Estimating the Value of Implicit Government Guarantees to Asian Banks

by Idanna Kaplan-Appio[*]

By using an option pricing technique that models deposit insurance as a put option on the unobserved value of bank assets with a strike price equal to bank debt, I measure the size of the contingent liabilities of Asian governments to their banking systems prior to the 1997 crisis. The results show that the magnitudes of these contingent liabilities are statistically significant suggesting that these guarantees provide a subsidy in the form of deposit insurance. Moreover, the magnitude of this estimated subsidy varies across countries according to the severity of the ensuing financial crisis. Additionally, by estimating the value of the implicit government guarantee to individual banks, I am able to identify weak banks before a crisis emerges. These results suggest that the estimated value of implicit deposit guarantees can serve as an early warning indicator of banking crises. I contrast the option-pricing results with traditional balance sheet approaches and demonstrate that these alternative approaches are unable to identify weaknesses in each of the banking systems before the crisis.

[*] Federal Reserve Bank of New York. Email: Idanna.Appio@ny.frb.org. The views expressed here are those of the author and do not reflect those of the Federal Reserve Bank of New York.

1. Introduction

This paper evaluates whether an option pricing technique can serve as an early warning indicator of banking crises by pricing implicit government guarantees to banks. Implicit government guarantees are worth more to banks that are more likely to fail. Weak banks and banking systems can be revealed by modeling the implicit government guarantee as a put option and estimating the value of this option. By modeling implicit government guarantees as a put option on the unobserved value of bank assets and bank equity as a call option on the value of the bank, I calculate the implicit government guarantee from an indirect maximum likelihood approach developed by Duan (1994) that estimates the unobserved value of bank assets and their volatility. In this paper, I apply this option-pricing technique to a sample of banks in five Asian countries prior to the 1997-98 financial crisis and show that the estimated implicit government guarantee identifies those banking systems that experienced financial crises and their relative severity. This paper estimates the value of the implicit government guarantee to the banking systems in Thailand, Malaysia, South Korea, Indonesia, and Singapore. For all of the countries, except Singapore, which did not experience a banking crisis, the estimated implicit guarantee is statistically significant and large, averaging over 8 percent of the banking systems' deposits.

This paper is organized as follows. First, I review the literature that constructs early warning indicators of banking crises and the option-pricing literature. Second, I review the deposit insurance option-pricing methodology, including the data and the estimation procedure. Third, after estimating the value of implicit government guarantees, I evaluate the results across banks and countries. The fourth section concludes.

2. Literature Review

Numerous papers have explored whether certain variables can be used as early warning indicators of banking crises. The majority of these empirical papers have used macroeconomic variables to predict financial crises.[1] While these empirical studies are successful in some cases at identifying crises 6-12 months prior to a speculative attack of the currency, they are unable to identify crises several years in advance and are also unable to distinguish between crisis and non-

crisis countries. Kaplan (2000) applies an approach developed by Kaminsky and Reinhart (1996) to Thailand, Malaysia, South Korea, Indonesia, and Singapore and shows that the same number of indicators signal a crisis in the four crisis countries as in Singapore in the year preceding the crisis. For the five Asian economies studied in this paper, these variables, however, do not indicate a crisis in Southeast Asia prior to 1996.[2]

Merton (1977) first showed that government guarantees of the banking system can be modeled as a put option on the value of bank assets. Empirical papers beginning with Marcus and Shaked (1984) and Ronn and Verma (1986) have focused on calculating actuarially fair deposit insurance premiums for U.S. commercial banks. This focus stems from the hypothesis that the moral hazard incentives produced by government guarantees could be eliminated if banks paid actuarially fair premiums. In the deposit insurance option-pricing literature, the debate has centered on whether banks, on average, paid too much or too little for this deposit guarantee. Marcus and Shaked determine that banks in the early 1980s overpaid for deposit insurance, while Ronn and Verma arrive at the opposite conclusion. Both authors find evidence of cross-subsidization of banks in the United States; some banks paid too much and others not enough for government guarantees. Duan (1994), using the maximum likelihood approach employed in this study, finds in the United States in the early 1980s the value of deposit insurance for a particular bank reached 0.4 percent of deposits.[3]

Other papers have extended the option pricing analysis to different institutions. Giammarino, Schwartz and Zechner (1989) calculate the value of deposit insurance for Canadian banks and establish that there was cross-subsidization across banks. Fries, Mason and Perraudin (1993) and Sato, Ramachandran and Kang (1990) estimate the value of deposit insurance to Japanese banks. Using the same maximum likelihood option-pricing approach, Fries, Mason, and Perraudin (1993) find that the average value of the government guarantee to a Japanese bank reached as high as 2.4 percent of deposits.[4] Duan and Yu (1994) apply an option-pricing

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[1] See Kaminsky and Reinhart (1996), Glick and Rose (1998), Sachs, Tornell, and Velasco (1996), and Frankel and Rose (1996).

[2] Moreover, the ability of this approach to identify crises 6-12 months prior to a crisis is also called into question, if the financial crisis is thought to begin before the devaluation of the currency. For instance, the first bank collapsed in Thailand and the first Chaebol collapsed in Korea a year before the devaluation of the baht in June 1997.

[3] Duan (1994) finds the average value of deposit insurance for Citicorp between 1981-85 was 0.4% of deposits and for First Interstate Bankcorp over 1981-85 averaged 0.38%.

[4] The average value of deposit insurance equaled 2.41% for Bank of Tokyo in the 4/1975-3/1984 period.

approach to estimate the value of the government guarantee in an emerging market economy. By looking at Taiwanese banks in the late 1980s, they find evidence of cross-subsidization of banks, although most banks paid too little for the deposit guarantee. Importantly, only Cordell and Gordon (1990) examine the wider effects of government guarantees by studying a group of savings and loans prior to the S&L crisis. Cordell and Gordon (1990) estimate the value of deposit guarantees for U.S. savings and loans and show that the insurance value indicated at an earlier date than traditional GAAP measures those banks that later failed.

