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RATINGS VERSUS MARKET-BASED MEASURES OF DEFAULT RISK OF EAST ASIAN BANKS

Prepared by Eric T.C. Wong and Cho-Hoi Hui[1]
Research Department

Chi-fai Lo
Institute of Theoretical Physics and Department of Physics
The Chinese University of Hong Kong and
Hong Kong Institute for Monetary Research

Abstract

This paper assesses whether agency ratings and market-based default risk measures are consistent for East Asian banks during the period 1996 to 2006. While the market-based measures are broadly consistent with the credit rating assessments for banks in developed economies, the discrepancy between ratings and the market-based measures for East Asian banks is significant. Credit ratings for East Asian banks were adjusted slowly during the onset of the Asian financial crisis. The relatively higher default risk implied by ratings during the post-crisis period is partly due to the conservatism of rating agencies and the unsolicited ratings. Discrepancies still exist after taking these two factors into account. From perspective of banking policies, the use of agency-based and market-based measures for calculating capital requirements for exposures to banks and deposit insurance premiums in East Asian economies could result in systematic differences.

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Author's E-mail Address:
etcwong@hkma.gov.hk; chhui@hkma.gov.hk; cflo@phy.cuhk.edu.hk

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Executive Summary

- *Measuring default risk of banks is a key part of two core banking policies, the risk-based capital standard (Basel II) and deposit insurance. Two approaches to assessing banks' default risk, credit agency ratings and market-based default risk measures, are used in the implementation of these policies. Under the market-based approach, default could happen if the value of a firm's assets falls below the firm's liability (i.e. the value of promised payments). Credit risk changes with the dynamics of the firm's value which is usually implied from the equity market. The probability of default of the firm should thus change continuously with variations in the firm's stock price, volatility and its leverage.*

- *This paper studies the issue of whether there are any systematic differences between these two approaches to assessing default risk of banks in the East Asian (excluding Japan) banking system before and after the Asian financial crisis. In order to identify whether this issue is unique to East Asia, we investigate differences between agency ratings and market-based default risk measures for a group of banks covering most of the developed economies. In a sample of 643 publicly listed banks rated by Standard & Poor's in 32 economies covering the period 1996-2006, the market-based measures are broadly consistent with the credit rating assessments for the sub-sample of the banks in the developed economies. However, for the banks in East Asian economies, rating agencies have been slow in adjusting their ratings since the onset of the Asian financial crisis as compared with the market-based measures. After 1999, rating-implied default risk of the banks was still higher than that implied by the market-based measures.*

- *The discrepancy between the market-based measures and agency ratings for the East Asian banks are statistically significant. As the banks' financial strengths are observed by both the rating agency and the equity markets, the discrepancy should be caused by factors which are not commonly incorporated into the market-based measures. While our empirical results identify that the relatively higher default risk implied by the agency ratings is partly due to the post-Asian financial crisis conservatism of the rating agency and the unsolicited ratings, the discrepancy still exists after taking these two factors into account. The unexplained discrepancy may be the result of stickiness in credit ratings because of the through-the-cycle rating approach adopted by the credit agency. In addition, the discrepancy may reflect that the assumptions of the market-based measures do not completely hold in East Asian markets, which are in general not efficient and not well-informed.*

- *The results indicate that the use of agency-based and market-based measures could result in systematic differences in the capital requirements of exposures to banks and deposit insurance premiums in East Asian economies.*

1. INTRODUCTION

In a number of economies, measuring default risk of banks has been incorporated into the formulations of two core banking policies which are the risk-based capital standard and deposit insurance. Two approaches to assessing banks' default risk, namely credit agency ratings and market-based measures, are used in the implementations of these policies. Any systematic discrepancy between the assessments based on these two approaches is likely to have important implications for the effectiveness of the policies and thus for banking stability.

The market-based approach to modelling credit risk starts with the work of Merton (1974). Since then the Merton model, which is termed the structural approach, has been extended in many different ways.[2,3] Under this approach, default could happen if the value of a firm's assets falls below the firm's liability (i.e. the value of promised payments). Credit risk therefore changes with variations in the value of the firm's assets and liability. As the dynamics of the firm's value is usually implied from the equity market, credit risk is dynamic and related to market risk. The probability of default (PD) of the firm should thus change continuously with variations in the firm's stock price and its leverage.

The structural approach has been extended to assessing solvency risk of banks for pricing of deposit insurance. Market-based evaluation of deposit insurance premiums has modelled a bank as a corporate firm with risky assets and insured liabilities (see Merton (1977, 1978), Pennacchi (1987), Allen and Saunders (1993), Ronn and Verma (1986), and Dermine and Lajeri (2001)). Bennett (2001) reports a sensitivity analysis using credit-risk models (including the structural model) to assess banks' solvency risk as a means of measuring risk to the insurance funds under the Federal Deposit Insurance Corporation.

In recent years, an increasing number of financial institutions have been using credit risk models to evaluate the risk of their loan portfolios. In particular, the Basel New Capital Accord (Basel II) allows sophisticated banks to use their internal rating systems and credit risk models to determine their capital requirements to cover credit risk of various asset classes including exposures to other banks.[4] Because of such development, the structural credit risk models have been increasingly studied or even employed by the industry. One of the related initiatives is Moody's KMV. It is a firm specialising in credit risk analysis and has developed a structural model, as well as an extensive database, to assess PDs of firms including banks. The KMV model is reviewed in Section 2 below.

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[2] See Black and Cox (1976), Longstaff and Schwartz (1995), Briys and de Varenne (1997), Collin-Dufresne and Goldstein (2001) and Hui et al. (2003).

[3] An alterative approach is the reduced-form models in which time of default is assumed to follow a stochastic process governed by its own distribution that is characterised by an intensity or hazard rate process. This approach has been considered by Jarrow and Turnbull (1995), Jarrow et al. (1997), Madan and Unal (1998), and Duffie and Singleton (1999). Their models in general focus on more sophisticated characterisation of the hazard process. The derived pricing formulas can be calibrated to market credit spreads. Some extensions explore assumptions surrounding recovery rate, risk-free interest rate processes, and contract boundary conditions.

[4] The Basel Committee on Banking Supervision is responsible for proposing capital requirements for internationally active banks. The Committee first proposed Basel II, in 1999, with the final version (Basel, 2004) in June 2004. Basel II is expected to replace the original Basel Accord, which was implemented in 1988.

Rating agencies regularly measure the historical default rates of their ratings, which have been an assessment of credit risk of firms including banks. Similar to the use of the structural models, banks' PDs implied from their credit ratings are used to evaluate deposit insurance premiums (see Bennett (2001)) and calculate regulatory capital for exposures to other banks.[5] Under Basel II, the standardised approach allows less sophisticated banks to use external credit ratings to classify their assets (including exposures to banks) into different risk classes for capital purposes.

The development of the use of both agency ratings and market-based measures in banking policies raises an issue of whether there are any systematic differences between these two approaches in assessing default risk of banks. The objective of this paper is to study this issue in the East Asian (excluding Japan) banking system before and after the Asian financial crisis in 1997-1998. In order to identify whether this issue is particular in East Asia, we investigate any differences between agency ratings and market-based default risk measures for a group of banks covering developed economies.

This study is related to some previous studies. Ferri et al. (2001) show that bank ratings tend to be highly dependent on the sovereign ratings in less developed countries and Ferri et al. (1999) demonstrate that East Asian countries had incorrect ratings at the onset of the crisis. Bongini et al. (2002) find that upward adjustments of implicit deposit insurance premiums based on the structural model in Ronn and Verma (1986) for individual banks, active in Indonesia, Korea, Malaysia and Thailand during the years 1996-1998, seemed to precede credit ratings with an average semester lag. Regarding other studies on default risk in general, Delianedis and Geske (1999) show that PDs produced by the structural models of Merton (1974) and Geske (1977) possess significant and very early information about credit rating migrations. While sample of companies that actually default is small, changes in the shape of the term structures of PDs appears to detect impending migrations to default. Kealhofer (2003) and Cantor and Mann (2003) show that market-based measures may be better predictors of short-term default risk than agency ratings.

Two credit risk models are used in this paper to obtain the market-based measures of default risk of East Asian banks. One is the KMV model and another one is a structural model modified from the corporate bond pricing model proposed in Briys and de Varenne (1997). In the Briys and de Varenne model, default occurs when a firm's asset value is below the default barrier which follows the dynamics of the risk-free interest rate. This bankruptcy mechanism implies that the ratio of the default barrier (i.e. the liability) to the asset value, which is the leverage ratio, is a summary measure of default risk of the firm and can be viewed as a proxy variable for the credit rating of the firm. When the firm's leverage ratio is above a predefined level, bankruptcy occurs. This is consistent with the event of bankruptcy being associated with a high level of the leverage ratio.

The remainder of the paper is organised as follows. In the following section we present the KMV model and the structural model. Section 3 illustrates the comparisons between the credit ratings and market-based credit risk measures of the banks including the East Asian banks in the dataset extracted from Credit Monitor of Moody's KMV. An

[5] The PDs implied from credit ratings of banks in Hong Kong are used to determine the appropriate size of the Deposit Insurance Scheme Fund managed by the Hong Kong Deposit Protection Board. See the discussion paper on "Funding and Premium Assessment for a Deposit Insurance Scheme" at http://www.dps.org.hk/en/download/hkma_consultations_on_detailed_design_features_of_the_dps/discussion_paper%20on%20funding%20&%20premium%20assessment.pdf.

econometric analysis of the credit ratings of the banks is conducted in Section 4. Section 5 presents the further comparisons between the credit ratings and market-based credit risk measures of the banks based on the results in Section 4. The final section summarises and discusses the findings.

