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Determinants of the Timing of Bank Failure in Ten Asian Countries

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Abstract
The purpose of this paper is to examine the determinants of the timing of bank failure/merger in 10 Asian countries over the period of 1999-2007 using a multivariate logit model and a split population duration analysis. Apart from bank-specific information, we also focus on the effects of macroeconomic and financial characteristics. The following empirical findings are obtained. First, the results based on the logit model and parametric survival time regressions (Weibull) indicate that individual bank factors such as asset quality, liquidity, earnings, as well as macroeconomic and financial characteristics, namely real interest rates, inflation and the ratio of M2 to foreign exchange reserves are important in explaining the likelihood and timing of bank failure. Second, using a split-population duration model, the evidence further demonstrates that relative timing had a significantly positive influence on the probability of bank failure during the 1999-2007 periods. The study also mentions that not all variables, which explain the probability of failure, are useful to explain the timing of failure. Additionally, these results confirm that bank liquidity, earnings, and macroeconomic environment significantly affect the likelihood and timing of bank failure.

Keywords: Early Warning Systems, Split Population Model, Bank Failures, Bank Mergers and Acquisitions

JEL Classification: E44, G21, N25

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1. Introduction

During the past two decades, many countries of developed and emerging market economies in the world have experienced large scale of financial sector crises. In particular, the Mexican currency crisis occurred in 1994-1995, the Asian financial crisis of 1997-1998, Russian debt crisis of 1998, the Brazilian financial crisis of 1998-1999, Turkish financial crisis of 2000-2001, Argentina's external debt crisis of 2001, and the U.S. subprime mortgage crisis of 2007-2008. As a result, both the academic and the official sectors have begun to develop early warning system (EWS) models to predict the risk of failure of financial institutions in the future.[1] Many EWS studies have been primarily concerned with explaining bank failure and most of them have tended to focus on either individual countries financial institutions or a large number of countries with widely differing economic and financial systems. The EWS model in this paper focuses the investigation on ten Asian countries that exhibit some similarities in their economic and financial systems and geographic proximity. Our goal is to examine factors influencing the bank failure and survival time. Bank-specific factors, macroeconomic and financial factors are the major determinants in concern.

The empirical literature on the EWS model of banking failure is large by using different techniques, such as Altman (1968) first used U.S. financial ratios data and applied multiple discriminant analysis (MDA) to predict corporate bankruptcies.[2] Due to MDA must meet the requirement of normal distribution and equal covariance assumption is not easy to achieve in practice. Subsequently both logit and probit regression techniques have been used with a focus of providing a measure of probability of bank failure. For example, Cole et al. (1995), Demirquc and Detragiache (1998), Poon et al.(1999), Hardy and Pazarbasioglu (1999) Bongini et al.(2001), Daniel (2004), and Daley et al. (2008).

There are also numerous other techniques that have been applied to bank failure prediction, such as Lane et al. (1986) is first based on a survival analysis using Cox's proportional hazard model and U.S. banks for the period between 1979 and 1984 to predict bank failure. Later, Whalen (1991) and Wheelock and Wilson (1995, 2000) also used Cox's proportional hazard model to explain failure and survival of U.S. commercial banks. These studies found that capital adequacy, return on assets, and non-performing loans are useful in explaining the probability of bank failure and survival time. Wheelock and Wilson (2000) further showed that the number of branches and technical efficiency was important factors in determining bank bankruptcies.

Cole and Gunther (1995) applied the split-population survival time model to prediction of time failure for 1043 banks in United States during the period 1986-1992. Their empirical results show that the factors influencing the probability of bank failure may be different from those explaining the survival time. Also, Dahl and Spivey (1995), Hunter et al. (1996) and Deyoung (1999) employed the split-population survival time model to the case of de-novo banks, undercapitalized banks and commercial banks, respectively. Recently Maggiolini and Mistrulli (2005) also used the same method to examine the determinants of the survival and survival probability of the Italian Co-operative Credit bank over the period 1990-2000. Their results found that survival is related to the market share of large banks and the local level of GDP. Evrensel (2008) applied parametric and non-parametric survival analysis to explain the effects of bank concentration, regulations, and macroeconomic policies on bank failures. Results show that lower inflation rate, lower domestic credit growth, lower real interest rate, higher real GDP growth, depreciation of the home currency result in a low probability of bank failure.

Arena (2008) estimated the logit model and survival duration model by using bank-level data from banking crises during the 1990s in East Asia and Latin America to examine the determinants of bank failure. Results show that bank-level fundamentals not only significantly affect the likelihood of bank failure but also explain why bank are likely to fail. He furthermore used survival time analysis for the Latin American case, and found that not only bank-level indicators, bank system liquidity and macroeconomic variables (such as real exchange rate volatility and GDP growth rate) as explain the likelihood of failure.

A number of papers have studied Taiwan's financial institutions, Lee (1993) applied the accelerated failure time model and used Taiwan's credit unions data to estimate the hazard function and the determinants of the survival time. Chuan and Jang (2002) employed an parametric survival analysis model to examine the determinants of the exit of foreign banks in Taiwan. Hsu et al. (2003) used

[1] See Wu et al. (2000) and Sahajwala and Bergh (2000).

[2] See Sinkey (1975) and Altman et al. (1981).

parametric survival analysis to explain the effects of bank failure for six East Asian countries, namely Taiwan, Korea, Thailand, Indonesia, Philippines, and Malaysia, during the period 1997-2000. Their results find that macroeconomic variables, bank scale, operating efficiency and capital adequacy plays a significant role in explaining the survival time and the crisis probability of bank in six East Asian countries.

Recently, Chen and Wang (2007) used a sample of mergers for financial institutions and financial holding companies and applied the parametric survival analysis model to measure the spell lengths of hazard rate. They showed that with lesser branches, lower total asset turnovers and smaller ownerships for the directors and supervisors, financial institutions may reduce the spell lengths to merge. Yu et al. (2008) chose a mixed distribution function for the split population duration model to investigate the bank runs in the Credit Department of Farmer's Institution. Their results found that higher the ratio of insured borrowing to total borrowing or join deposit insurance would likely to have later bank runs and lower the risk of bank runs.

