	Y	Country	Probability	Y
Vietnam	0.940127	1	China,	0.000734	0
Philippines	0.008745	1	Laos	1.13E-07	0
Indonesia	0.998920	1	Cambodia	1.14E-08	0
Malaysia	0.999433	1	Egypt	2.71E-05	0
Bangladesh	0.980862	1	Fiji	0.000792	0

Table 3 can be seen directly, the result of estimating the probability of twin crisis in the Philippines does not match with the actual situation, and other countries almost agree with the fact, with the rate to be nearly 90%. It illustrates that the effect of estimating the probability of the model is well. By observing five significant indicators of Philippines, as X10 and X12 perform well, the probability of twin crisis is lower. But the Philippine carries out financial liberalization too quickly, and ties closely to crisis countries in economics, so when the financial tsunami sweeping the global, the Philippines does not escape.

CONCLUSIONS

As can be seen from the results that have been derived from the above theoretical model, the probability of twin crisis in a country depends on kinds of economic factors. The balance of domestic and foreign policies and the degree of economic integration into the world trigger the fuse of twin crisis. Therefore, the conclusions are as follows:

First, with rapid economic growth, a country must take practical methods to prevent the formation of the bubble economy. Thailand carried out financial liberalization too fast, attracted foreign investment constantly, developed economy rapidly and formed a “prosperity” of the scene all over the whole country: real estate expansion, the stock market frenzy, ahead of consumption, over-lending and so on. Thailand’s bubble factors that exist in economy are potential problems which result in twin crisis.

Second, Excessive expansion of domestic credit would create bubble economy. In 1996, Thailand’s lending balances by twenty-nine banks to private enterprise and individuals increased by more than 3.33 times than in 1991. South Korean companies borrowed foreign debt wantonly. High debt and blind expansion led to a chain of

enterprises breakdown and eventually led to twin crisis. Therefore, the state can properly raise interest rates and reduce credit to curb over-investment and inflation.

Third, Bank is the lifeblood of a country’s financial system, and it plays a key role as “affecting the situation as a whole” to economic development of the country. The banking crisis even tends to impending currency crisis as a synchronous or early warning indicator. This is the same as points of Liu (2003). Therefore, a country can prevent the currency crisis and the recession of macro-economic by monitoring all aspects of banking indicators.

Fourth, Structure of foreign debt and foreign exchange reserves must be suitable. Only from June 1997 to June 1998, there were 45 billion U.S. dollars foreign debts in Thailand. In the lack of foreign exchange reserves, it would lead to the debt crisis, creating serious impact on the banking sector. International hot money would make use of this opportunity to attack currencies speculatively, and finally it leads to banking crisis and currency crisis.

REFERENCES

- Bleaney, M., Bougheas, S., & Skamnelos, I. (2008). A Model of the Interactions Between Banking Crises and Currency Crises. *Journal of International Money and Finance*, (27), 695-706.
- Flood, P., & Marion, P. (2004). A Model of the Joint Distribution of Banking and Currency Crises. *Journal of International Money and Finance*, (23), 841-865.
- Kaminsky, G., & Reinhart, C. (1999). The Twin Crises: The Causes of Banking and Balance-of-Payments Problems. *American Economic Review*, (11), 524-607.
- Liu, L. (2003). The Empirical Study of Symbiotic Between Banking Crisis and Currency Crisis. *Financial Research*, (10), 47-59.
- Shen, Z. (2000). Banking Crisis and Currency Crisis is Really Symbiotic? *Financial Research*, (6), 33-41.