2. MARKET-BASED CREDIT RISK MEASURES

2.1 KMV model

The KMV model produces a PD for each firm at any given point in time.[6] To calculate the PD, the model consists of the following procedures: estimation of the market value and volatility of the firm's asset; calculation of the distance-to-default; and scaling of the distance-to-default to actual PD using a proprietary default database.
The KMV model estimates the market value of a firm's asset by applying the Merton model.[7] The KMV model makes two assumptions. The first is that the total value of a firm is assumed to follow geometric Brownian motion,

$$dV = mVdt + s_V V dz_V \tag{1}$$

where V is the market value of the firm's assets, μ is the expected continuously compounded return on V, s_V is the volatility of firm's asset value and dz_V is a standard Weiner process. The second assumption of the KMV model is that the capital structure of the firm is only composed of equity, short-term debt which is considered equivalent to cash, long-term debt and convertible preferred shares. With these simplifying assumptions it is then possible to derive analytical solutions for the value of equity E, and its volatility s_E:

$$E = f(V, s_V, K, c, r), \tag{2}$$

$$s_E = g(V, s_V, K, c, r), \tag{3}$$

where K denotes the leverage ratio in the capital structure, c is the average coupon paid on the long-term debt and r the risk-free interest rate.[8, 9]

The KMV model estimates s_E from market data (i.e. from either historical stock returns data or from option implied volatility data). An iterative technique is used to simultaneously solve equations (2) and (3) numerically for values of V and s_V.[10]

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6 The KMV model was developed by the KMV Corporation founded in 1989. The KMV Corporation was acquired by Moody's in April 2002.

7 See Vasicek (1997) and Kealhofer (1998).

8 In the simple Merton's framework, where the firm is financed only by equity and a zero coupon debt, equity is a call option on the assets of the firm with striking price (the face value of the debt) and maturity (the redemption date of the bond). The equity value of a firm satisfies

$$E = VN(d_1) - e^{-rT} KN(d_2),$$

where, d_1 is given by

$$d_1 = \frac{\ln(V/K) + (r + s_V^2/2)T}{s_V\sqrt{T}},$$

$d_2 = d_1 - s_V\sqrt{T}$, T is the time-to-maturity of the debt and $N(.)$ is the cumulative normal distribution function.

9 It can be shown that $s_E = h_{E,V}\, s_V$ where $h_{E,V}$ denotes the elasticity of equity to asset value, i.e. $h_{E,V} = (V/E)(\partial E/\partial V)$.

10 Vasicek (1997) notes that the numerical technique is complex due to the complexity of the boundary conditions attached to the various liabilities.

Using the values of V and s_V, the KMV model computes an index called "distance-to-default" (DD). DD is the number of standard deviations between the mean of the distribution of the asset value, and a critical threshold, the "default point", set at the par value of current liabilities including short term debt to be serviced over the time horizon, plus half the long-term debt. The default point F is based on KMV's observations from a sample of several hundred companies that firms default when the asset value reaches a level somewhere between the value of total liabilities and the value of short-term debt. DD can be calculated as:

$$DD = \frac{\ln(V/F) + (m - s_V^2/2)T}{s_V \sqrt{T}}, \tag{4}$$

where T is a forecasting horizon.

Based on historical information on a large sample of firms, the distance-to-default can be mapped to the corresponding implied PD for a given time horizon. This implied PD is the expected default frequency (EDF) of the firm.[11]

If the assumptions of the Merton model really hold, the KMV model should give very accurate default forecasts. In fact, if the Merton model holds completely, the EDF should be a sufficient statistic for default forecasts. It is noted that the most critical inputs to the KMV model are clearly the market value of equity, the details of capital structure, and the volatility of equity. As the market value of equity declines, the PD increases. This is both a strength and weakness of the model. For the KMV model to work well, both the Merton model assumptions must be met and markets must be efficient and well informed.

2.2. Structural model

The structural model employed for generating term structures of PDs is based on the model proposed by Briys and de Varenne (1997). In the Briys and de Varenne model, a firm's asset value follows a lognormal diffusion process and the default barrier (i.e. the firm's liability) follows the dynamics of the risk-free interest rate. The firm's leverage ratio which is defined as the ratio of the firm's liability to its asset value is the summary measure of default risk. The leverage ratio thus follows a lognormal diffusion process. The dynamics of the interest rate is drawn from the term structure model of Vasicek (1977), i.e. the Ornstein-Uhlenbeck process.

The Briys and de Varenne model is generalised by incorporating a drift term into the dynamics of the leverage ratio such that a firm's asset value and liability could have different risk-adjusted drifts. The risk-adjusted dynamics of the leverage ratio L in the structural model is therefore modelled by the following stochastic differential equation:

$$dL = a(t)Ldt + s_L(t)Ldz_L, \tag{5}$$

where $a(t)$ and $s_L(t)$ are the drift and the volatility of L respectively. The continuous stochastic movement of the interest rate r follows:

$$dr = k(t)\left[q(t) - r\right]dt + s_r(t)dZ_r \tag{6}$$

[11]The probability below the default point is $N(-DD)$ which is the EDF in the simple Merton's framework (see footnote 8 above).

where $s_r(t)$ is the instantaneous volatility. The short-term interest rate r is mean-reverting to long-run mean $q(t)$ at speed $k(t)$. The Wiener processes dZ_L and dZ_r are correlated with

$$dZ_L dZ_r = r(t)dt .$$

Applying the Ito's lemma, the partial differential equation governing the price $P(L, r, t)$ of a corporate discount bond with time-to-maturity of t based on the model is

$$\begin{aligned}\frac{\partial P(L,r,t)}{\partial t} &= \frac{1}{2}s_L^2(t)L^2\frac{\partial^2 P}{\partial L^2}+\frac{1}{2}s_r^2(t)\frac{\partial^2 P}{\partial r^2}+r(t)s_L(t)s_r(t)L\frac{\partial^2 P}{\partial L\partial r} \\ &\quad + aL\frac{\partial P}{\partial L}+k(t)[q(t)-r]\frac{\partial P}{\partial r}-rP\end{aligned} . \tag{7}$$

The bond value is obtained by solving equation (7) subject to the final payoff condition and the boundary condition. When the firm's leverage ratio is above a predefined level L_0, bankruptcy occurs before bond maturity at $t = 0$. This is consistent with the event of bankruptcy being associated with a high level of the leverage ratio. On the other hand, if the leverage ratio has never breached the predefined level L_0, the payoff to bondholders at bond maturity is the face value of the bond.

As shown in the appendix of Hui et al. (2005), the corresponding default probability, $P_{def}(L, t)$, of a corporate discount bond over a period of time t based on equation (7) can be approximated by

$$\begin{aligned}P_{def}(L,t) = 1-\Bigg\{ & N\left[\frac{\ln\left(\frac{L_0}{L}\right)-b_2(t)}{\sqrt{2b_1(t)}}\right]-\exp\left[4b\left(\ln\left(\frac{L}{L_0}\right)+b_2(t)\right)+16b^2 b_1(t)\right]\times \\ & N\left[\frac{\ln\left(\frac{L}{L_0}\right)+b_2(t)+8bb_1(t)}{\sqrt{2b_1(t)}}\right]\Bigg\}\end{aligned} , \tag{8}$$

where $N(.)$ is the cumulative normal distribution function, b is a real number parameter, and $b_1(t)$ and $b_2(t)$ are defined as follows:

$$b_1(t) = \frac{1}{2}\int_0^t s_L^2(t')dt' ,$$

$$b_2(t) = \int_0^t g(t')dt' ,$$

$$g(t) = a(t) + r(t)s_L(t)s_r(t)a_2(t)\exp[a_1(t)] - \frac{1}{2}s_L^2(t) ,$$

$$a_1(t) = -\int_0^t k(t')dt' ,$$

$$a_2(t) = -\int_0^t \exp[-a_1(t')]dt' .$$

The parameter b is adjusted such that the approximate solution in equation (8) provides the best approximation to the exact results by using a simple method developed by

Lo et al. (2003) for solving barrier option values with time-dependent model parameters. When the model parameters are constant, b is a fixed value and thus equation (8) is in a closed-form.

The problem of downward-biased PDs at short maturities is common to all Merton-type models which assume continuous dynamics.[12] This means that the 1-year PD generated directly by the structural model does not represent the appropriate default risk assessed by the model. As the term structures of PDs generated by the model reflect the characteristics of default risk of companies over longer time horizons, they are used to produce the appropriate measure. The use of the term structures is also consistent with the findings of the predictive capability of structural models in Leland (2004) and Hui et al. (2005). Leland (2004) finds that PDs generated from the Longstaff and Schwartz (1995) model (in which the default barrier is a constant) fit the term structures of actual default rates provided by Moody's (1998) for longer time horizons quite well for reasonable parameters with proper calibrations. Hui et al. (2005) show that the Briys and de Varenne model is capable of generating term structures of PDs consistent with the term structures of actual default rates of credit ratings of BBB and below provided by Standard & Poor's (S&P's).

The measure of the default risk of a bank is obtained by mapping the term structure of PDs of the bank generated by the structural model to the "closest" term structures of default rates (i.e. up to the cumulative default rate of 15 years) reported by S&P's using the least square method.[13] The 1-year default rate of the corresponding term structure is assigned to the bank as its 1-year market-based PD. The mapping process implies that the bank and an entity with the closest term structures of default rates have the similar characteristics of default risk, while the assessment of the bank's risk is based on the market information input into the model. This mapping process is used in a benchmarking model for validation of PDs of listed companies proposed by Hui et at. (2005) for Basel II purposes.[14]

3. RATINGS VERSUS MARKET-BASED CREDIT RISK MEASURES

This section studies whether the market-based credit risk measures are consistent with the credit agency ratings for the East Asian banks and how the consistency or inconsistency evolves over time, particularly after the Asian financial crisis. The dataset for the analysis consists of 27,555 monthly observations from 643 publicly listed banks in 32 economies covering the period 1996-2006, in which there are 3,805 and 23,750 monthly observations for banks in East Asian economies (excluding Japan) and for banks in developed economies respectively.[15] The distribution of the economies of the data is presented in Table 1. The dataset is from Credit Monitor of Moody's KMV. Only banks with S&P's credit ratings are included in the analysis. The 1-year EDF, which is a common market-based credit risk measure adopted by market practitioners, and the model inputs of the structural model for generating banks' credit risk measures, including the asset volatility, the default point (barrier) and the market asset value of the banks, are extracted from the dataset. As the volatility of a bank's liability is assumed to be immaterial, its s_L fall close to its asset

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[12] See the discussion in Leland (2004).