Our study applies the split population survival model to investigate the factors determining the bank failure in ten Asian countries over the period 1999 through 2009. The methodological is adopted in our study because it assume some banks will never experience exits and therefore our results are more appropriate than standard survival analysis. This is the first study to using the split population survival time model to predict bank failure for Asian countries. For comparison purpose, we also use both logit and parametric survival analysis model. This study will help further understand the determinants of the timing of bank failure and merger in ten Asian countries.

The paper is organized as follows. Section 2 discusses our sample data and describes the methodology used in this paper. Section 3 summarizes the empirical results. Section 4 concludes the paper.

2. Data and Methodology

2.1. Data Description

In this paper, we investigate the failure decisions for commercial banks from ten Asian countries: Taiwan, Japan, Hong Kong, Korea, Singapore, China, Indonesia, Malaysia, the Philippines, and Thailand. The data cover the period 1999-2007 and countries are observed annually. The sample contains 349 banks that have complete records from 1999 to the year of exit or to the final sample date, 2007. Macroeconomic and financial data used for each country were collected from the World Development Indicators (WDI). The bank-level balance sheet and income statements data used in our sample come from the Bank Scope database, published by the Bureau yan Dijk. The sample was split into two groups: failed and non-failed banks. Table 1 provides the frequency distribution of our sample with respect to survival and distressed. A total of 349 banks are assessed, 52 of which are classified as failed.[1] Average survival time is 54.48 years. Japan had the most bank failed, followed by Malaysia and Indonesia. Thailand and China have the lowest number of failed institutions. The maximum survival time is censored at 156 years in Philippines. The minimum survival time is censored at 7 year in Japan.

The bank-specific variables are mainly based on CAMEL rating categories (capital adequacy, asset quality, management, earnings, and liquidity), growth and size, which are taken from the bank's financial statements. Regarding macroeconomic and financial variables, we used six indicators measures, which are commonly adopted in the literature: GDP per capita growth, inflation, real interest rate, M2/foreign exchange reserves, domestic credit growth and the volatility of exchange rate.[2] Appendix A summarizes bank-specific, macroeconomic and financial variables, along with the expected signs of their impact on the likelihood of a bank's failure and survival time.

2.2. Methodology

Our empirical work on the determining of banking failure adopted the survival analysis. Most studies of survival analysis are based on parametric model and Cox's (1972,1975) proportional hazard rate model, while these model assume that each bank will eventually experience an exit is not appropriate. In fact it is

[1] A bank is identified as being in distress when at least one of the following criteria is met according to the information from the Bankscope database: Bankruptcy, Dissolved merger, In liquidation. Of the 52 distress 1 are further classified as bankruptcy, the remaining 49 were subject to dissolved merger.

[2] See Demirgüc-Kunt and Detragiache (1998,2005), Kaminsky and Reinhart (1999) and Davis and Karim (2008).

a possibility that some banks will never experience exits while others will. Thus, the split population duration models relax this assumption by essentially splitting the sample into two groups, one that will eventually experience an exit and one that will never experience an exit. Thus, the probability that a bank will eventually exit is assumed to be less than one. Let F be a binary variable that equals one for banks that eventually exit and zero for those that will never exit. Then we assume

$P(F = 1) = \delta$,

$P(F = 0) = 1 - \delta$

The parameter δ is the "split population parameter" that denotes the probability of eventual exiting, and 1-δ is the survival rate.

We define a cumulative distribution function $F(t|F = 1) = P(T \le t|F = 1)$ for banks that ultimately exit, and let $f(t|F = 1)$ be the corresponding probability density function. Let T is the length of time that a bank will ultimately exit. Similarly, the survival function conditional on F=1 can be written as $S(t|F = 1) = 1 - F(t|F = 1)$.

Next, let Q_i be an indicator variable that equals one for an uncensored observation and equals zero otherwise, i.e., Q_i=1 for bank that exit, Q_i=0 for bank that survived over the entire sample period. The number of banks in the sample is denoted as N. For the cases that experience exit, Q_i=1, which implies that F=1. For these observations, the appropriate density is:

$$P(F = 1)P(t \le T|F = 1) = \delta f(t|F = 1) \quad (1)$$

On the other hand, for the sample banks who would never exit, we observe only F=0. The probability of this event is:

$$P(F = 0) + P(F = 1)P(t_i > T_i|F = 1) = (1 - \delta) + \delta S(t_i|F = 1) \quad (2)$$

Therefore, the likelihood function for the split population duration model consists of expressions (1) and (2):

$$L = \prod_{i=1}^{N} \delta f(t_i|F = 1)^{G_i} [(1 - \delta) + \delta S(t_i|F = 1)]^{(1-G_i)} \quad (3)$$

Then performing a log transformation produces the log-likelihood:

$$\ln L = \sum_{i=1}^{N} G_i[\ln\delta + \ln f(t_i|F = 1)] + (1 - G_i)\ln[(1 - \delta) + \delta S(t_i|F = 1)]$$

We fit split population durations to our data using the log-logistic distribution. The log-logistic hazard and survival functions are respectively given by:

$$h(t) = \frac{\lambda p(\lambda t)^{p-1}}{1 + (\lambda t)^{p}} \quad (4)$$

$$S(t) = \frac{1}{1 + (\lambda t)^{p}} \quad (5)$$

where λ>0 and p>0 are the definition parameters. $\lambda = \exp(-\beta' x)$, x is a vector of bank characteristics and time invariant covariant.