3. Estimating the Value of Implicit Government Guarantees for Asian Banks

The option-pricing model of deposit insurance stems from Merton (1977), in which deposit insurance is modeled as a put option. The insurer issues a one-year put option that allows the bank to sell the bank in one year's time for the value of its liabilities today. If at the end of the year the bank is solvent and its value is greater than the value of its liabilities, the option expires without being exercised. However, if the bank is insolvent and its value falls below the value of its liabilities, the bank exercises its option to sell the bank to the insurer for the value of its liabilities and debt holders are repaid. This option is worth more to a bank that is more likely to fail. This paper will calculate the value of the deposit insurance option for several banks across five countries to examine whether this variable can be used as an early warning indicator of banking crises.

In the five Asian countries, I assume the government implicitly guaranteed deposits, even though these countries lacked formal deposit insurance systems. In Thailand, although the government never passed specific deposit insurance legislation, banks were required to pay 0.1 percent of their deposits into an insurance fund. In the remaining countries banks did not pay a premium for the government guarantee, but depositors likely perceived deposits to be implicitly insured because of the government's rescue of banks within the past two decades in Thailand, South Korea, Malaysia, and Indonesia.[5] In Thailand, South Korea, Malaysia, and Indonesia, the implicit government guarantee was made explicit in 1997-98 when the

[5] In Thailand banks were rescued in the mid-1980s, in Malaysia, in the mid-1980s, and in Indonesia in the early 1990s. In South Korea, while there were no explicit bank bailouts, the government played a dominant role in the banking system and did not allow them to fail. (Nam and Lee 1995).

governments made statements that depositors would be protected. To date, the governments have upheld this guarantee and have additionally guaranteed most of the banks' liabilities.[6]

The Option-Pricing Model

In Merton's model, given a firm that issues a single, homogenous debt that will mature to *$B*, the firm will be solvent if the value of its assets, *V*, are larger than the value of its total debt. If the value of the firm is less than the value of its debt, then the firm is insolvent and the insurer assumes the claims to the debt holder.

To apply the option-pricing model to a bank, several assumptions are made. First, it is assumed that the bank's liabilities are equal to its deposits and that all deposits including their interest are insured.[7] Therefore, insured deposits are riskless and their book value, *D*, equals Be^{-rT}.[8] Second, it is assumed that the time, *T*, until the maturity of the deposits is equal to the time until the next annual audit of the bank. Finally, it is assumed that the bank's asset values follow geometric Brownian motion:

$$d \ln V_t = \mu dt + \sigma dW_t, \qquad (1)$$

where V is the value of assets, μ is the instantaneous expected return on assets, σ is the instantaneous standard deviation of asset returns, and W_t is a standard Wiener process.

Given the above assumptions, Merton (1977) shows that the value of deposit insurance as a percent of deposits, *I*, can be expressed as follows:

$$I = N(\sigma\sqrt{T-t} - y_t) - \frac{V_t}{D} N(-y_t) \qquad (2)$$

where:

[6] In October 1997, the Thai government made a formal statement guaranteeing the deposits of the 15 commercial banks and the 33 operating finance companies. In January 1997, the Korean government instituted a formal deposit insurance system that limited the coverage to deposits of W20 million; however, once the crisis was underway the government announced it would protect all bank deposits and their interest. In Indonesia, after initially closing 16 banks and stating depositors would not be protected, in January 1998, and in March 1998, the government extended the guarantee to all bank liabilities. In Malaysia, in September 1997, the government announced it would protect depositors.

[7] I assume that only the deposits were implicitly insured in the Asian countries, even though *ex post* all of the banks' liabilities were insured. Kaplan (2000) reports the results assuming the liabilities of banks are insured, and the results are qualitatively the same.

[8] Ronn and Verma (1986) show that compounding the non-deposit debt of the bank by the rate paid and discounting it by the risk-free interest rate makes little empirical difference in the value of deposit insurance.

$$y_t \equiv \frac{\ln\left(\frac{V_t}{D}\right) + \frac{\sigma^2}{2} \cdot (T-t)}{\sigma\sqrt{T-t}},$$

and N is the cumulative standard normal density function.

From equation (2), an increase in the standard deviation of asset returns, σ, which can be interpreted as an increase in the volatility or risk of bank assets, increases the magnitude of the deposit insurance put option. Similarly, a decrease in the value of bank assets relative to its deposits, V/D, which can be interpreted as an increase in bank leverage, also increases the size of deposit insurance put option.

To use this model empirically to calculate the value of the guarantee to the bank, estimates of the unobserved value of bank assets, V, and their volatility, σ are needed. Ronn and Verma (1986) approach this problem by modeling the bank's equity as a call option on the value of the bank's assets with a strike price equal to the value of the bank's debt. [9]

$$E_t = V_t N(x_t) - DN(x_t - \sigma\sqrt{T-t}) \qquad (3)$$

where:

$$x_t \equiv \frac{\ln\left(\frac{V_t}{D}\right) + \frac{\sigma^2}{2} \cdot (T-t)}{\sigma\sqrt{T-t}},$$

and E_t refers to the market capitalization of the bank at time t, D is the face value of debt, and T refers to the time until maturity of the call option. In order for this approach to be valid, the time until maturity, T, and the debt, D, of the put and call options must be the same.

This paper retains the basic structure of Ronn and Verma (1986), but utilizes a maximum likelihood framework based on Duan (1994).[10] Since the unobserved values of bank assets follow a continuous time lognormal process, the log-likelihood function for V can be expressed as:

[9] Ronn and Verma also include forbearance in the model by lowering the strike price from D to $.97*D$. Including forbearance increases the estimate of deposit insurance. In this paper, I exclude forbearance.