[13] S&P's (2005) reports the cumulative average default rates by rating modifier 1981 to 2004.

[14] Hui et al. (2005) show that there is a strong positive association between credit ratings by S&P's and the model-implied ratings based on the Briys and de Varenne model for a dataset consisting of 3,943 observations from 193 listed industrial companies in the United States from March 1900 to July 2004.

[15] In this study, developed economies refer to the high-income economies defined by the World Bank. All Japanese banks are included in the sample of banks in developed economies.

volatility. The effect of the risk-free interest rate on PDs is very small (see Longstaff and Schwartz (1995)) and is thus assumed to be constant. Other common parameters used in calculations for the structural model are $L_0 = 1.0$ and $a = 0$.[16]

One-year PDs are used to study the consistency between the market-based measures and the credit ratings. For each observation, a bank's agency-based PD refers to the 1-year default rate of its S&P's long-term issuer rating.[17] Its market-based PDs are the 1-year EDF from the KMV model and the 1-year PD implied from the structural model through the mapping process presented in the previous section.

The quarterly averages of the market-based and agency-based PDs for the East Asian banks and those for the banks in the developed economies are presented in Figures 1 and 2 respectively. Figure 1 shows that there are significant differences between the levels of the market-based and agency-based PDs for the East Asian banks. The agency-based PDs are lower than the market-based PDs in the pre-crisis period, while it is the reverse in the post-crisis period.[18] In contrast, Figure 2 shows that the market-based PDs appear to be more consistent with the agency-based PDs for the banks in the developed economies over time.

To test whether the agency-based and market-based PDs are statistically different for the East Asian banks, as well as for the banks in the developed economies, a set of bootstrapping tests is performed to derive the distributional properties of mean differences between the agency-based and market-based PDs. For an individual observation in a given quarter, the difference between the PDs, $D_{i,j}^{n} = PD_{i}^{n} - PD_{j}^{n}$, where PD_{i}^{n} denotes the PD from i credit risk measure (i.e. agency- or market-based measure) for the n^{th} observation in the sample, is calculated. For each selection of i and j, by re-sampling $D_{i,j}^{n}$ with replacement from the original sample, we create B bootstrap samples of size N each, where N is the number of observations in the original sample in the quarter. We denote each bootstrap sample by a vector $\{D_{i,j}^{1,b}, D_{i,j}^{2,b}, ..., D_{i,j}^{N,b}\}$, where $D_{i,j}^{n,b}$ is the $D_{i,j}^{n}$ in the b bootstrap sample and $b = 1,\ldots, B$. Therefore, the average difference of the PDs between i and j credit risk measures in the b bootstrap sample which is defined as $\overline{D}_{i,j}^{N,b} = (\sum_{n=1}^{N} D_{i,j}^{n,b}) / N$ can be computed. B is set to be 5,000 to give a reliable estimate.[19] Distributional properties of the mean difference of the PDs between i and j credit risk measures can be revealed from the vector $\overline{D}_{i,j} = \{ \overline{D}_{i,j}^{N,1}$, $\overline{D}_{i,j}^{N,2}$,…, $\overline{D}_{i,j}^{N,B}$ }. The 95% confidence interval is defined as the values covered by the 2.5 and 97.5 percentiles of $\overline{D}_{i,j}$. The null hypothesis that the mean difference of the PDs between i and j measures is zero can be rejected at the 5% level if zero is out of the range of the bootstrapped 95% confidence interval. Measures i and j are said to be consistent if the null hypothesis cannot be rejected.

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[16] If a firm's asset and liability are assets that some agent is willing to hold, their risk-adjusted drift will be equal to the instantaneous interest rate. The drift a of their ratio L is therefore zero.

[17] The default rates are those of the broad S&P's rating scale (AAA, AA, A, BBB, BB, B, CCC to CC, and SD/D) reported in S&P's (2005).

[18] The structural model generally gives higher default risk for the East Asian banks than that from the KMV model. The differences in the PDs between the structural model and KMV model may be largely due to the calibration of the KMV model, as the KMV model calibrated its model outputs by using a proprietary default database, while the structural model solely uses the stock market information.

[19] For estimation of confidence intervals, Efron and Tibshirani (1993) suggested using at least 1000 replications. (i.e. B = 1,000)

For each combination of the agency-based and the market-based measures, the bootstrapping test is performed for every quarter. The point estimates of $\overline{D}_{i,j}$ and the corresponding 95% confidence intervals are shown in Figure 3. Panels A and B indicate that the market-based PDs are in general statistically different from the agency-based PDs for the East Asian banks where the agency-based PDs are significantly lower (higher) than the market-based PDs before (after) 1999. The numbers of quarters with non-rejection of the null hypothesis as a percentage of the total number of quarters (covered by the sample[20]) are only 13% for the KMV model and 36% for the structural model. The higher number for the structure model is due to the relatively consistent assessments between the corresponding market-based and agency-based PDs during the period of 1999-2003 (i.e. more non-rejections of the null hypothesis).

The differences before 1999 are consistent with the findings by Bongini et al. (2002) that rating agencies have been slow in adjusting their ratings for the East Asian banks during the onset of the Asian financial crisis. On the other hand, according to the empirical results in Ferri et al. (1999, 2001), the differences after 1999 could be the results of the downward-biased sovereign ratings. Their results have taken the fundamental factors relating to the macroeconomic environments into account. After having failed in predicating the Asian financial crisis, rating agencies have become excessively conservative. There were broad-based downgrades of the sovereign and bank ratings for the East Asian economies amid the Asian financial crisis, that was more than the worsening in the economic fundaments of the East Asian economies would have justified. In addition, Poon and Firth (2005) find that rating agencies tend to be conservative in assigning unsolicited ratings to banks. Among the 3,805 observations for the East Asian banks, 1,978 (52%) of them are with unsolicited ratings.[21] Such high proportion of unsolicited ratings of the East Asian banks could also cause the differences in the market-based and agency-based PDs.

In contrast, Panels C and D show that the market-based PDs of the banks in the developed economies are consistent with their agency-based PDs. The numbers of quarters with non-rejection of the null hypothesis as a percentage of the total number of quarters (covered by the sample) are 52% for both the KMV and the structural models, which are significantly higher than those for the East Asian banks.

The extent to which the conservatism of the credit agency can reconcile the discrepancy between the market-based and agency-based PDs for the East Asian banks is studied by econometric analyses of the determinants of the banks' credit ratings in the following two sections.

4. ECONOMETRIC ANALYSIS OF BANKS' CREDIT AGENCY RATINGS

A total of eight models will be specified to estimate the determinants of the banks' credit agency ratings. A bank's credit rating is hypothesised to depend on various bank characteristics and other non-bank factors. The models assume that the credit rating is determined by: (i) profitability; (ii) asset quality; (iii) liquidity; (iv) capital structure of the bank; (v) the sovereign credit rating of the economy where the bank is incorporated in; (vi) rating types (i.e. whether the bank's rating is unsolicited); and (vii) two time-varying factors which reflect the judgmental consideration of the credit agency for the credit quality of the

[20] The sample covers 44 quarters from 1996 Q1 to 2006 Q4.

[21] In contrast, the corresponding percentage for the banks in the developed economies is only 11%.

East Asian banks before and after the Asian financial crisis respectively. Factors (i) to (v) capture the financial/risk factors, which are considered by credit agencies for assessing banks' credit ratings (see Fitch (2004) and S&P's (2004)).[22] Factors (vi) and (vii) are identified by Poon and Firth (2005) and Ferri et al. (1999, 2001) to reveal the impact of the conservatism of the credit agency on the credit ratings of the East Asian banks. The general form of the model adopted to examine the relevance and the extent of the factors determining the actual agency rating of a bank is defined as:

$$\begin{aligned} \textit{Credit rating} = f(&\textit{Profitability}, \textit{Asset quality}, \textit{Liquidity}, \textit{Capital structure}, \\ &\textit{Sovereign credit rating}, \textit{Unsolicited rating}, \\ &\textit{Pre crisis Asian banks}, \textit{After crisis Asian banks}, \mathbf{X}) + e, \end{aligned} \tag{9}$$

where the dependent variable *Credit rating* is the actual agency rating of a bank; **X** is a vector of control variables; e is the disturbance term.[23] *Credit rating* is coded on an eight-point ordinal scale (from 1 to 8), where AAA=8, AA=7, A=6, BBB=5, BB=4, B=3, CCC and CC = 2, and SD/D=1. The ordinal values of 1 and 8 correspond to the highest and the lowest credit risk respectively.

Regarding the explanatory variables used in estimations, profitability is represented by the return on asset (*ROA*) which is the ratio of net income to average of total assets. The estimated coefficient of *ROA* is expected to be positive, as a higher level of profit should lead to a better credit rating (i.e. a higher ordinal value of *Credit rating*).

For asset quality of a bank, the loan loss reserve ratio (*LOSS*) is defined as the ratio of loan loss reserves to total loans. Assuming consistent credit policies of a bank, a higher *LOSS* indicates a loan portfolio with poorer credit quality, which should lead to a lower credit rating. This implies a negative estimated coefficient for *LOSS*.