Substitution of Equation (4) and Equation (5) into Equation (3) results in the complete likelihood function. The parameters can be estimated using maximum likelihood estimation procedures. A significantly negative coefficient indicates that an increase in that variable reduces the chances that the bank will exit.[1]

3. Empirical Results

3.1. Descriptive statistics and correlations

We calculated the differences in means of the explanatory variables of both groups and tested the statistical significance of those differences. The mean differences of the variables for both non-failed and failed banks are given in Table 2. In the first and second column, the mean values for both failed and non-failed banks are shown and the last column illustrates the p-value of mean difference tests. According to the mean difference test, 11 variables are found significantly differences in their means. Comparing the difference, we find that the failed banks had a lower average equity to asset ratio with 5.778%, higher average rate of loan loss reserve to the sum of equity and loan loss reserve(96.43%) and average ratio of loan loss reserve to total loans(6.833%), higher average cost-to-income ratio(123.20%), higher average operating expense ratio(4.176%) and higher average non-interest ratio(3.913%), lower average return on total asset(-0.871), lower average liquidity ratio(22.57%) , lower average deposit growth(0.450%), lower average loan growth(-1.515%), and lower average total assets growth(-1.501%). This means that the performance of these survival banks is better than failed banks. The failed banks presented a lower capital adequacy, less relative managerial efficiency, weaker asset quality, lower profitability, less liquid and lower growth during the sample period.

Table 3 shows the summary statistics for major macroeconomics variables. Over the

[1] For a detailed discussion of split population duration models, see Schmidt and Witte (1989) and Cole and Gunther(1995).

sample period, China's average GDP per capita growth rate 10.02% and domestic private credit growth rate 14.26% were the highest among these economies, Japan was lowest. The ratio of M2 to foreign exchange reserve in Japan was largest (11.90%), while Singapore's was smallest (1.23%). As for the inflation, Indonesian has the highest average inflation rate (13.89%). The volatility of exchange rate in the Philippines, Indonesia, and Thailand were largest (-6.091%, -5.936%, -5.630%), Hong Kong and Taiwan were the lowest (-0.0691% and -0.326%). The average rate of exchange rate depreciation was positive only in Japan, indicating the yen depreciated trend over the period, and the other countries show appreciation trend. Regarding the real interest rate, Hong Kong, South Korea and Singapore had the highest average real interest rates (8.779%, 6.285% and 5.013), Thailand, Mainland China and Taiwan were the lowest (2.409%, 2.465% and 2.699%). It is noteworthy that the volatility of the standard deviation of the overall macroeconomic and financial indicators in Taiwan was smaller. In other words, Taiwan's macroeconomic performance was relative stability over the period.

Table 4 reports the results of the correlation matrix and the variance inflation factor (VIF) of the variables.[1] The variance inflation factor values are less than 10 for all variables, indicating a low degree of multicollinearity. The correlation coefficients are markedly higher in several variables. First, the correlation between cost-to-income ratio and return on assets is 0.78. Second, loan growth is positively and highly correlated with deposit growth, with a correlation coefficient of 0.65. Third, the correlation between deposit growth and total assets growth is 0.74. Fourth, loan growth is correlated with total asset growth, with a correlation coefficient of 0.79. It appears that these variables are highly correlated over the sample period. These correlations suggest that when we add them in each of the regression, multicollinearity might be serious. To solve the problem, only one of them was included in each of the regressions.

3.2. Results

We first use the logit model to estimate the determinants of bank failure/merger. The logit model is a binary outcome. It is used to assess whether bank-specific variables and macro-environment are important for explaining Asian countries differences in bank failure. The dependent variable takes the value of one if bank is identified in any of the categories of failure during sample. Table 5 reports the results of the estimation. We specified ten different models. Columns (1) to (5) are to add the cost to income ratio variable. Columns (6)~(10) incorporate the return on average assets indicator. Columns (1) and (6) only consider the results of bank-specific variables, columns (2)~(5) and (7)~(10) include not only the bank-specific variables but also macroeconomic and financial variables. Table 5 also show the overall model selection criteria with Akaike's information criteria (AIC) and the pseudo R^2. According to both criteria, the estimates in the full model specification, which use overall bank-specific, macroeconomic and financial variables, provide higher pseudo R^2 and lower AIC values than that of the former one, which uses only bank-specific variables. In addition to, the classification accuracy measures the performance of the model. A high overall classification accuracy suggests that the model is good and fits the data well. The logit model show a good predictive power, between 86% and 94% of financial institutions were correctly classified. From Table 5, model (3) and (8) seems to have the highest pseudo R^2, lowest AIC value and highest predicted power.

For comparison purposes, we will discuss only columns (3) and (8) results. As shown in columns (3) and (8) of Table 5, the ratio of loan loss reserve to the sum of equity and loan loss reserve and cost-to-income ratio are positive and statistically significant, the ROA and liquidity ratio are negative and statistically significant, as expected. This means that banks with weaker asset quality, management inefficiency, lower earnings and lower liquidity, have higher risk of failure. With regard to macroeconomic and financial variables, the inflation rate, real interest rate and the ratio of M2 to foreign exchange reserves have a positive effect on the probability of failure. The results reveal that high ratio of M2 to foreign exchange reserves, high inflation and high real interest rate are the main macroeconomic and financial factor that explain the banking failure in ten Asian countries. These findings are consistent with Demirgüc-Kunt and Detragiache (1998, 2005), who suggest that high inflation, real interest rate and the ratio of M2 to foreign exchange reserves are associated with banking distress increasing the likelihood of bank failure. Hardy and Pazarbasioglu

[1] As a rule of thumb, if VIF is greater than 10, a problem with multi-collinearity is indicated.

(1999) also have similar findings.[1] Finally, except in column (3) of Table 5, none of the coefficient on the domestic private credit growth rate is statistically significant. The results suggest that the probability of bank failure and merger is not related to credit growth.