[10] Fries, Mason, and Perraudin (1993) use a similar technique to value deposit insurance for Japanese financial institutions.

$$L_t(V_t;\mu,\sigma) = -\frac{n-1}{2}\ln(2\pi\sigma^2) - \frac{1}{2\sigma^2}\sum_{t=2}^{n}\left[\ln\left(\frac{V_t}{V_{t-1}}\right) - \mu\right]^2 \qquad t=1,\ldots,n \qquad (4)$$

Since the call-option formula (equation (3)) is an element-by-element transformation from unobserved asset values to observed equity values, we can write the sample log-likelihood function for equity as:

$$L(E_t;\mu,\sigma) = -\frac{n-1}{2}\ln(2\pi\sigma^2) - \sum_{t=2}^{n}\ln(N(\hat{x}_t)) - \frac{1}{2\sigma^2}\sum_{t=2}^{n}\left[\ln\left(\frac{\hat{V}_t(\sigma)}{\hat{V}_{t-1}(\sigma)}\right) - \mu\right]^2 \quad t=1,\ldots,n \quad (5)$$

where $\hat{V}_t(\sigma)$ is the unique solution to equation (3) for any σ, and $\hat{x}_t$ is x_t evaluated with $\hat{V}_t(\sigma)$ instead of V_t.[11]

Data Description

The countries studied in this paper are Indonesia, Malaysia, Singapore, South Korea, and Thailand. The data comes from annual bank balance sheets and income statements reported by banks to Datastream and Datastream's archive of daily, bank market capitalization values. Balance sheet and daily market capitalization data was available for 60 banks across the five countries. The variables used in the estimation were daily bank market capitalization values, and annual deposit data.[12] For each year and each bank, the option value of the implicit government guarantee is estimated using the December value of deposits and daily, January through December, market capitalization data.[13] The sample includes all of the days the stock market was open for trading.

For Indonesia, Datastream only reports balance sheet and income statement data on 10 of the country's 238 banks beginning with data from 1993. These 10 banks, were however, among

[11] Duan derives equation (5) showing that the likelihood function of observed equity values is equal to the likelihood function of unobserved asset values (evaluated at the optimal sigma) minus the sum of the logarithm of the first derivative of the observed equity values with respect to the unobserved asset values, or

$$-\sum_{t=2}^{T}\ln\left(\frac{\partial E}{\partial V}\right) = -\sum_{t=2}^{T}\ln(N(\hat{x}_t)).$$

[12] Market capitalization values are listed as datatype MV. Total deposits are total interest and non-interest bearing deposits (code 847) and equal the sum of fixed term deposits (844), deposits on demand (954), savings accounts (959), and other customer accounts (963). Total liabilities (code 2401) equal total short and long-term liabilities.

[13] For Malaysia, I use daily data for the year preceding the date the bank reported its deposits; this date varied by bank.

the largest private banks in the country, holding over 20 percent of the banking system's assets in 1997.[14] For Malaysia, Datastream reports data on 12 of the country's 22 domestic banks and 3 finance companies. Malaysian banks report their balance sheets in different quarters, so in order to aggregate across banks, data was included in the year it was reported, regardless of the quarter. Datastream carries Malaysian balance sheets and income statements beginning in 1993. For Singapore, Datastream carries data on all 5 distinct, private banks.[15] Balance sheet and income statement data was available from 1992. For South Korea, Datastream reports data for 17 of the country's 26 banks. Balance sheet and income statement data was available from 1991 for 10 of the country's 16 national banks, and 7 of the country's 10 regional banks. For Thailand, Datastream reports data for all 15 of the country's banks from 1992. However, annual deposit data was only available for 13 of Thailand's banks.[16]

Estimation Procedure

In applying the option-pricing procedure detailed above, I retain most of the assumptions used in the previous literature. I preserve the assumption that the put and call options expire in one year's time.[17] With the exception of Malaysia, Datastream reported bank balance sheets and income statements in December; therefore the put option is assumed to expire in December of the following year. Changing this assumption, either assuming the option expires in a shorter or longer period does not systematically affect the results. Instead, the results are sensitive to whether the standard deviation of asset returns is smaller or larger over the alternative period.[18] Finally, I do not include forbearance as modeled by Ronn and Verma, even though forbearance was practiced in the Asian crisis. Including a forbearance term increases the estimated values of the government guarantee, but I have no justification for assuming either that the depositor *ex*

[14] The state-owned banks in Indonesia held over 40% of the banking system's assets in 1997. Therefore because of the prevalence of non-traded banks in Indonesia, this option-pricing technique may not give an accurate indication of the magnitude of the government's contingent liability to the banking system as a whole.
[15] There were 10 banks in total in Singapore; however, the Post Office Savings Bank was a government-owned bank and the remaining 4 banks were owned by the 5 banks in the Datastream sample.
[16] Kaplan (1998) reports results for Thailand's 15 banks using total liabilities, and not deposit data, as the strike price in the option-pricing model.
[17] The literature has settled on a one-year put option under the assumption that the regulator audits the banks on an annual basis. It is therefore assumed that the regulator will ascertain the solvency of the bank at the annual audit.
[18] All estimates of the value of the implicit government guarantee are statistically greater than zero, with the exception of Pusan Bank in South Korea in 1994. The estimated value of the implicit government guarantee for Pusan Bank in 1994 is not statistically greater than zero, regardless of the inclusion of dividends.

ante believed forbearance would be practiced or had knowledge of the degree of forbearance that would be granted.[19]

An implied assumption of the option-pricing methodology is that the standard deviation of asset returns is constant in the year the option is priced. For 1997, this assumption is likely to be violated with the sharp fall in asset prices that occurred following the depreciation of the Asian countries' currencies. Thus, I only estimate the value of the implicit guarantee through 1996. As an additional reason for excluding the 1997 results, the 1997 put option expired at end-1998 and by that time most banks had already "put" their claims back to the guarantor.