Liquidity is represented by the liquid asset ratio (*LAR*) which is defined as the ratio of total liquid assets (the sum of cash and near-cash asset, interbank asset, and marketable security and other short-term investment) to total deposits. The estimated

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[22] These factors are consistent with those identified in previous studies (e.g. Poon and Firth (2005), Agusman et al. (2006) and Arena (2007)). While credit agencies usually consider several financial variables to assess banks' default risk, many of the variables are highly correlated. Therefore, only key financial ratios representing profitability, asset quality, liquidity and capital structure of banks are selected as the explanatory variables in estimations to avoid the multicollinearity problem. It is noted that the selected explanatory variables are not exactly those used by the credit agency.

[23] The determinants of the market-based measures are also estimated using equation (9). Specifically, the explanatory variables are the same as those in equations (9), except that the *unsolicited rating* is excluded and the year-on-year changes of the stock price indexes of individual stock markets where the banks are listed (as a proxy for general stock market movements) are used for estimations. The estimation results are found to be not robust, as the values and significance of the explanatory variables vary significantly across the models. Nevertheless, the following observations can be drawn from the estimation results: (i) Goodness-of-fit statistics of the market-based measures are strictly lower than that of the agency ratings, indicating that some useful factors are not being captured to explain the market-based measures; (ii) Using return-on-equity as a proxy of banks' profitability generally improves the estimations. This is generally consistent with the objective of stock investors; (iii) While most of the banks' financial variables are significant, liquidity appears to be not a significant variable to explain the market-based measures. Stock market movements are found to be positively related to the market-based measures. The results suggest that the factors affecting the market-based measures are not completely the same as those used to explain the agency ratings (i.e. equation (9)). To estimate the determinants of the market-based measures is left for future research.

coefficient is expected to be positive, as a higher value of *LAR*, which indicates the bank has higher ability to meet obligations as they come due, should lead to a higher credit rating.

Capital structure of a bank is measured by the asset-to-equity ratio (*ATE*) which is calculated as the ratio of average total assets to average total common equity.[24] A higher *ATE* indicates a lower level of capital to absorb losses, which should lead to a lower credit rating and a negative estimated coefficient for *ATE*.

As credit agencies consider sovereign credit ratings (*Sovereign*) as a key factor that determines a bank's credit rating (see Fitch (2004) and S&P's (2004)), the S&P's sovereign credit rating of the economy where a bank is incorporated in is included in the model to explain the credit rating of the bank. The S&P's sovereign credit ratings are coded on the same eight-point ordinal scale for coding *Credit rating*. Since a bank in an economy with high sovereign risk may suffer severe stress, a positive estimated coefficient of *Sovereign* is expected.

A dummy variable *Unsolicited* is added into estimations which is defined as 1 for banks with unsolicited ratings and 0 otherwise. A negative value of the estimated coefficient is expected according to the findings in Poon (2003) and Poon and Firth (2005) that unsolicited credit ratings are biased downward.

To examine whether the rating agency rated the East Asian banks in the pre- and post-crisis periods differently, two dummy variables *PCAB* and *ACAB* are added respectively. The former is defined as 1 for the East Asian banks before 1998 and 0 otherwise, while the latter is defined as 1 for the East Asian banks at or after 1998 and 0 otherwise. A negative (positive) coefficient indicates that the East Asian banks tend to receive lower (higher) ratings. The estimated coefficients for *PCAB* and *ACAB* are expected to be positive and negative respectively.

The asset value of a bank in natural logarithm form (*ASSET*), which reflects the size of the bank, is added as an explanatory variable to control for the heterogeneity in the sample.

A total of eight models (Models A to H) are specified for estimations. Model A is specified as:

$$\begin{aligned} Credit\ rating_{i,t} = {} & a_0 + a_1 ROA_{i,t} + a_2 LOSS_{i,t} + a_3 LAR_{i,t} + a_4 ATE_{i,t} \\ & + a_5 Sovereign_{i,t} + a_6 Unsolicited_{i,t} \\ & + a_7 PCAB_{i,t} + a_8 ACAB_{i,t} \\ & + a_9 ASSET_{i,t} + e_{it}, \end{aligned} \tag{10}$$

where *i* and *t* denote bank and time respectively. The specification in equation (10) assumes that the credit rating of a bank depends on the explanatory variables linearly. This specification gives a straightforward interpretation of the estimation results, as the estimated coefficients explicitly indicate the increase in the ordinal rating given a one-unit increase in

[24] While the tier-one capital ratio, the capital adequacy ratio or the asset-to-equity ratio can be considered as proxies for the capital structure of a bank, the asset-to-equity ratio is more commonly available and is thus selected as the proxy for capital structure of a bank.

the corresponding explanatory variables (i.e. the marginal effect of the explanatory variables on the ordinal ratings of banks).[25]

Since there may be some time lag for the credit agency to access banks' financial information, Models B and C, which follow Model A by using the same set of financial variables of banks with a time lag of 6 months and 12 months respectively, are specified to estimate.[26]

The analysis is extended to consider a non-linear relationship between the credit ratings and the explanatory variables by using the ordered-logit specification. Similar non-linear models have been considered by Kaplan et al. (1979), Poon et al. (1999) and Poon (2003) to study credit ratings. Three ordered-logit models D, E, and F are specified, which are modified from Models A, B, and C respectively with the same set of explanatory variables. The following equation illustrates the specification of Model D:

$$\begin{aligned} Y_{i,t} = a_0 + a_1 ROA_{i,t} + a_2 LOSS_{i,t} + a_3 LAR_{i,t} + a_4 ATE_{i,t} \\ + a_5 Sovereign_{i,t} + a_6 Unsolicited_{i,t} \\ + a_7 PCAB_{i,t} + a_8 ACAB_{i,t} \\ + a_9 ASSET_{i,t} + e_{it}, \end{aligned} \tag{11}$$

where Y is a latent variable. Models E and F follows the same equation (11) with a time lag of 6 and 12 months respectively, which are similar to Models B and C. The credit rating of a bank is determined from Y using the following rule:

$$Credit\ rating = \begin{cases} 1 & & Y \le g_1 \\ 2 & & g_1 < Y \le g_2 \\ 3 & & g_2 < Y \le g_3 \\ 4 & \text{if} & g_3 < Y \le g_4 \\ 5 & & g_4 < Y \le g_5 \\ 6 & & g_5 < Y \le g_6 \\ 7 & & g_6 < Y \le g_7 \\ 8 & & Y > g_7 \end{cases}.$$

With the specification in equation (11), the estimated probability of each value of *Credit rating* is given by

$$\Pr(Credit\ rating = 1) = F(g_1 - \hat{Y})$$
$$\Pr(Credit\ rating = 2) = F(g_2 - \hat{Y}) - F(g_3 - \hat{Y})$$
$$\dots$$
$$\Pr(Credit\ rating = 8) = 1 - F(g_7 - \hat{Y})$$

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[25]While a linear regression method gives a straightforward interpretation on the estimation results, it should be noted that a limitation of the linear regression model is that it does not constrain the prediction values to lie within the "reasonable" range (i.e. from 1 to 8 in this case). Nevertheless, such linear regression specification is still frequently used in empirical applications on credit rating predication due to its convenience for interpretation of the regression results.

[26]Specifically, they are *ROA*, *LOSS*, *LAR*, *ATE*, and *ASSET*.

where $\hat{Y}$ is the estimated value of the latent variable Y and $F(.)$ is the cumulative distribution function of the logistic distribution. It should be noted that only the signs of the estimated coefficients in Models D, E, and F are comparable to those obtained from Models A, B, and C.[27] If the explanatory variables chosen for the estimations are reasonably adequate to explain the credit ratings, the signs of the estimated coefficients should be consistent across the models.

As credit agencies usually examine the relevant financial variables in the past few years to determine credit ratings, Models G and H incorporate this consideration by using three-year averages of the financial ratios employed in Models A and D.

The sample consists of the publicly listed banks which have S&P's long-term issuer credit ratings during the period 1990-2006. Their annual financial statements, rating history (long-term local and foreign currencies credit ratings) and corresponding sovereign ratings are extracted from Bloomberg. The panel dataset consists of 3,744 yearly observations from 288 listed banks in 34 economies, in which 2,129 are local currency ratings and 1,615 are foreign currency ratings.[28] Tables 2 and 3 present the economy and rating distributions of the sample respectively. Summary statistics of the banks' financial variables are presented in Table 4.

The eight models, Models A to H, are estimated by the panel dataset. For the linear regression models (A, B, C, and G), a feasible generalised least-squares (FGLS) procedure is adopted instead of applying the method of ordinary least squares (OLS) because estimators of the former are more efficient with a large sample. In the FGLS procedure, cross-section weights are used to correct for cross-section heteroskedasticity. The standard errors reported are derived based on the method proposed by White and Domowitz (1984) to accommodate serial correlation and time-varying variances in the disturbances. Regarding the ordered-logit models (D, E, F, and H), the maximum likelihood method is used. Standard errors of the estimated coefficients of the ordered-logit models are computed by the method proposed by White (1982), which is robust to misspecifications of the likelihood function.[29]

5. EMPIRICAL RESULTS AND ADJUSTED RATINGS VERSUS MARKET-BASED MEASURES

The results of the eight models are presented in Table 5. The adjusted R-squared statistics of the linear regression models (Models A, B, C, and G), which measure the goodness of fit, range from 0.8520 to 0.8994, indicating that the specifications are reasonably adequate. For the ordered-logit models (Models D, E, F, and H), the pseudo R-squared statistics also attain a reasonable range from 0.2773 to 0.2926.[30]

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[27] As the values of the estimated coefficients in the ordered-logit models are not the marginal effect of the explanatory variables on the credit ratings as it is in the linear regression models, the estimated coefficients of Models D, E, and F are not comparable to that of Models A, B, and C. See chapter 13, Johnston and Dinardo (1997) for a detailed discussion on the interpretation of the estimated coefficients of ordered-logit models.