To highlight the characteristics of this conduct to facilitate comparison, the next section of the survival model will be based on both selected model (3) and (8). Table 6 report the results of the re-estimation of two specifications of both selected model (3) and (8) using a standard parametric survival model. We applied the maximum likelihood method to estimate four different distribution types of the Weibull, Exponential, Log-logistic and Log-normal distributions, respectively. The four distributions of the model may be compared using the AIC and log-likelihood value. On the basis of this both criteria, the Weibull regression model is preferred, because it has the smallest AIC value and the largest log-likelihood. To save space, we only report the results of estimation of the Weibull regression model as shown in Table 6. The estimated values of the scale parameter (σ) is significantly less than 1 (i.e., $p = 1 / \sigma > 1$), indicate that the hazard function is monotonically decreasing in duration. This means that the probability of bank failure will increase over time. Among the bank-specific variables, only the coefficients on ratio of loan loss reserve to the sum of equity and loan loss reserve, the return on average assets and liquidity ratio have the expected signs and are statistically significant, respectively. This suggests that the weaker assets quality, lower return on assets, lower liquidity ratio, higher risk of failure and the shorter the survival time. This is consistent with the result of Wheelock and Wilson (2000). With respect to the role of macroeconomic and financial variables, it is found that the inflation rate, real interest rate, the ratio of M2 to foreign exchange reserves, and domestic private credit growth rate have a negative influence and are significant, as expected. The results reveal that asset quality, profitability, liquidity, macroeconomic and financial factors explain the survival time of banks in ten Asian countries.

Finally, we consider that some banks will never experience exits. We apply the split population survival time model to our data and compare the results with those of the parametric survival model and logit model. The results show in Table 7. Comparing the estimated values of reciprocal of scale parameter in model (1) or (2) of Table 6 and Table 7, the reciprocal of scales parameters (1/0.482= 2.075) and (1/0.485 = 2.062) in Table 6 are less than (1/0.425 = 2.353) and (1/0.467 = 2.141) in Table 7, indicating that the hazard function is higher estimated with split population duration model. Therefore, if we don't consider that some banks will never experience exits, it will underestimate the probability of failure/exit. The last row of Table 7 reports the average predict failure probability. The probability of failure is within the range 36.68% to 43.98%.

Turning to the explanatory variables, the coefficient on ratio of equity to assets, cost to income ratio, return on average assets, inflation and real interest rate have the expected signs and are statistically significant, respectively. Note that some of the split population survival time model estimation results are different from those of the standard logit and parametric survival model. However, the three econometric methods have consistently demonstrated that return on average assets, liquidity ratio, inflation and real interest rate are important determinant of bank failure.

4. Conclusion

In this paper, we examine various determinants of the timing of bank failure and merger using ten Asian countries data. The major findings are as follows. First, the logit model and parametric survival time regressions (Weibull) show that individual bank factors such as asset quality, liquidity, earnings, as well as macroeconomic and financial characteristics, namely real interest rates, inflation and the ratio of M2 to foreign exchange reserves are important in explaining the likelihood and timing of bank failure. Second, using a split-population duration model, the evidence further demonstrates that relative timing had a significantly positive influence on the probability of bank failure during the 1999-2007 periods. The study also mentions that not all variables, which explain the probability of failure, are useful to explain the timing of failure. Additionally, these results confirm that bank liquidity, earnings, and macroeconomic environment significantly affect the likelihood and timing of bank failure.

[1] Their results are also show that high inflation and real interest rate have higher risk of bank failure.

References

1. Akaike, H. (1974), "A New Look at the Statistical Model Identification," IEEE Transaction and Automatic Control AC-19: 716-723.

2. Altman, E. I. (1968), "Financial Ratios, Discriminant Analysis and the Prediction of Corporate Bankruptcy," *The Journal of Finance*, 23, 589-609.
3. Altman, E. I., R. G. Haldeman, and P. Narayanan (1977), "ZETA Analysis: A New Model to Identify Bankruptcy Risk of Corporations," *The Journal of Banking and Finance*, 1, 29-54.
4. Altman, E. I., R. B. Avery, R. A. Eisenbeis, and J. F. Sinkey Jr.(1981), Application of Classification Techniques in Business, Banking and Finance, Greenwich, CT: JAI Press.
5. Arena, M. (2008), "Bank Failures and Bank Fundamentals: A Comparative Analysis of Latin America and East Asia During the Nineties using Bank-Level Data," *Journal of Banking and Finance*, 32, 299-310.
6. Bongini, P. , G. Ferri and T. S. Kang (1999), "Financial Intermediary Distress in The Republic of Korea: Small Is Beautiful," Policy Research Working Paper Series: no.2332.
7. Bongini, P., S. Claessens and G. Ferri (2001), "The Political Economy of Distress in East Asian Financial Institution," *Journal of Financial Services Research*, 19, 5-25
8. Braga, M. J., V. G. F. Bressan, E. A. Colosimo and A. A. Bressan (2006), "Investigating The Solvency of Brazilian Credit Unions using a Proportional Hazard Model," *Annals of Public and Cooperative Economics*, 77, 83-106.
9. Bussiere M. and M. Fratzscher (2006), "Towards a New Early Warning System of Financial Crises," *Journal of International Money and Finance*, 25, 953-973.
10. Chuan, H. C., Jang, S. L., 2002. The Exit Behavior of the foreign banks in Taiwan. Proceedings of the Sixth Conference in Memory of Professor Kuo-shu Liang. 59-88. (In Chinese)
11. Cole, R. A. and J. W. Gunther (1995), "Separating the Likelihood and Timing of Bank Failure," *Journal of Banking and Finance*, 26, 1011-1028.
12. Cox, D. R. (1972), "Regression Models and Life Tables," *Journal of the Royal Statistical Society*, Series B, 34, 187-220.
13. Cox, D. R. (1975), "Partial Likelihood," *Biometrika*, 62, 269-275.
14. Daley, J., K. Mattews, and K. Whitfield (2008), "Too-Big-to-Fail: Bank Failure and Banking Policy in Jamaica," *Journal of International Financial Markets*, Institutions and Money, 18, 290-303.
15. Daniel, P. (2004), "Estimating Probabilities of Default for German Savings Banks and Credit Cooperatives," Deutsche Bundesbank, Research Centre, Discussion Paper Series 2: Banking and Financial Studies no. 06/2004.
16. Davis, E. P. and D. Karim (2008), "Comparing Early Warning Systems for Banking Crises," *Journal of Financial Stability*, 4, 89-120.
17. Demirgüc-Kunt, A and E. Detragiache (1998), "The Determinants of Banking Crisis in Developing and Developed Countries," *IMF Staff Papers*, 45, 81-109.
18. Demirgüc-Kunt, A and E. Detragiache (2005), "Cross-Country Empirical Studies of System Bank Distress: A Survey," IMF Working Paper no. 96.
19. DeYoung, R.(1999), "Birth, Growth, and Life or Death of Newly Chartered Banks," Working Paper, Federal Reserve Bank of Chicago.
20. Evrensel, A. Y. (2008), "Banking Crisis and Financial Structure: A Survival-Time Analysis," *International Review of Economics and Finance,* 17, 589-602.
21. Kaminsky, G. L. (1999), "Currency and Banking Crises: The Early Warnings of Distress," IMF Working Paper no. 178.
22. Kaminsky, G. L., and C. M. Reinhart (1999), "The Twin Crises: The Causes of Banking and Balance-of-Payments Problems," The American Economic Review, 89, 473-500.
23. Kaminsky, G. L., S. Lizondo and C. M. Reinhart (1998), "Leading Indicators of Currency Crises," IMF Staff Papers, 45, 1-48.
24. Hardy, D. C. and C. Pazarbasioglu (1999), "Determinants and Leading Indicators of Banking Crises: Further Evidence," IMF Staff Papers, 46, 247-258.
25. Hsu, C. M., W. C. Liu, and S. L. Hsieh (2003), "A Model of Early Warning System of Financial Crisis of Financial Institutions," *Quarterly Journal of Deposit Insurance Information*, 17, 51-75.
26. Lancaster, T. (1990), "The Econometric Analysis of Transition Data," Econometric Society Monographs, no. 17 Cambridge; New York and Melbourne: Cambridge University Press.
27. Lane W. R., S.W. Looney and J. W. Wansley (1986), "An Application of the Cox Proportional Hazards Model to Bank Failure," *Journal of Banking and Finance*, 10, 511-531.
28. Lee, J. C., 1993, "Financial Institution Failure Prediction Model – the Application of Accelerated Failure Time Nodel. *Taiwan Economic Review,* 21, 355-379. (In