To estimate the option value of the implicit government guarantee, I construct a constrained maximum likelihood estimation procedure that used as inputs starting values for μ and σ, and data on bank market capitalization, dividends, and deposits.[20] In the maximum likelihood estimation, σ was constrained to be positive because the put and call option formulas (equations (2) and (3)) are sensitive to small values of σ. The procedure then generated a daily series of implied asset values using the call pricing formula (equation (3)). The implied asset values were used to construct the likelihood function (equation (5)). Maximizing the likelihood function produced estimates of the expected return on bank assets, $\hat{\mu}$, and the standard deviation of asset returns, $\hat{\sigma}$. The maximum likelihood estimates were used in the call option formula (equation (3)) to construct the end-year asset value, $\hat{V}(\sigma)$ and its standard error.[21] Using the estimates $\hat{V}(\sigma)$ and $\hat{\sigma}$, the program calculated the value of the one-year deposit insurance put-

[19] Ronn and Verma assume the government would intervene when deposits equaled 97 percent of the bank's assets because this figure set the premiums banks paid in the early 1980s exactly equal to the value of deposit insurance they received.

[20] The estimation code was written in Gauss and utilized the optimization library, Optmum, and the constrained maximum likelihood library, CML. The estimation code is available upon request.

[21] The asymptotic standard error of $\hat{V}$ is given by $\sqrt{\left(\frac{d\hat{V}}{d\sigma}\right)^2}$ * std. error of $\hat{\sigma}$, where

$\frac{d\hat{V}}{d\sigma} = -\sqrt{\frac{1}{2\pi}}\frac{D}{N(x_t)}\exp\left[-\frac{(x_t-\sigma)^2}{2}\right]$ and is evaluated at $\sigma = \hat{\sigma}$.

option, $I(\hat{V}(\sigma),\hat{\sigma})$ and its standard error, using equation (2). [22] Then for each estimate, the null hypothesis that the value of the government guarantee was equal to zero was tested. This procedure was conducted for each of the 60 banks for each year data was available.

3. Evaluating the Estimates of the Implicit Government Guarantee

This section presents the results of the option-pricing technique that was used to estimate the value of the government's implicit guarantee to the banking system. To evaluate whether this approach can serve as an early warning indicator of banking crises, I compare the magnitude of implicit guarantee estimates across countries and time. The complete set of results for each of the 60 banks is listed in the Appendix, Tables 1 through Table 5.[23]

These results show that the estimated value of the implicit government guarantee was large and statistically greater than zero in all five countries. For the sample of banks examined, in Indonesia, the estimated value of the implicit guarantee averaged 18 percent of the banks' deposits; in Thailand 12 percent of the banks' deposits, in South Korea and Malaysia 8 percent of banks' deposits, and in Singapore 3 percent of banks' deposits. These estimates are also large compared to previous studies on banks in other countries. Using the same estimation technique, Duan (1994) estimated the value of deposit insurance for a U.S. bank at 0.4 percent of the bank's deposits, Fries, Mason, and Perraudin (1993) found the average value of deposit insurance for a Japanese bank reached as high as 2.4 percent of deposits, and Duan and Yu (1994) estimated the value of the implicit government guarantee at 2.5 percent of deposits for a bank in Taiwan. In the studies using banks in the United States and Japan, evidence was found of cross-

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[22] The asymptotic standard error of I is given by $\sqrt{\left(\frac{\partial I}{\partial V}\frac{d\hat{V}}{d\sigma}+\frac{\partial I}{\partial \sigma}\right)^2}$ * std. error of $\hat{\sigma}$, where

$\frac{\partial I}{\partial V} = -\frac{N(-y_t)}{D}$,

$\frac{dI}{d\sigma} = \sqrt{\frac{1}{2\pi}}\exp\left[-\frac{(y_t-\sigma)^2}{2}\right]$ and is evaluated at $\sigma = \hat{\sigma}$.

[23] For a complete set of results that includes the data used and the estimated values of the bank's assets, the standard deviation of asset returns, and the expected return on the bank assets, with the standard errors of the estimated parameters, see Kaplan (2000).

subsidization of banks, i.e. on average some banks paid too much for the government guarantee and other banks underpaid. However, the results of this paper indicate that cross-subsidization was not present in the five Asian countries studied. Instead, all of the banks were receiving a subsidy in the form of implicit deposit guarantees, since only Thai banks paid premiums and the premium paid was less than the value of the guarantee.[24]

The results also indicate that the government's total contingent liability to the banking system was large as a fraction of GDP. To compare the magnitude of the contingent liability across the five Asian countries, I extrapolated the total estimated value of the guarantee from the banks in my sample to the entire commercial banking system based on the relative share of bank assets in my sample to the entire banking system. Consequently, in addition to the relative weakness of the banking sector, the total contingent liability of the government to the banking system is also affected by the relative size of the banking system in the economy. For instance, in Malaysia and Thailand, the banking system's assets totaled 120 percent of GDP and 170 percent of GDP, respectively, but in Indonesia only totaled 70 percent of GDP. For each country, Table 1 reports the estimated implicit government guarantee as a percent of deposits for the sample of banks and, extrapolating from the sample, as an average percent of GDP. From Table 1, based upon the contingent liability estimates, regulators should have been concerned about the fragility of the banking systems and the substantial contingent liabilities this placed on the governments' finances as early as 1992-93. The estimates remain fairly constant overtime, and with the exception of Thailand, do not show a sudden increase in 1996. Thus, according to these results a crisis was no less likely in 1992 than 1996.