[28] Note that the number of observations presented is based on that used in Model C, which covers the largest number of observations in this study. The number of observations in each model varies due to the differences in data availability.

[29] The standard errors here take into account that the "true" model is an ordered-probit model, while we maximise the likelihood function associated with the ordered-logit specification.

[30] Note that the adjusted R-squared statistics used in the linear regression models and the pseudo R-squared statistics for the ordered-logit regression models are not comparable due to different definitions.

Table 5 shows that the estimated coefficients of the financial variables of the banks are significant with the expected signs in all the models and therefore provide adequate explanations for the credit ratings of the banks. A bank with higher profit, better asset quality, lower financial leverage, more liquid assets relative to deposits and larger in size tends to have a better credit rating. As the estimated coefficients of *Sovereign* are positive and significant at the 1% level in all the eight models, a bank incorporated in an economy with a higher sovereign rating also receive a higher credit rating.

The estimated coefficients of the dummy variable *Unsolicited* are negative and significant at the 1% level in all the models. This suggests that the rating agency tends to be conservative in assigning unsolicited ratings for banks, after controlling for the differences in the sovereign risk and key financial characteristics of banks. The result is consistent with the finding by Poon and Firth (2005).

The estimated coefficients of the dummy variable *PCAB* are positive, while those of *ACAB* are negative in all the models, with both being significant at the 1% level. This indicates that the credit ratings of the East Asian banks generally received lower ratings after the crisis, after controlling for differences in the sovereign risk, key financial characteristics of the banks and the unsolicited ratings.

To evaluate the extent to which the conservatism of the credit ratings revealed from the estimation results can explain the differences between the credit ratings and the market-based measures of the East Asian banks, each East Asian bank's rating is adjusted by taking out the conservatism effect of the credit agency from the bank's actual credit rating. The adjustment is based on the estimated coefficients of *Unsolicited* (-0.37), *PCAB* (0.42), and *ACAB* (-0.29) from Model A.[31] For example, a bank with an unsolicited S&P's rating of BB in 2001, its adjusted ordinal rating increased from 4 (i.e. the ordinal rating for BB) to 4.66 (= 4 (the ordinal rating of the bank's actual rating) + 0.37 (the unsolicited rating effect) + 0.29 (the post-crisis effect)). As an adjusted credit rating is mostly non-integer, its corresponding PD is obtained by the interpolating the PDs of the two closest integer ordinal ratings.[32]

In Figure 4, Panel E shows that the discrepancy between the agency-based and market-based PDs obtained from the KMV model for the East Asian banks is reduced during the period of 1999-2006 after adjusting for the conservatism of the credit agency. However, default risk of the East Asian banks implied by the market-based assessments after 2003 Q4 is still lower than that implied by the adjusted credit ratings and such discrepancy is statistically significant at the 5% level. Panel F where the market-based PDs are obtained from the structural model shows the similar discrepancy after 2003 Q4. On the other hand, the discrepancy between the market-based and adjusted agency-based PDs during the period of 1999-2003 is larger than that based on unadjusted agency-based PDs. The reason may be that the impact from the Asian financial crisis anticipated in the equity markets and captured

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[31] It is found that using the estimated coefficients from the other linear regression models (i.e. Model B, C, and G) do not materially affect the values of the adjusted ratings, and hence the *adjusted agency-based PDs*.

[32] As reported in Table 10 of S&P's (2005), the long-run default rates increased exponentially when the credit ratings deteriorated. Natural logarithm of the default rates are thus used for interpolation that exhibits a more linear-like relationship with the ordinal credit ratings. For example, for a bank with an ordinal rating of 4.7, its PD is obtained by the following two steps: (i) interpolating the logarithm of the default rates of the ordinal rating of 4 (= ln (0.12) = -4.4228) and the ordinal rating of 5 (= ln (0.0029) = -5.8430), which gives a value of -5.4170 (= 0.7*-5.8430+0.3*-4.4228); (ii) transforming the interpolated value (*x*) to PD by exp (*x*) = exp(-5.4170) = 0.0044.

by the structural model during the period is similar to that anticipated by the credit agency, while the KMV model captures less impact according to the calibrations based on its proprietary default database. In Panels E and F, the discrepancy between the market-based and adjusted agency-based PDs in 1998 is larger because the crisis is defined to start as at 1998 Q1 in the estimations, but the credit ratings had been downgraded slowly for the East Asian banks during 1998 and the corresponding PDs are lower than the market-based PDs. The lower adjusted agency-based PDs therefore further increase the discrepancy.[33]

The unexplained discrepancy after 2003 Q4 may be the result of stickiness in credit ratings as the credit agency adopts the through-the-cycle rating approach to maintain rating stability (see Cantor (2001), Cantor and Mann (2003), and S&P's (2002)).[34] Credit ratings therefore generally do not fully reflect all currently available information. On the other hand, the equity markets are in principle able to summarise the new sources of available information dispersed among market participants. The banks' market-based measures should therefore react faster than the agency-based measures. Having said that, the discrepancy may also be due to the biased market-based measures because the assumptions of the structural approach to modelling default risk may not be completely hold in the East Asian markets which may not be efficient and well informed.

Among the East Asian economies, China was much less affected by the Asian financial crisis.[35] The Appendix shows that the discrepancy between the market-based and the agency-based PDs for the Chinese banks are also significant.

6. CONCLUSION

In a sample of 643 publicly listed banks rated by S&P's in 31 economies covering the period of 1996-2006, the market-based default risk measures based on the KMV and structural models are broadly consistent with the credit rating assessments for the sub-sample of the banks in the developed economies. However, for the banks in East Asian economies (excluding Japan), rating agencies have been slow in adjusting their ratings for the East Asian banks during the onset of the Asian financial crisis as compared with the market-based measures. After 1999, rating-implied default risk of the banks was however higher than that implied by the market-based measures.

The bootstrapping test shows that the discrepancy between the market-based measures and agency ratings for the East Asian banks are statistically significant. As the banks' financial strengths are observed by both the rating agency and the equity markets, the discrepancy should be caused by the factors which are not commonly incorporated into the market-based measures. While the empirical results identify that the relatively higher default risk implied by the agency ratings is partly due to the post-Asian financial crisis conservatism of the rating agency and the unsolicited ratings, the discrepancy still exists after taking these

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[33] The starting time of the crisis was different among the East Asian economies.

[34] According to rating agencies, one characteristic of rating is that they balance the conflicting aims of timeliness and stability. To maintain rating stability, credit agencies generally do not adjust the ratings to small and temporally movements in the risk profiles of the firms being rated. As a result, credit ratings generally do not fully reflect all currently available information and stickiness in credit ratings are generally observed. Note that the timelier a rating system is, the better is the discrimination between high-risk and low-risk firms; the more stable a rating system is, the lower transaction costs in the market.

[35] While most of the East Asian economies suffered from different degrees of economic downturns during the crisis, China still maintained an average annual real GDP growth rate of over 7.5% during the period 1997-1999.

two factors into account. The unexplained discrepancy may be the result of stickiness in credit ratings because of the through-the-cycle rating approach adopted by the credit agency. In addition, the discrepancy may reflect that the assumptions of the structural approach to modelling default risk of banks do not completely hold in the East Asian markets which are in general not efficient and well informed.

From the perspective of banking policies on the risk-based capital standard and deposit insurance, the results indicate that the use of agency-based and market-based measures for capital requirements of exposures to banks and deposit insurance premiums in East Asian economies could raise an issue of systematic differences between the two measures. As default risk of the East Asian banks implied by the market-based assessments is lower than that implied by the credit ratings after the Asian financial crisis and such discrepancy is statistically significant and partly attributable to the post-Asian financial crisis conservatism of the rating agency and the unsolicited ratings, the unsophisticated banks which use the standardised approach under Basel II (i.e. based on credit ratings of their bank exposures) will be at a disadvantage against the sophisticated banks which use market-based credit risk models under the internal ratings-based approach.

Appendix

This appendix presents the results following the analyses in Sections 4 and 5 above for the 112 Chinese bank observations concerning five Chinese banks. Figure A1 shows that the differences between the agency-based and market-based PDs are significant even after accounting for the rating agency's conservatism using the estimates for the East Asian banks in Table 5. This may reflect the rating agency's concerns on the outlook for the Mainland economy (i.e. whether the rapid growth is sustainable), the effectiveness of the banking supervisory regime, transparency of banking and economic policies, and management quality (e.g. corporate governance) of the Chinese banks. The assumptions of the structural approach to modelling default risk may not completely hold in the Chinese equity market which is in general not efficient and well informed.

The relatively low market-based PDs of the Chinese banks are in line with recent benign price movements of the Chinese bank stocks which have been traded with a relatively high price-earning ratio after their initial public offerings.[36] A very positive outlook for the Chinese banking sector has been anticipated by stock investors. However, stock markets generally contain significant noisy information, in particular in emerging markets such as China. The investors could be less informed compared to rating agencies whose rating processes include bilateral communications with the banks being rated in addition to publicly available information. Owing to the small number of observations of the Chinese banks, the factors accounting for the discrepancy between the agency-based and market-based PDs cannot be clearly identified by econometric analysis.[37]

[36]Based on the sample used in Section 4, the mean and median of the price-earning ratio of the Chinese banks are 28.5 and 26.2 respectively, while the corresponding values of the non-Chinese banks are 21.9 and 14.9 respectively.