Chinese)
29. Lin, H. L. (1993), "Econometric Models of Firm's Exit Rate and Survival Time – The Evidence of Taiwan Electronic and Electric Appliance Industry," *Taiwan Economic Review*, 21, 411-440. (In Chinese)
30. Ohlson, J. A. (1980), "*Financial Ratios and the Probabilistic Prediction of Bankruptcy*," *Journal of Accounting Research*, 18, 109-31.
31. Sahajwala, R., and P. V. den Bergh (2000), "Supervisory Risk Management and Early Warning Systems," Basel Committee on Banking Supervision, Working papers no.4, Bank for International Settlements.
32. Schmidt, P. and A. D. Witte (1989), "Predicting Recidivism Using Split Population? Survival Time Model," *Journal of Econometric*s, 40, 141-59.
33. Sinkey, J. F., Jr. (1975), "A Multivariate Statistical Analysis of the Characteristics of Problem Banks," *The Journal of Finance*, 30, 21-36.
34. Sinkey, J. F., Jr. (1978), "Identifying Problem Banks—How Do the Banking Authorities Measure a Bank's Risk Exposure?" *Journal of Money, Credit and Banking*, 10, 185-193.
35. Pinches, G. E. and K. A. Mingo (1973), "A Multivariate Analysis of Industrial Bond Ratings," *The Journal of Finance*, 28, 1-18.
36. Pettway, R. H. and J.F. Jr. Sinkey (1980), "Establishing On-Site Bank Examination Priorities: An Early Warning System Using Accounting And Marketing Information," *The Journal of Finance*, 35, 137-150.
37. Whalen, G. (1991), "A Proportional Hazards Model of Bank Failure: An Examination of Its Usefulness as an Early Warning Tool," *Economic Review*, Federal Reserve Bank of Cleveland, First Quarter, 21-31.
38. Wheelock, D. C. and P. W. Wilson (2000), "Why Do Banks Disappear? The Determinants of U.S. Bank Failures and Acquisitions," *Review of Economics and Statistics*, 82, 127-38.
39. Wu, Y. J., T. T. Yen., and P. W. Chen, (2000), Early Warning System for Currency Crises: An Empirical Study of SEACEN Countries, the SEACEN Centre, Kuala Lumpur.
40. Yu, S., C. H. Chang, and C. Y. Chi (2008), "Applying the Mixture Probability Distribution to Investigate the Risk of Bank Runs in the Credit Department of Farmer's Institutions," Journal of Agricultural Economics Semiannual *Publication*, 83, 1-20. (In Chinese)

Table 1: Number of bank mergers and duration by country and year
Unit: Number, Years

Country name	Number of banks			Duration (in years)			
	Exited	Other	Total	Mean	Standard deviation	Min	Max
Taiwan	4	28	32	42.03	31.59	10	108
Japan	19	113	132	75.94	27.15	7	134
Hong Kong	5	20	25	58.76	17.87	25	95
Korea	3	14	17	45.94	21.34	24	110
Singapore	2	5	7	55.00	13.53	39	75
China	1	37	38	20.11	22.13	9	99
Indonesia	6	33	39	30.38	20.10	10	94
Malaysia	8	18	26	48.42	32.34	8	132
Philippines	3	17	20	50.60	32.00	10	156
Thailand	1	12	13	60.92	15.79	38	101
Total	52 (14.90%)	297 (85.10%)	349 (100%)	54.48	32.27	7	156

Note: Data come from author. The number in parentheses indicates the number of event banks as a fraction of the total number of sample banks.