[24] With the exception of South Korea's Pusan Bank in 1994, the null hypothesis that the estimated value of the deposit guarantee is equal to zero is rejected for all banks. For Thailand, since banks paid insurance premiums of 0.1% of deposits, the null hypothesis that the estimated value of deposit insurance was less than or equal to 0.1 is rejected for all banks.

Table 1: The Estimated Contigent Liability of the Government to Asian Banking Systems

	Estimated Implicit Government Guarantee (% of deposits)						*(% of GDP)*	*Recapitalization Requirement (% of GDP)*	*Peak NPLs (% of Loans)*
Country	*1991*	*1992*	*1993*	*1994*	*1995*	*1996*	*Average*		
Indonesia			13.0	21.8	17.5	17.5	8.4	42[25]	70
Malaysia			8.6	26.7[26]	12.9	9.3	10.4	11	19
Singapore		3.7	3.0	5.7	2.4	1.5	2.9	0	8
South Korea	12.0	12.6	7.5	10.7	7.2	6.0	4.8	10	25
Thailand		12.5	10.7	12.9	8.0	15.9	9.6	26	48

The value of the implicit government guarantee as a percent of deposits was estimated using the procedure of section 2. To calculate the contingent liability as a percent of GDP, the estimates were extrapolated to the entire banking system. The recapitalization requirement as a percent of GDP is from Merrill Lynch (1999) and the peak level of non-performing loans as a percent of total loans is from the Claessens, Djankov, and Klingebiel (1999) for Thailand, Malaysia, Indonesia, and South Korea. Singapore's NPLs are reported by the Monetary Authority of Singapore.

The estimated value of the government guarantee to the banking system corresponds to those countries that later had banking crises and the ensuing severity of the crisis. Table 1 reports two indicators of the severity of the banking crises in the five countries. The recapitalization requirement reported by Merrill Lynch (1999) is the estimated cost to recapitalize the commercial banking system. The non-performing loan ratio is the peak ratio of non-performing loans for the commercial banking system as a percent of total loans as reported by Claessens, Djankov, and Klingebiel (1999). According to both the recapitalization costs and the peak non-performing loan measures, Indonesia's crisis was the most severe, followed by

[25] In Indonesia, banks are only required to raise their capital to 4 percent of risk adjusted assets, as opposed to the BIS norm of 8 percent.

[26] For Malaysia, the estimated value of implicit government guarantees was substantially larger in 1994 than the other years because the estimated standard deviation of asset returns was larger that year. In 1994, the stock market, and the value of bank stocks in particular, were more volatile than other years because the authorities implemented and then removed a series of controls on the inflow of foreign capital into the domestic banking system. These abrupt changes in regulations and sudden swings in stock price are likely to violate the assumption of a constant standard deviation of asset returns in that year. Consequently, the results reported as period averages exclude the results for 1994.

Thailand, Malaysia and Korea, and Singapore, which did not experience a crisis. This ranking matches the estimated value of the government guarantee as a percent of deposits.

For the four crisis countries (Indonesia, Malaysia, South Korea, and Thailand), the estimated contingent liability as a percent of GDP is less than the estimated cost to recapitalize the banking system. However, the estimated contingent liability of the banking system is an expected value, which weights the value of the implicit government guarantee by the likelihood that a banking crisis will occur and the option will be exercised. Thus, we would expect the estimated contingent liability to underestimate the actual magnitude of the crisis. Nevertheless, for Indonesia the estimated contingent liability as a percent of GDP, while large seems understated compared to the severity of the crisis. This understatement could be caused by a sample selection bias. In Indonesia, unlike the other countries, state-owned banks comprised nearly half of the domestic commercial banking system and, by most accounts, the state-owned banks were among the weakest banks in the system.[27] Therefore, because I am assuming the 228 banks not in my sample were no weaker than the 10 banks in the sample, the estimated contingent liability of the government is likely to be understated.

The estimated values of the implicit government guarantee help detect the worst banks within a particular country prior to the 1997 crisis. In order to identify the worst banks, an inexact measure such as whether the bank was nationalized, recapitalized, forced to merge, or bought by a foreign bank had to be used. These indicators are problematic because the government's decision to save certain banks may not be based solely on economic factors. For each country, the banks were ranked according to the average estimated deposit insurance subsidy value as a percent of deposits. These rankings were then matched with bank outcomes. In Thailand, only three of the 13 banks were not nationalized, recapitalized, or bought by foreign banks, and these three banks were ranked by the deposit guarantee indicator as the best three banks in the country.[28] Table A.4 ranks the Thai banks according to the average estimated value of the government guarantee. The banks listed in bold were nationalized by the government, the banks in italics were recapitalized, and the banks underlined were bought by foreign banks in

[27] IMF (2000).

[28] I assume that banks bought by foreign banks are among the worst banks in Thailand because shareholder's equity was written down and the Thai government 'guaranteed' the foreign banks a minimum rate of return and gave the foreign banks the option to sell back non-performing loans in the future to the government.

1997-99. In Malaysia, six of the eight banks with the largest estimated values of the government guarantee belonged to a financial group that received government support during the banking crisis.[29] These six banks are listed in bold in Table A.2. However, the deposit insurance subsidy estimates cannot identify the particular member of the holding company in which the government intervened. In the sample of 10 Indonesian banks only three banks have survived the crisis without either being nationalized (listed in Table A.1 in bold) or recapitalized (in italics) by the government in 1997-99. The bank with the smallest estimated value of the government guarantee was one of these banks. In South Korea, 9 of the 17 banks in the sample were nationalized following the financial crisis. The estimated value of the government guarantee identifies two banks that were later nationalized (listed in bold in Table A.3) as the two worst banks and two banks that were not nationalized as the best two banks. However, for the remaining banks, the estimated value of the government guarantee does not help identify those banks that were later nationalized by the government.