[37]The number of annual Chinese bank observations is only 17, as the Chinese banks were listed in or after 2003.

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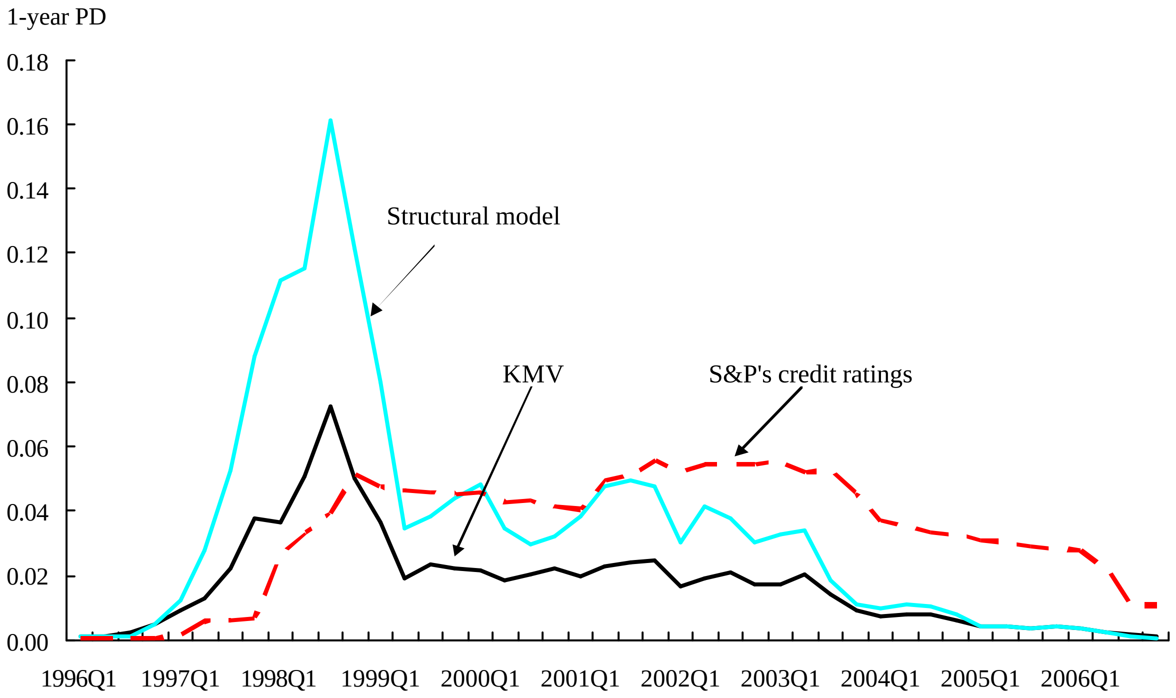
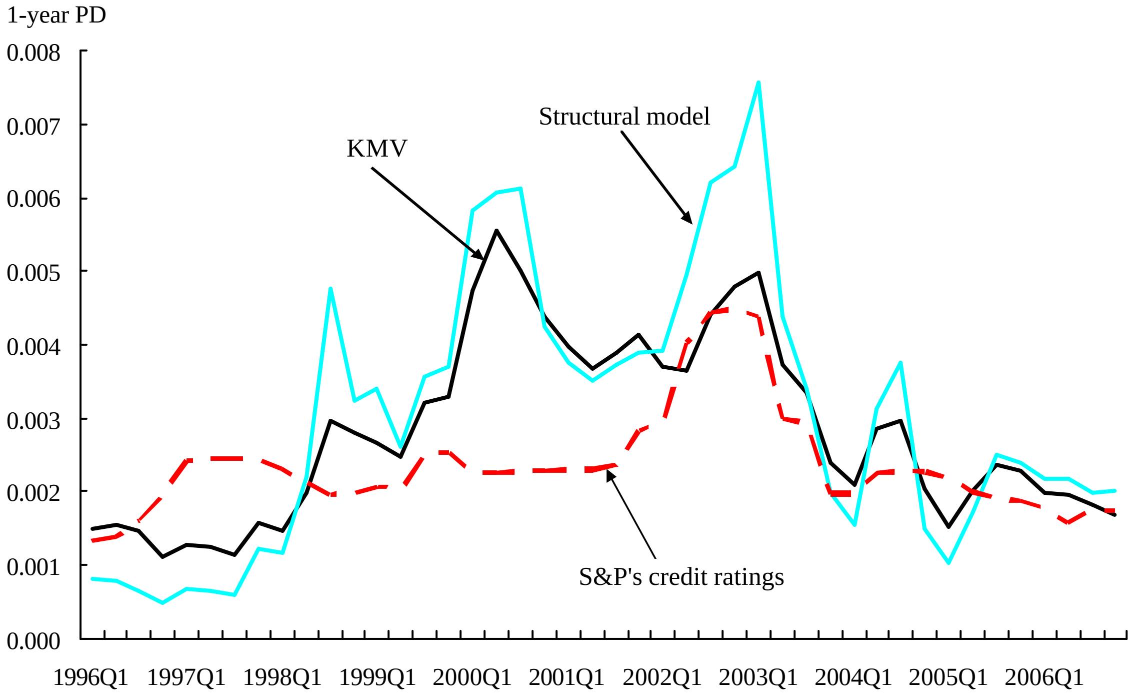
Figure 1: Average market-based PD and average agency-based PD of the East Asian banks



Sources: Bloomberg, Moody's KMV

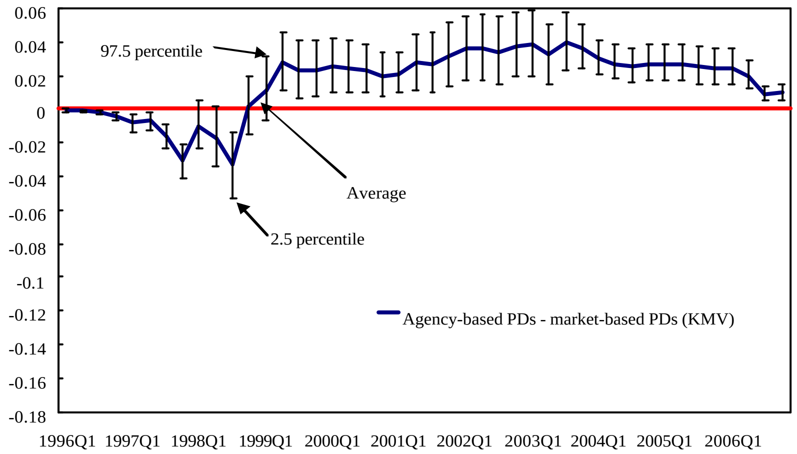
Figure 2: Average market-based PD and average agency-based PD of the banks in the developed economies



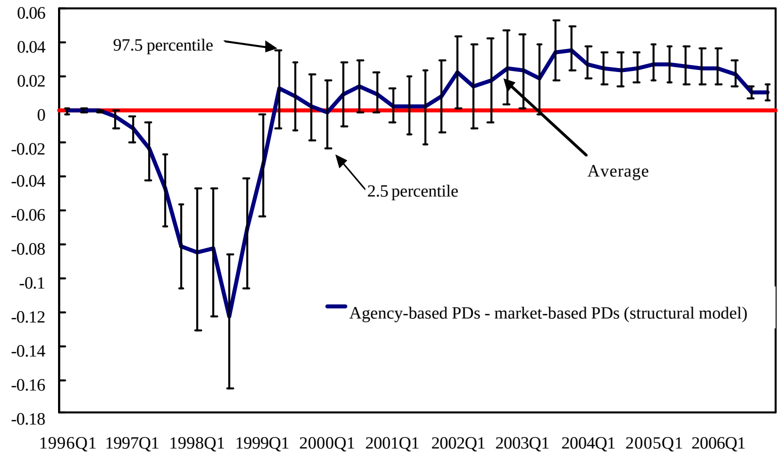
Sources: Bloomberg, Moody's KMV

Figure 3: Estimates of mean differences of agency-based PDs and market-based PDs of banks

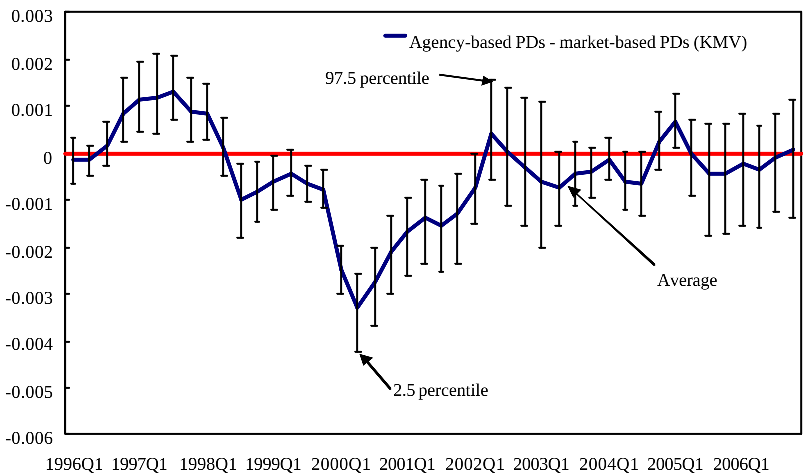
Panel A: Estimates of mean differences of agency-based PDs and market-based PDs (KMV) of the East Asian banks