Source: Authors

Table 2: Descriptive Statistics

Variable name	Exit banks	Other banks	All Banks	t-Statistics (p-value)
Capital adequacy				
Tier 1 capital ratio	7.255 (5.295)	11.76 (18.01)	11.31 (17.23)	0.1896
Equity / total assets	5.778 (7.556)	8.253 (7.480)	7.884 (7.532)	0.0287**
BIS	12.09 (7.483)	15.15 (18.00)	14.75 (17.03)	0.2777
Asset quality				
Loan loss reserve/ (equity + loan loss reserve)	96.43 (4.069)	91.52 (10.77)	92.25 (10.20)	0.0013**
Loan loss reserve / total loans	6.833 (10.03)	2.927 (5.581)	3.509 (6.570)	0.0001***
Management				
Cost-to-income ratio	123.2 (94.04)	74.13 (35.68)	81.44 (51.82)	0.0000***
Operating expenses / total assets	4.176 (6.778)	2.200 (1.950)	2.495 (3.235)	0.0000***
Non-interest expense / average assets	3.913 (5.734)	2.268 (1.678)	2.513 (2.749)	0.0001***
Earnings				
Return on average assets	-0.871 (4.791)	0.660 (1.278)	0.431 (2.247)	0.0000***
Return on average equity	14.49 (94.58)	2.983 (52.23)	4.697 (60.40)	0.2055
Net interest margin	2.488 (1.110)	2.677 (1.530)	2.649 (1.475)	0.3957
Net interest Spread	4.348 (3.791)	-2.267 (109.1)	-1.281 (100.6)	0.6626
Liquidity				
Liquidity ratio	22.57 (13.75)	28.21 (17.69)	27.37 (17.26)	0.0297**
Loans/Deposits	84.42 (23.96)	270.5 (2690.9)	242.8 (2482.7)	0.6188
Growth				
Deposit Growth	0.450 (14.96)	9.868 (20.92)	8.464 (20.40)	0.0020***
Loan Growth	-1.515 (16.60)	12.830 (39.27)	10.692 (37.13)	0.0100***
Asset Growth	-1.501 (13.14)	11.295 (20.73)	9.389 (20.29)	0.0000***
Scale				
Log(total assets)	8.164 (2.165)	8.534 (2.345)	8.479 (2.320)	0.2892

Note: Numbers in parentheses are standard errors. ***,** and * indicate significant differences between failed and non-failed banks at the 1%, 5%, and 10% level, respectively.
Capital ratio is the book value of shareholder equity divided by total assets.
Source: Authors

Table 3: Descriptive Statistics for macro data Unit: %

	Taiwan	Japan	Hong Kong	Korea	Singapore	China	Indonesia	Malaysia	Philippines	Thailand	Total
GDP per capita growth	3.681	2.073	5.816	4.738	3.637	10.020	3.879	3.935	3.203	4.449	4.009
	(2.71)	(0.62)	(1.74)	(0.86)	(4.05)	(0.40)	(1.31)	(0.66)	(0.69)	(0.57)	(2.70)
Inflation	-1.079	-0.934	-1.085	-0.061	0.425	3.560	13.890	3.336	5.533	4.728	2.157
	(0.14)	(0.21)	(2.00)	(0.97)	(1.64)	(0.25)	(1.75)	(1.65)	(0.88)	(1.02)	(4.83)
Real interest rates	2.699	2.667	8.779	6.285	5.013	2.465	2.703	3.499	4.229	2.409	3.455
	(0.35)	(0.33)	(2.32)	(0.69)	(1.62)	(0.21)	(2.84)	(2.50)	(0.29)	(0.64)	(2.20)
M2/ Reserves	3.043	11.900	3.895	2.719	1.233	4.162	3.459	2.662	2.941	3.269	6.543
	(0.31)	(5.85)	(0.20)	(0.36)	(0.05)	(0.90)	(0.19)	(0.56)	(0.10)	(0.20)	(5.55)
Credit growth	5.143	-0.651	1.280	13.550	8.326	14.260	8.753	4.118	7.065	6.484	4.628
	(2.41)	(0.92)	(1.81)	(7.60)	(2.29)	(0.47)	(18.68)	(2.94)	(3.18)	(7.02)	(8.54)
exchange rate	-0.326	4.464	-0.0691	-5.651	-2.433	-2.624	-5.936	-2.796	-6.091	-5.630	-0.387
	(1.48)	(4.22)	(0.16)	(5.21)	(3.65)	(0.44)	(5.58)	(0.99)	(2.35)	(0.66)	(5.47)

Note: Standards errors are in parentheses.

Source: Authors

Table 4: Results of the test of Multi-collinearity Diagnosis

	Equity / total assets	Loan loss reserve/ (equity + loan loss reserve)	Loan loss reserve / total loans	Cost-to-income ratio	Return on average assets	Liquidity ratio	Deposit Growth	Loan Growth	Asset Growth	GDP per capita growth	Inflation	Real interest rates	M2/ Reserves	Credit growth	exchange rate	VIF value
Equity / total assets	1.00															3.29
Loan loss reserve/ (equity + loan loss reserve)	-0.54	1.00														2.39
Loan loss reserve / total loans	0.07	0.18	1.00													3.27
Cost-to-income ratio	-0.41	0.33	0.38	1.00												3.39
Return on average assets	0.51	-0.28	-0.55	-0.78	1.00											6.72
Liquidity ratio	0.38	-0.36	0.17	-0.18	0.20	1.00										2.01
Deposit Growth	0.29	-0.19	-0.02	-0.23	0.19	0.17	1.00									2.89
Loan Growth	0.05	-0.08	-0.12	-0.14	0.11	0.14	0.65	1.00								3.02
Asset Growth	0.15	-0.17	-0.20	-0.31	0.29	0.28	0.74	0.79	1.00							4.61
GDP per capita growth	0.18	-0.26	-0.11	-0.34	0.19	0.22	0.35	0.22	0.36	1.00						2.12
Inflation	0.26	0.01	0.31	-0.05	0.04	0.52	0.22	0.21	0.22	0.20	1.00					2.73
Real interest rates	0.10	-0.26	0.05	-0.06	0.12	0.07	-0.12	-0.04	-0.03	0.04	-0.23	1.00				1.96
M2/ Reserves	-0.28	0.19	-0.10	0.23	-0.17	-0.36	-0.20	-0.17	-0.26	-0.43	-0.38	-0.15	1.00			1.78
Credit growth	0.20	-0.09	-0.10	-0.24	0.13	0.19	0.37	0.28	0.39	0.59	0.31	-0.28	-0.38	1.00		2.14
exchange rate	-0.27	0.03	-0.23	0.11	-0.19	-0.39	-0.19	-0.13	-0.23	-0.31	-0.52	-0.28	0.33	-0.20	1.00	2.24