Table 2 examines typical balance sheet indicators and reveals that these variables cannot be used as reliable early warning indicators. Large capital-to-asset ratios and market capitalization to asset ratios should indicate stronger banks and banking systems. These ratios however may not reflect the true health of banks. Reported capital-to-asset ratios rely on the book value of capital and banks may be able to manipulate capital and asset data. Moreover, market capitalization to asset ratios may overstate the net worth of banks, if they reflect an implicit government guarantee accruing to shareholders.

Singapore's banks maintained the largest capital-to-asset ratios and did not experience a banking crisis. However, in the other four countries, capital-to-asset ratios would have given the impression that the banking systems were relatively strong. For the sample of banks studied in each country, the capital-to-asset ratios averaged 10 percent in Malaysia and South Korea and averaged 7 percent in Thailand and Indonesia.[30] Additionally, the reported capital-to-asset ratios also do not indicate that any bank within a country was substantially weaker than the other

[29] This support consisted of Danaharta purchasing non-performing loans and Danamodal recapitalizing the institutions.

[30] For all countries, the capital-to-asset ratios were calculated using data from Datastream and equaled the ratio of assets minus liabilities to assets. Thus, because these capital-asset ratios are not risk adjusted, they cannot be directly compared to the Bank for International Settlement's recommended 8 percent risk-adjusted capital adequacy standard.

banks.[31] In Indonesia and South Korea, reported capital ratios prior to the crisis bore little resemblance to the capital of the bank as ascertained by outside auditors in 1998. In Indonesia, bank auditors found in 1998 that 40 banks had capital-adequacy ratios below -25 percent, 56 banks had risk-adjusted capital-adequacy ratios between -25 percent and 4 percent, and 54 banks had capital-adequacy ratios above 4 percent. In South Korea, 12 of the country's 26 banks were found to have risk-adjusted capital-to-asset ratios below 8 percent in 1998.

Table 2: Comparison of Estimated Government Guarantee and Balance Sheet Indicators (Period Averages in Percent)

Country	*Government Guarantee (% Deposits)*	*Capital Asset Ratio*	*Asset Growth Rate*	*Market Capitalization to Asset Ratio*	*Adjusted Market Capitalization to Asset Ratio (1996)*
Indonesia	17.9	10.0	31.0	16.5	4.0
Malaysia	8.0	10.0	32.0	22.5	19.0
Singapore	3.0	11.5	20.0	21.0	15.0
South Korea	8.3	7.0	17.0	6.0	-0.5
Thailand	12.1	7.0	20.5	16.0	-2.0

Estimated values of the implicit government guarantee as a percent of deposits are the results of the option-pricing model; the complete results are in the Appendix. The capital-asset ratio, the asset growth rate, and the market capitalization-asset ratio are calculated from data provided by Datastream. For these variables the average for Indonesia was taken over 1993-96, for Malaysia from 1993-96, for Singapore from 1992-96, for South Korea from 1991-96, and for Thailand from 1992-96. The adjusted market capitalization to asset ratio in 1996 is calculated by subtracting off the estimated implicit government guarantee in 1996 from the market capitalization value of the bank that year and dividing by total assets.

For Thailand, Malaysia, and Indonesia, the market capitalization to asset ratios were large, averaging 16 percent in Thailand, 22.5 percent in Malaysia, and 16.5 percent in Indonesia. To bank regulators, these ratios may have indicated that given time, banks would be able to increase their paid-in capital and thus raise shareholders' stakes in the future profitability of the bank. However, if a portion of the market capitalization value of the bank were attributable to the implicit government subsidy, these market capitalization ratios would be overstated.

[31] For capital-asset ratios on a bank-by-bank basis for each year see, Kaplan (2000).

Therefore, I adjust the market capitalization to asset ratio by assuming shareholders capture the entire rent from the government guarantee accruing to the bank.[32] I calculate the adjusted market capitalization to asset ratio by subtracting off the estimated value of the government guarantee from the market capitalization value of the bank. Table 2 lists the adjusted market capitalization to asset ratio in 1996 for each country's banking system. For South Korea and Thailand the adjusted market capitalization-to-asset ratios were negative and for Indonesia these ratios were small in 1996. As a result, in the absence of the implicit government guarantee, shareholders in these countries did not have a stake in the future profitability of these banks.

Banks can enlarge the rent accruing from the implicit government guarantee by either growing rapidly and increasing leverage or, by undertaking riskier projects (from equation (2)). Although anecdotal evidence exists, it is difficult to measure the riskiness of bank projects overtime. However, Kane (1985) and White (1991) show that a rapid pace of bank asset growth can indicate that banks are increasing the size of the implicit government guarantee. Table 2 reports the average growth rate of bank assets over the sample period. All five countries experienced a rate of asset growth above nominal GDP. In Malaysia and Indonesia the rate of bank asset growth averaged over 30 percent for the banks studied, in Thailand and Singapore bank asset growth rates averaged over 20 percent, and the rate of bank asset growth averaged 17 percent for South Korean banks. While this indicator seems to raise concerns about the health of the banking system in the mid-1990s, these criteria cannot distinguish between Singapore and the four crisis countries. Moreover, within a particular banking system, there was little variation in asset growth rates, even though there was variation in the estimated value of the government guarantee and variation in bank outcomes from the crisis.[33]

4. Conclusions

This paper estimates the value of implicit government guarantees by modeling them as a put option and shows that these estimates can serve as an early warning indicator for regulators by identifying weak banks and banking systems. By estimating the value of the implicit

[32] The implicit subsidy from the government's guarantee of bank deposits could accrue to depositors, borrowers, or shareholders.
[33] For asset growth rates on a bank-by-bank basis, see Kaplan (2000).

government guarantee before the 1997 crisis, I am able to separate the crisis (Thailand, Malaysia, Indonesia, and Korea) from non-crisis (Singapore) countries. I find that the estimated implicit subsidy is large, averaging over 8 percent of deposits in the crisis countries and 3 percent in Singapore. Moreover, all banks received a subsidy in the form of implicit deposit guarantees, given that the majority of banks did not pay premiums in return for implicit depositor protection. Moreover, this approach can provide an estimate of the government's total contingent liability to the banking system. Ranking countries by their total contingent liability to their banking system, Indonesia would have been expected to experience the worst crisis, followed by Thailand, and then Malaysia and Korea. These estimates of the severity of the crisis match the ex post indicators of the severity of the crisis in terms of recapitalization costs and peak levels of non-performing loans. In some countries, the estimated value of the implicit government guarantee also identified those banks that later required government assistance following the crisis. In contrast, balance sheet indicators are unable to identify weak banks and banking systems in Southeast Asia.