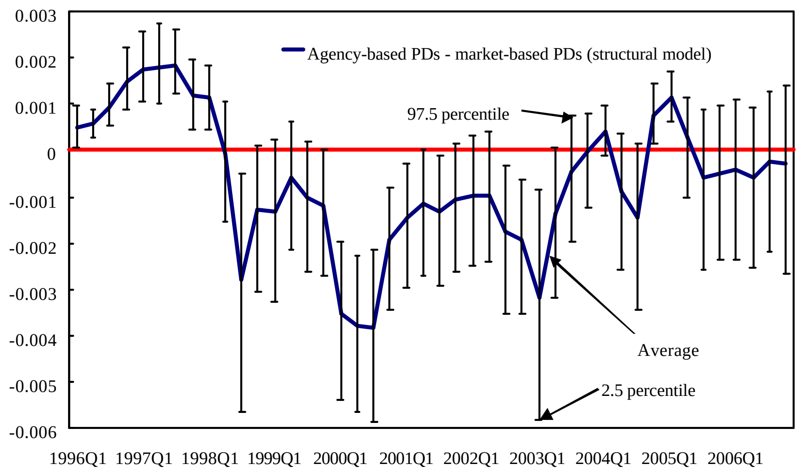
Panel B: Estimates of mean differences of agency-based PDs and market-based PDs (structural model) of the East Asian banks



Panel C: Estimates of mean differences of agency-based PDs and market-based PDs (KMV) of the banks in the developed economies



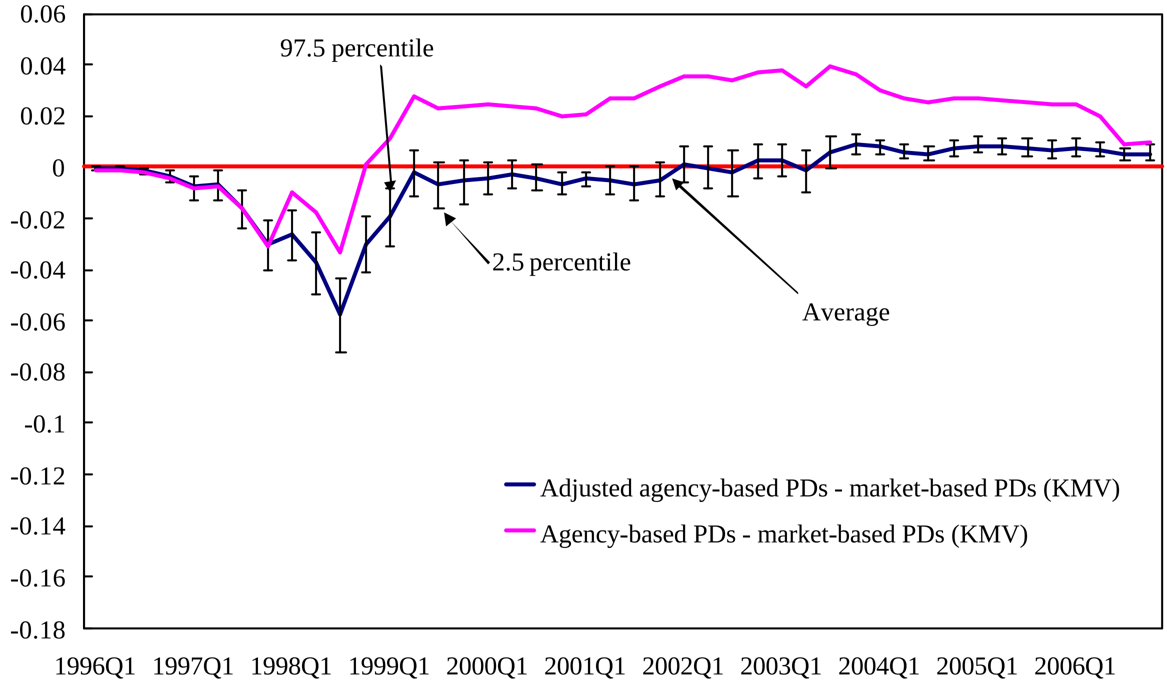
Panel D: Estimates of mean differences of agency-based PDs and market-based PDs (structural model) of the banks in the developed economies



Sources: Bloomberg, Moody's KMV

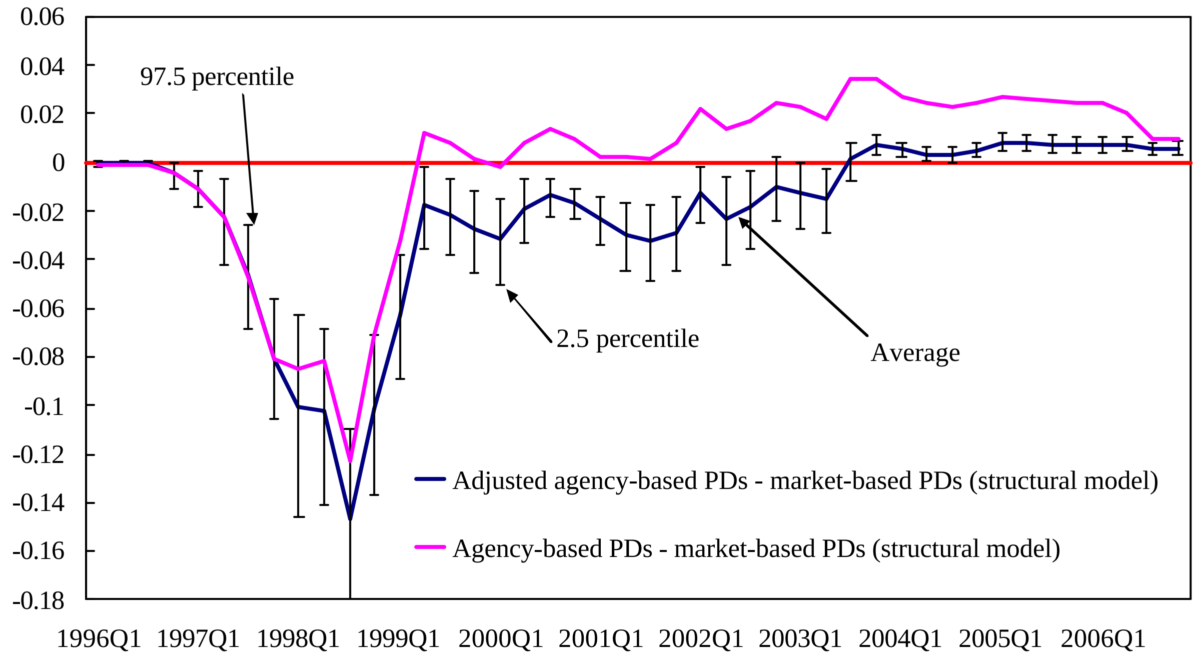
Figure 4: Estimates of mean differences of adjusted agency-based PDs and market-based PDs of the East Asian banks

Panel E: Agency-based PDs versus PDs from KMV



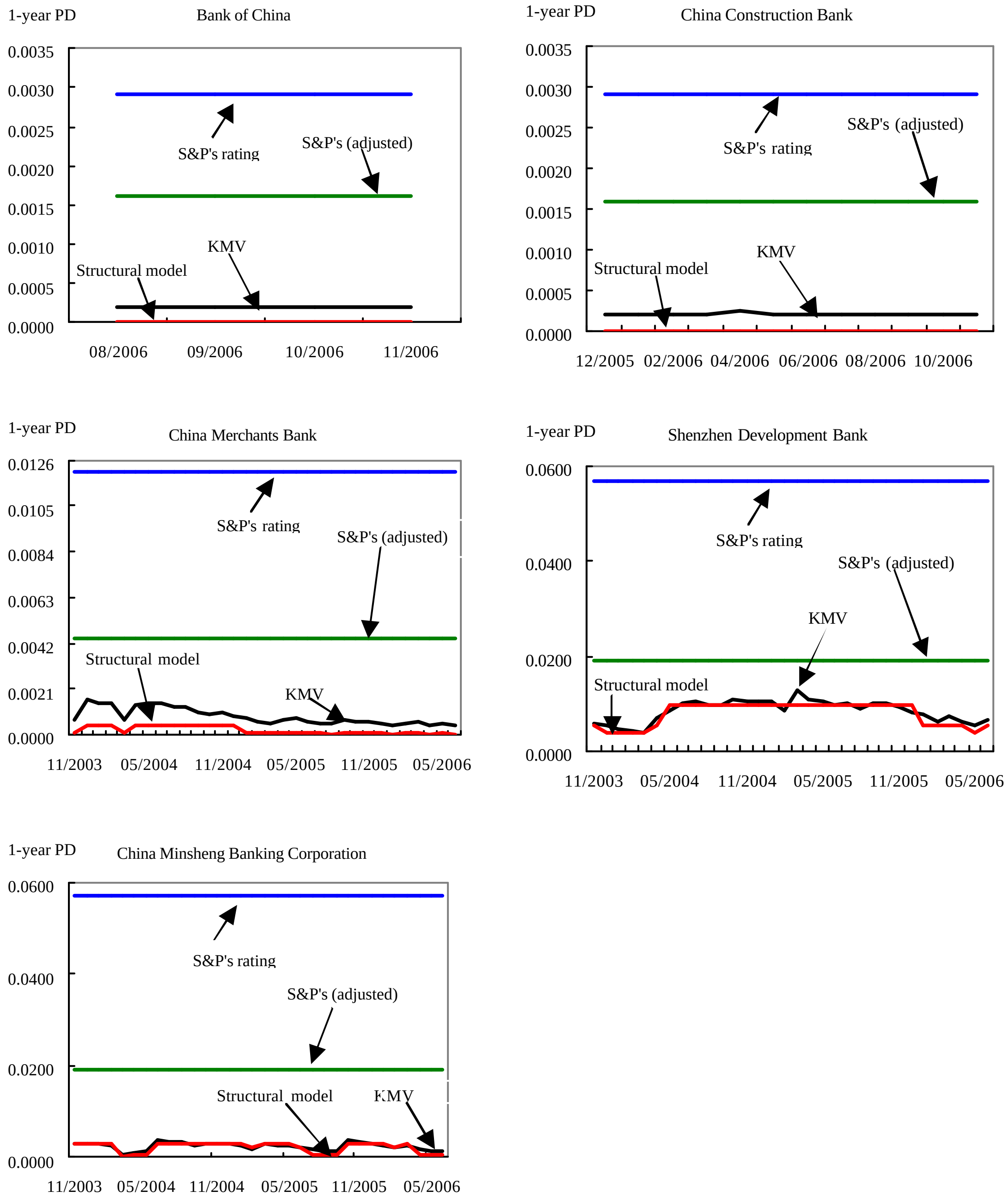
Sources: Bloomberg, Moody's KMV

Panel F: Agency-based PDs versus PDs from structural model



Sources: Bloomberg, Moody's KMV

Figure A1: 1-year default probability of Chinese banks



Notes:
(1) KMV: 1-year probability of default (i.e. 1-year EDF) by Credit Monitor, Moody's KMV.
(2) Structural model: 1-year probability of default based on Briys and de Varenne (1997).
(3) S&P's rating: 1-year probability of default implied from the bank's actual S&P's rating.
(4) S&P's (adjusted): the 1-year probability of default implied from the bank's adjusted S&P's rating.
(5) Number of samples varies across the banks due to differences in the data availability.