Source: Authors

Table 5 Results of Logit estimation

	Including cost-to-income ratio					Including return on average assets				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Constant	-14.500***	-25.990***	-26.400***	-22.880***	-23.980***	-1.223***	-1.659***	-4.835***	-4.026***	-3.656***
	(2.60)	(3.76)	(4.06)	(3.61)	(3.51)	(3.62)	(3.48)	(5.64)	(4.74)	(4.52)
Total equity / total assets	0.059	0.040	0.048	0.024	0.033	0.028	-0.043	-0.0001	0.025	0.015
	(1.61)	(1.00)	(1.16)	(0.54)	(0.70)	(0.94)	(1.01)	(0.00)	(0.66)	(0.40)
Loan loss reserve/ (equity + loan loss reserve)	0.130**	0.226***	0.203***	0.178***	0.185***					
	(2.24)	(3.23)	(3.12)	(2.79)	(2.76)					
Loan loss reserve / total loans	0.027	0.006	0.005	0.034	0.035					
	(1.02)	(0.24)	(0.18)	(1.28)	(1.26)					
Cost-to-income ratio	0.008**	0.011**	0.011*	0.010**	0.010**					
	(2.21)	(2.51)	(1.93)	(2.00)	(2.06)					
Return on average assets						-0.319***	-0.426***	-0.458***	-0.346***	-0.297***
						(2.96)	(2.98)	(3.07)	(2.88)	(2.72)
Liquidity ratio	-0.026*	-0.044**	-0.046**	-0.016	-0.016	-0.020	-0.041**	-0.053**	-0.025	-0.018
	(1.83)	(2.32)	(2.16)	(0.84)	(0.83)	(1.50)	(2.25)	(2.55)	(1.46)	(1.10)
Deposit Growth	-0.037**	-0.029*	-0.030	-0.023	-0.026	-0.040***	-0.014	-0.027	-0.022	-0.016
	(2.46)	(1.73)	(1.48)	(1.15)	(1.26)	(2.71)	(0.91)	(1.52)	(1.20)	(0.94)
GDP per capita growth					0.041		-0.469***			-0.224*
					(0.33)		(3.41)			(1.94)
Inflation		0.095*	0.305***				0.198***	0.315***		
		(1.65)	(4.19)				(3.20)	(4.27)		
Real interest rates		0.661***	0.966***	0.696***	0.710***		0.686***	0.731***	0.451***	0.501***
		(5.96)	(6.31)	(5.42)	(5.44)		(6.03)	(6.33)	(4.87)	(5.48)
M2/ Reserves			0.189***	0.132***	0.146***			0.195***	0.160***	0.152***
			(3.19)	(2.92)	(3.32)			(3.69)	(3.01)	(3.04)
Credit growth			-0.066*	-0.015				-0.055	-0.032	
			(1.70)	(0.40)				(1.40)	(0.78)	
exchange rate				-0.007	0.007				-0.085*	-0.090*
				(0.16)	(0.14)				(1.73)	(2.01)
Log likelihood	-121.869	-94.766	-77.449	-85.966	-85.996	-131.346	-101.344	-90.449	-97.620	-95.742
χ^2	50.10***	104.30***	138.94***	121.90***	121.84***	31.14***	91.15***	112.94***	98.59***	102.35***
Pseudo R^2	0.1705	0.3550	0.4728	0.4149	0.4147	0.1060	0.3102	0.3844	0.3355	0.3483
AIC	257.738	207.532	176.898	193.933	193.992	272.691	218.687	198.897	213.241	209.484
Overall predicted power	86.82%	88.83%	94.56%	93.12%	93.41%	86.25%	91.40%	93.12%	91.69%	92.84%

Note: A t-statistic is reported in parentheses. ***, ** , and * indicate statistical significance at the 1%, 5%, and 10% level, respectively. The estimation software package used is STATA 10.0.