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Appendix

Table A.1: Estimated Implicit Government Guarantee for Indonesian Banks

BANKS	*1993*	*1994*	*1995*	*1996*
Bank Tiara Asia		53.9	35.6	13.4
		(2.5)	(2.2)	(1.2)
Bank PDFCI	18.6	31.9	53.2	20.5
	(1.4)	(1.9)	(2.3)	(1.5)
Bk. International	12.1	30.7	19.6	22.5
	(1.3)	(1.9)	(1.5)	(1.7)
Inter Pacific Bank	17.9	22.0	28.0	14.3
	(2.0)	(1.7)	(1.8)	(1.1)
Bk. Pan Indonesia	17.9	23.9	19.1	13.3
	(1.6)	(1.8)	(1.4)	(1.1)
Lippobank	7.7	18.0	23.3	19.3
	(0.8)	(1.3)	(1.5)	(1.4)
Bk. Danamon Ind.		22.9	9.3	16.6
		(1.5)	(0.8)	(1.2)
Bank Bali	8.9	12.6	29.5	11.4
	(1.0)	(1.2)	(1.8)	(0.9)
Bank Niaga	20.5	10.6	7.7	15.6
	(1.5)	(0.9)	(0.6)	(1.2)
Bank Nisp				9.3
				(0.8)
Average	13.0	21.8	17.5	17.5

Estimates of implicit government guarantee as a percent of deposits use the procedure from section 2. A complete set of the results can be found in Kaplan (2000). The standard errors of the estimated parameters are in parentheses. The banks are ranked by the averaged estimated value of the government guarantee. The banks nationalized by the government are listed in bold. The banks recapitalized by the government are in italics.

Table A.2: Estimated Implicit Government Guarantee for Malaysian Banks

BANKS	*1993*	*1994*	*1995*	*1996*
United Merchant Group		40.3	36.9	8.4
		(4.0)	(2.2)	(0.9)
Pacific Bank	17.4	33.0	11.2	34.5
	(1.4)	(2.0)	(1.1)	(2.3)
Ban Hin Lee Bank	10.6	33.9	59.3	13.6
	(1.1)	(2.1)	(2.3)	(1.3)
Hock Hua Bank			10.8	23.8
			(1.0)	(1.7)
AMMB Holdings	6.8	45.6	20.5	19.8
	(0.8)	(2.6)	(1.8)	(1.7)
RHB Capital	8.8	28.2	20.7	9.0
	(1.0)	(2.0)	(1.7)	(1.0)
Affin Holdings		21.6	12.0	13.6
		(1.7)	(1.2)	(1.2)
Commerce-Asset Holdings	11.8	23.9	12.3	6.9
	(1.1)	(1.7)	(1.1)	(0.8)
Southern Bank	11.1	15.4	5.5	14.2
	(1.1)	(1.3)	(0.6)	(1.3)
Hong Leong Bank			11.8	7.2
			(1.4)	(0.8)
Arab-Malaysia Finance		24.2	14.2	7.0
		(1.8)	(1.2)	(0.8)
Malayan Banking	6.5	26.0	10.9	5.8
	(0.7)	(1.9)	(1.1)	(0.7)
Public Finance	7.0	14.4	7.1	8.5
	(0.7)	(1.1)	(0.7)	(0.8)
BIMB Holdings	7.1	37.6	7.0	2.8
	(0.6)	(2.2)	(0.8)	(0.4)
Public Bank	10.5	21.4	7.6	3.4
	(1.0)	(1.5)	(0.7)	(0.4)
Average	8.6	26.7	12.9	9.3

Estimates of implicit government guarantee as a percent of deposits use the procedure from section 2. A complete set of the results can be found in Kaplan (2000). The standard errors of the estimated parameters are in parentheses. The banks are ranked by the averaged estimated value of the government guarantee. The institutions listed in bold either received support or were part of a financial group that received support from the government in 1998.