Sources: Bloomberg, Moody's KMV

Table 1: Economy distribution of samples for calculating agency-based PDs and market-based PDs.

Banks in the developed economies				East Asian banks		
Economy	Number of observations	Percentage share		Economy	Number of observations	Percentage share
Australia	1,537	6.5%		China	112	2.90%
Austria	114	0.5%		Hong Kong	333	8.80%
Belgium	118	0.5%		Indonesia	436	11.50%
Bermuda	22	0.1%		Malaysia	355	9.30%
Canada	895	3.8%		Philippines	732	19.20%
Denmark	125	0.5%		Singapore	161	4.20%
Finland	44	0.2%		South Korea	496	13.00%
France	667	2.8%		Taiwan, province	548	14.40%
Germany	1,060	4.5%		Thailand	632	16.60%
Greece	517	2.2%				
Ireland	437	1.8%				
Israel	440	1.9%				
Italy	1,440	6.1%				
Japan	4,262	17.9%				
Luxembourg	90	0.4%				
Netherlands	70	0.3%				
Norway	14	0.1%				
Portugal	389	1.6%				
Spain	1,082	4.6%				
Sweden	246	1.0%				
Switzerland	402	1.7%				
UK	1,006	4.2%				
USA	8,773	36.9%				
Total	**23,750**	**100.0%**		**Total**	**3,805**	**100.0%**

Sources: Moody’ s KMV

Table 2: Economy distribution of samples for econometric estimations

Non-East Asian banks				East Asian banks		
Economy	Number of observations	Percentage share		Economy	Number of observations	Percentage share
Argentina	58	1.8%		China	17	3.7%
Australia	266	8.1%		Hong Kong	69	15.2%
Belgium	14	0.4%		Indonesia	58	12.8%
Canada	132	4.0%		Malaysia	12	2.6%
Colombia	4	0.1%		Philippines	90	19.8%
Denmark	2	0.1%		Singapore	17	3.7%
Egypt	6	0.2%		South Korea	48	10.6%
Finland	8	0.2%		Taiwan, province	63	13.9%
France	39	1.2%		Thailand	80	17.6%
Germany	43	1.3%				
Greece	44	1.3%				
Hungary	3	0.1%				
Israel	53	1.6%				
Italy	191	5.8%				
Japan	536	16.3%				
Norway	3	0.1%				
Panama	20	0.6%				
Poland	27	0.8%				
Portugal	21	0.6%				
South Africa	8	0.2%				
Spain	175	5.3%				
Switzerland	30	0.9%				
Turkey	43	1.3%				
UK	190	5.8%				
USA	1,374	41.8%				
Total	**3,290**	**100.0%**		**Total**	**454**	**100.0%**

Sources: Bloomberg

Table 3: Distributions of credit rating information of samples for econometric estimations

	Non-East Asian banks		East Asian banks	
By banks' credit ratings	Number of observations	% share	Number of observations	% share
AAA	17	0.5%	0	0.0%
AA	437	13.3%	2	0.4%
A	1,400	42.6%	33	7.3%
BBB	1,152	35.0%	170	37.4%
BB	176	5.3%	120	26.4%
B	74	2.2%	107	23.6%
CCC – CC	8	0.2%	22	4.8%
SD/D	26	0.8%	0	0.0%
Total	**3,290**	**100.0%**	**454**	**100.0%**
By rating types of the bank's ratings	Number of observations	% share	Number of observations	% share
Unsolicited ratings	265	8.1%	164	36.1%
Solicited ratings	3,025	91.9%	290	63.9%
Total	**3,290**	**100.%**	**454**	**100.0%**
By sovereign credit ratings	Number of observations	% share	Number of observations	% share
AAA	2,221	67.5%	17	3.7%
AA	802	24.4%	106	23.3%
A	127	3.9%	157	34.6%
BBB	28	0.9%	97	21.4%
BB	58	1.8%	43	9.5%
B	30	0.9%	30	6.6%
CCC – CC	0	0.0%	4	0.9%
SD/D	24	0.7%	0	0.0%
Total	**3,290**	**100.%**	**454**	**100.0%**

Sources: Bloomberg

Table 4: Descriptive statistics of financial variables of samples for econometric estimations

Non-East Asian banks (Number of observations=3,290)			
Variable	***Mean***	***Median***	***Standard deviation***
ROA	0.008	0.008	0.016
Loss	0.021	0.016	0.020
LAR	0.415	0.335	0.348
ATE	23.803	15.870	278.018
ASSET	10.455	10.386	1.431
East Asian banks (Number of observations = 454)			
ROA	0.005	0.009	0.032
Loss	0.051	0.030	0.058
LAR	0.324	0.305	0.164
ATE	19.524	11.954	65.298
ASSET	9.520	9.619	1.282

Sources: Bloomberg

Table 5: Empirical results of credit rating determination models of banks

Explanatory Variables	Model A	Model B	Model C	Model D	Model E	Model F	Model G	Model H
ROA	2.192** (2.357)	2.048** (2.358)	2.403** (2.467)	12.048*** (1.712)	14.757** (2.177)	17.083* (2.747)	7.623* (5.779)	28.306* (3.464)
Loss	-5.212* (-10.482)	-4.937* (-10.882)	-4.155* (-7.831)	-14.346* (-8.742)	-13.612* (-8.489)	-11.502* (-7.482)	-6.324* (-12.959)	-15.659* (-7.860)
LAR	0.108* (3.367)	0.096* (3.091)	0.066*** (1.801)	0.398* (3.421)	0.403* (3.573)	0.411* (3.822)	0.106* (3.285)	0.466* (3.491)
ATE	-0.592** (-2.501)	-0.417* (-6.714)	-0.509* (-9.126)	-1.992* (-4.429)	-1.586* (-6.952)	-1.924* (-7.602)	-0.702* (-3.759)	-3.329* (-3.580)
Asset	0.319* (42.064)	0.319* (44.318)	0.306* (16.526)	0.906* (27.937)	0.935* (29.300)	0.932* (29.832)	0.337* (47.075)	0.991* (26.270)
Sovereign	0.293* (17.475)	0.298* (19.162)	0.323* (38.829)	0.726* (13.494)	0.769* (14.837)	0.776* (16.140)	0.286* (16.681)	0.749* (11.978)
Unsolicited	-0.371* (-12.454)	-0.384* (-13.773)	-0.437* (-16.379)	-0.981* (-8.987)	-1.045* (-10.086)	-1.163* (-11.662)	-0.325* (-12.294)	-0.894* (-7.635)
PCAB	0.425* (5.515)	0.329* (3.081)	0.405* (8.858)	1.167* (3.690)	0.751* (2.781)	0.760* (3.326)	0.830* (13.459)	2.431* (8.749)
ACAB	-0.291* (-8.996)	-0.329* (-15.255)	-0.272* (-6.876)	-0.870* (-6.445)	-0.949* (-7.235)	-0.806* (-6.522)	-0.203* (-7.030)	-0.641* (-4.374)
Constant	0.091 (0.722)	0.067 (0.528)	-0.035 (-0.234)	--	--	--	-0.060 (-0.534)	--
g_1	--	--	--	5.220* (7.420)	5.528* (8.307)	6.101* (10.619)	--	6.177* (7.658)
g_2	--	--	--	6.628* (12.034)	7.020* (13.477)	7.333* (15.429)	--	7.536* (11.655)
g_3	--	--	--	9.554* (18.706)	10.146* (20.394)	10.332* (23.088)	--	10.672* (17.754)
g_4	--	--	--	11.534* (22.205)	12.105* (23.685)	12.173* (26.497)	--	12.573* (20.516)
g_5	--	--	--	14.592* (27.086)	15.211* (28.709)	15.275* (31.982)	--	15.733* (24.814)
g_6	--	--	--	17.553* (31.133)	18.255* (32.755)	18.252* (36.207)	--	18.788* (28.231)
g_7	--	--	--	21.205* (31.630)	22.063* (32.693)	22.048* (35.444)	--	22.775* (28.506)
Adjusted-R^2	0.8751	0.8803	0.8520	--	--	--	0.8994	--
Pseudo-R^2	--	--	--	0.2773	0.2873	0.2820	--	0.2926
N	3,291	3,516	3,744	3,291	3,516	3,744	2,742	2,742
F-statistic	2,562	2,872	2,395	--	--	--	2,713	--
LR statistic	--	--	--	2,608	2,876	3,022	--	2,277

Notes: 1. Numbers in brackets are t-statistics unless specified.
2. *, ** and *** denote statistical significance at the 1%, 5% and 10% levels respectively.