Source: Authors

Table 6: Results of estimations of parametric survival model

Explanatory variables	Weibull		Exponential		Log-logistic		Log-normal	
	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
Constant	11.127***	6.006***	17.999***	7.593***	11.009***	5.791***	11.992***	6.063***
	(4.95)	(20.33)	(4.17)	(15.47)	(5.08)	(19.14)	(5.02)	(16.77)
Total equity / total assets	-0.004	0.002	-0.008	0.003	-0.018	-0.011	-0.025	-0.017
	(0.21)	(0.11)	(0.26)	(0.09)	(1.14)	(0.62)	(1.43)	(0.85)
Loan loss reserve/ (equity + loan loss reserve)	-0.053**		-0.106**		-0.053**		-0.059**	
	(2.35)		(2.40)		(2.42)		(2.44)	
Loan loss reserve / total loans	-0.011		-0.015		-0.007		-0.004	
	(1.03)		(0.76)		(0.69)		(0.29)	
Cost-to-income ratio	-0.001		-0.002		-0.002		-0.003*	
	(0.49)		(0.78)		(1.34)		(1.77)	
Return on average assets		0.054*		0.091*		0.063**		0.078**
		(1.92)		(1.65)		(2.12)		(2.09)
Liquidity ratio	0.016**	0.016**	0.025*	0.026**	0.024***	0.023***	0.026***	0.028***
	(2.43)	(2.29)	(1.90)	(1.98)	(3.00)	(2.84)	(2.98)	(3.10)
Deposit Growth	0.007	0.007	0.012	0.014	0.007	0.007	0.008	0.008
	(1.31)	(1.30)	(1.10)	(1.23)	(1.32)	(1.25)	(1.15)	(1.18)
Inflation	-0.085***	-0.097***	-0.111***	-0.132***	-0.104***	-0.112***	-0.113***	-0.127***
	(4.34)	(4.84)	(2.77)	(3.29)	(4.70)	(5.12)	(4.55)	(5.24)
Real interest rates	-0.222***	-0.210***	-0.376***	-0.355***	-0.222***	-0.212***	-0.238***	-0.228***
	(7.18)	(6.62)	(6.99)	(6.32)	(6.56)	(6.18)	(5.62)	(5.44)
M2/ Reserves	-0.037***	-0.043***	-0.069***	-0.082***	-0.030***	-0.041***	-0.042***	-0.053***
	(4.14)	(4.63)	(4.04)	(4.88)	(2.72)	(3.62)	(3.02)	(3.75)
Credit growth	-0.017***	-0.01	-0.028**	-0.015	-0.008	-0.003	-0.011	-0.004
	(2.62)	(1.53)	(2.16)	(1.10)	(1.07)	(0.42)	(1.16)	(0.38)
Scale parameter(σ)	0.482***	0.485***			0.425***	0.435***	0.922***	0.948***
	(8.46)	(8.49)			(8.63)	(8.39)	(9.16)	(8.94)
Log likelihood	-111.995	-117.975	-126.319	-132.168	-114.457	-121.423	-119.054	-125.865
χ^2	99.06***	87.10***	83.00***	71.30***	93.61***	79.68***	85.55***	71.93***
AIC	247.990	255.950	274.638	282.337	252.913	262.845	262.108	271.730

Note: A t-statistic is reported in parentheses. ***, ** , and * indicate statistical significance at the 1%, 5%, and 10% level, respectively. The estimation software package used is STATA 10.0.

Source: Authors

Table 7: Results of estimations of Split Population survival models

	(1)	(2)
Constant	14.751	6.013***
	(0.79)	(2.06)
Total equity / total assets	-0.552**	-0.827**
	(2.40)	(2.20)
Loan loss reserve/ (equity + loan loss reserve)	-0.041	
	(0.21)	
Loan loss reserve / total loans	-0.019	
	(0.08)	
Cost-to-income ratio	-0.054**	
	(2.25)	
Return on average assets		4.180*
		(1.73)
Liquidity ratio	0.102**	0.155*
	(2.04)	(1.71)
Deposit Growth	0.023	-0.001
	(0.49)	(0.02)
Inflation	-0.503*	-0.920**
	(1.75)	(2.14)
Real interest rates	-0.766**	-1.039**
	(2.53)	(2.19)
M2/ Reserves	-0.187	-0.197
	(1.27)	(1.60)
Credit growth	0.040	0.066
	(0.44)	(0.55)
Scale parameter(σ)	0.425***	0.467***
	(7.38)	(8.22)
Log likelihood	-98.459	-105.877
Average predict failure probability	36.68%	43.98%

Note: A t-statistic is reported in parentheses. ***, ** , and * indicate statistical significance at the 1%, 5%, and 10% level, respectively. The estimation software package used is Limdep

Source: Authors

Appendix
A.1 Description of the Variables

Item	Variables name	Definition	Source	Expected Sign on Survival Time/ Failure Rate:
Capital adequacy	Tier 1 capital ratio	the ratio of a bank's core equity capital to total risk-weighted assets	BankScope	+ / —
	Total equity / total assets	The ratio of total equity to total assets	BankScope	+ / —
	BIS ratio (bank of international settlement ratio)	the rate of equity capital to risk-weighted assets	BankScope	+ / —
Asset quality	(loan loss reserve/ (equity + loan loss reserve)	The rate of loan loss reserve to the sum of equity and loan loss reserve	BankScope	- / +
	loan loss reserve / total loans	The rate of loan loss reserve to total loans	BankScope	- / +
	Cost-to-income ratio	Overheads to net interest income plus other operating income.	BankScope	- / +
management	Operating expenses / total assets	The rate of operating expenses to total assets	BankScope	- / +
	Non-interest expense / average assets	Non-Interest Expense as a percent of Average Assets	BankScope	- / +
Earnings	Return on average assets (ROAA)	the ratio of net income to Average assets	BankScope	+ / —
	Return on average equity (ROAE)	the ratio of net income to shareholder equity	BankScope	+ / —
	Net interest margin	Total interest income less total interest expense (annualized) as a percent of average earning assets.	BankScope	+ / —
	Net interest spread	interest yield on earning assets minus interest rates paid on borrowed funds.	BankScope	+ / —
Liquidity	Liquidity ratio	The liquid asset as a percentage of total assets.	BankScope	+ / -
	Loans/Deposits	Total loans as a percentage of total deposit.	BankScope	- / +
Growth	Deposit Growth	The growth rate of total deposit.	BankScope	+ / —
	Loan Growth	The growth rate of total loans.	BankScope	?/?
	Asset Growth	The growth rate of total assets.	BankScope	+ / —
Scale	Log(total assets)	The logarithm of total assets	BankScope	?/?
Macroeconomic Variables	GDP per capita growth	The growth rate of real per cap GDP.	WDI	+ / —
	Inflation	Rate of change of the GDP deflator.	WDI	- / +
	Real interest rate	Nominal interest rate minus the contemporaneous rate of inflation.	WDI	- / +
Financial Variables	M2/ foreign reserves	The ratio of M2 to foreign exchange reserves.	WDI	- / +
	domestic credit growth	Rate of growth of real domestic credit to private sector.	WDI	- / +
	the volatility of exchange rate	Change in the exchange rate.	WDI	- / +

Source: Authors