Table A.3: Estimated Implicit Government Guarantee for Korean Banks

BANKS	*1991*	*1992*	*1993*	*1994*	*1995*	*1996*
Cheju Bank	19.5	25.9	15.3	21.3	17.3	15.3
	(1.6)	(1.9)	(1.4)	(1.6)	(1.3)	(1.1)
Kangwon Bank	18.0	19.2	12.7	15.5	11.3	11.5
	(1.4)	(1.4)	(1.1)	(1.2)	(0.9)	(0.8)
Hana Bank	28.6	22.8	9.0	14.0	5.8	5.1
	(2.2)	(1.7)	(0.8)	(1.1)	(0.5)	(0.4)
Chongbuk Bank	18.5	18.6	14.2	9.5	8.9	9.0
	(1.5)	(1.4)	(1.1)	(0.8)	(0.7)	(0.7)
Shinhan Bank	16.3	17.4	7.4	16.4	11.3	8.9
	(1.4)	(1.4)	(0.7)	(1.3)	(1.0)	(0.7)
Koram Bank	12.0	14.6	7.8	14.6	10.4	15.6
	(1.0)	(1.2)	(0.7)	(1.1)	(0.8)	(1.1)
Kwangju Bank	16.5	16.6	11.7	6.3	11.3	8.9
	(1.3)	(1.3)	(1.0)	(0.6)	(0.8)	(0.6)
Korea First Bank	11.2	13.3	7.8	11.2	8.1	6.2
	(0.9)	(1.0)	(0.7)	(0.9)	(0.6)	(0.5)
Kookmin Bank				17.1	5.6	3.8
				(2.3)	(0.5)	(0.3)
Cho Hung Bank	11.5	11.1	6.3	10.6	7.3	5.1
	(0.9)	(0.9)	(0.6)	(0.9)	(0.6)	(0.4)
Daegu Bank	11.6	12.4	8.5	7.0	6.5	5.6
	(0.9)	(0.9)	(0.7)	(0.6)	(0.5)	(0.4)
Kyong Nam Bank	11.3	12.2	8.4	6.8	6.8	5.5
	(0.9)	(0.9)	(0.7)	(0.5)	(0.5)	(0.4)
Seoul Bank	11.3	11.1	8.1	9.2	5.7	5.3
	(0.9)	(0.9)	(0.7)	(0.8)	(0.5)	(0.4)
Pusan Bank	9.9	11.2	7.3	1.7	7.5	7.6
	(0.8)	(0.9)	(0.6)	(2.3)	(0.6)	(0.6)
Hanvit Bank	10.1	9.5	5.5	7.9	5.1	5.9
	(0.8)	(0.8)	(0.5)	(0.7)	(0.5)	(0.5)
Korea Exchange Bk.				5.9	7.4	7.4
				(0.6)	(0.6)	(0.6)
Housing & Coml.						3.9
Bank.						(0.4)
Average	12.0	12.6	7.5	10.7	7.2	6.0

Estimates of implicit government guarantee as a percent of deposits use the procedure from section 2. A complete set of the results can be found in Kaplan (2000). The standard errors of the estimated parameters are in parentheses. The banks are ranked by the averaged estimated value of the government guarantee. The banks nationalized by the government are listed in bold.

Table A.4: Estimated Implicit Government Guarantee for Thai Banks

BANKS	*1992*	*1993*	*1994*	*1995*	*1996*
Bank of Asia	17.2	16.0	21.5	20.9	16.3
	(1.8)	(1.6)	(1.4)	(1.0)	(1.4)
Union Bank of Bangkok	34.7	13.8	19.4	8.8	(16.8)
	(1.9)	(1.2)	(1.4)	(1.1)	(1.3)
First Bangkok City Bank	22.8	16.7	16.4	14.6	18.2
	(1.4)	(1.3)	(1.0)	(1.0)	(2.0)
Nakornthon Bank	13.5	21.1	21.7	13.3	15.6
	(3.1)	(5.1)	(1.0)	(1.1)	(1.2)
Laem Thong Bank	19.3	10.5	16.9	16.8	16.0
	(1.3)	(1.2)	(1.4)	(1.2)	(1.2)
Krung Thai Bank	9.7	9.0	10.6	8.4	27.2
	(0.7)	(0.9)	(1.0)	(1.2)	(1.0)
Siam Commercial Bank	13.5	11.2	14.5	8.3	16.6
	(1.3)	(1.3)	(0.9)	(0.9)	(0.9)
Thai Military Bank	15.8	12.4	13.6	10.4	13.0
	(1.6)	(1.0)	(0.9)	(1.0)	(0.8)
Siam City Bank	17.6	10.4	10.2	8.5	17.1
	(1.1)	(1.0)	(0.8)	(0.8)	(1.0)
Thai Danu Bank	7.1	10.3	9.1	11.8	17.6
	(0.7)	(0.8)	(0.7)	(1.2)	(1.1)
Bank of Ayudhya	11.8	11.7	8.6	6.7	19.6
	(1.2)	(0.7)	(1.0)	(0.6)	(1.0)
Bangkok Bank	10.5	8.8	15.0	5.7	9.1
	(1.2)	(1.1)	(0.8)	(0.7)	(1.2)
Thai Farmers Bank	10.0	10.4	10.4	4.7	11.3
	(1.1)	(1.1)	(0.7)	(0.6)	(1.3)
Average	12.5	10.7	12.9	8.0	15.9

Estimates of implicit government guarantee as a percent of deposits use the procedure from section 2. A complete set of the results can be found in Kaplan (2000). The standard errors of the estimated parameters are in parentheses. The banks are ranked by the averaged estimated value of the government guarantee. The banks nationalized by the government are listed in bold. The banks bought by foreign banks are underlined and the banks recapitalized by the government are in italics.

Table A.5: Estimated Implicit Government Guarantee for Singaporean Banks

BANKS	*1992*	*1993*	*1994*	*1995*	*1996*
Development Bk. of Singapore	2.8	2.7	3.6	1.7	1.6
	(0.4)	(0.4)	(0.5)	(0.2)	(0.2)
Keppel Bk. of Singapore		4.2	3.7	1.9	5.3
		(0.8)	(0.5)	(0.3)	(0.7)
Overseas Chinese Bkg.		4.5	7.3	3.1	1.2
		(0.6)	(0.8)	(0.4)	(0.2)
Overseas Union Bk.	5.9	2.8	6.7	2.6	1.5
	(0.6)	(0.4)	(0.7)	(0.4)	(0.2)
United Overseas Bk.		1.8	5.9	2.8	1.1
		(0.3)	(0.7)	(0.4)	(0.2)
Average	(0.3)	(0.7)	(0.4)	(0.2)	(0.8)

Estimates of implicit government guarantee as a percent of deposits use the procedure from section 2. A complete set of the results can be found in Kaplan (2000). The standard errors of the estimated parameters are in parentheses.