A DECADE OF AUSTRALIAN BANKING RISK: EVIDENCE FROM SHARE PRICES

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ABSTRACT

The stability of the banking sector has long been a matter of concern for public policy. The likelihood of bank failure depends on two factors: (i) the variability of bank income (which primarily reflects the variability of the rate of return on bank assets), and (ii) the capacity of a bank to absorb losses in the short run (which depends on bank capital). Accounting measures of the volatility of the rate of return on bank assets and bank capital ratios may not reflect the appropriate economic concepts. In this paper, we use share price data to calculate the economic values of Australian bank asset volatilities, capital ratios and the potential public sector liability which might arise as a result of claims by depositors of a failed bank. The public sector liability is found to be extremely small. We find that the estimated capital ratio for the Australian banking sector has risen over the past decade, while there has been no noticeable increase in the riskiness of banks. A preliminary investigation of the relation between asset volatility and bank capital is conducted which suggests that riskier banks do tend to maintain higher capital ratios, and that there is a positive relation between the two variables across time.

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1. INTRODUCTION

Problems in the banking sector traditionally have been a concern of public policy. Part of this concern arises from the likely macro economic effects of banking sector contractions and the consequences of sudden and unanticipated withdrawals of bank credit (see for example Bernanke (1983)). An additional source of the concern is potential public sector (and taxpayer) liability which may be thought to arise from the deposit protection provisions of the Banking Act, or in some cases the direct guarantees of the Commonwealth and state governments.[1] Because of these depositor protection provision requirements, severe losses by financial institutions may lead to calls for direct expenditures by the public sector, or at the very least increase the probability, and therefore the expected value, of such expenditures.

Both the macro economic effects and the public sector budget effects are greatest in cases in which a bank "fails" in the economic sense, that is when the present value of the bank's assets fall short of the present value of its liabilities, thereby exhausting the bank's own economic capital. In such cases an institution must close, or must receive assistance if it is to continue operating. The likelihood of this type of failure depends on the probability that the bank will suffer seriously damaging losses. This probability in turn depends on two factors: (i) the variability of bank income, and (ii) the capacity of the bank to absorb losses in the short run.

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[1] The Commonwealth Government does not formally guarantee bank deposits. Rather the Banking Act places a duty on the Reserve Bank to exercise its powers and functions for the protection of depositors of banks authorised under the Act (with the exception of foreign bank branches). The Act contains a number of specific provisions to protect the position of depositors. In particular, where a bank is likely to become unable to meet its obligations, the Act confers power on the Reserve Bank to investigate the bank's affairs and assume control of the bank for the benefit of its depositors. The Act also provides that the assets of the bank in Australia shall be available to meet its deposit liabilities in Australia in priority to all its other liabilities. This protection applies regardless of the amount of the deposit.

The first factor, the variability of bank income, primarily reflects the variability of the rate of return on bank assets, referred to as the "volatility" of the bank's asset portfolio. Volatility can be quantified by the statistical standard deviation of percentage changes in the value of bank assets. A bank with higher asset volatility is more likely to fail for any given capital ratio. The second factor, the bank's ability to withstand potential losses, depends on the its net worth or equity capital. For a given level of asset volatility, the probability that a bank will fail varies inversely with its capital.[2] Capitalisation is expressed most conveniently and most commonly in terms of the capital ratio (the ratio of capital to total assets), with a higher capital ratio implying lower risk, all else equal.

Estimates of asset volatilities and capital ratios can be computed from figures reported under standard accounting conventions. However, these figures may not correspond to the relevant economic concepts. Economic capital ratios are based on the economic values of assets and liabilities, reflecting discounted future flows of economic earnings. Similarly, the relevant volatilities are the volatilities of the actual economic returns on the assets; these returns may be very different from the observable accounting returns on the book value of assets. This problem often is resolved in financial economics by using market values as proxies for economic values, but most bank assets and liabilities do not trade regularly in markets.

One piece of market-based information is observable for many Australian banks: the value of shareholder equity. In an efficient share market, the total market value of a bank's equity shares reflects the present value of total assets net of total liabilities, although if the share market is less than perfectly efficient the reflection may be imperfect as well. A model that correctly specifies the relationship between equity and asset values can be used to infer the latter from the former. In addition, the volatility of equity reflects the unobservable volatility of the underlying assets, again suggesting the possibility of inferring one from the other.

In this paper, we calculate Australian bank asset volatilities and capital ratios from share price data, for the period January 1983 to March 1992. The connections between share prices and the value of bank assets are developed more formally in the next section, and the conceptual foundation of the computational methods is

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[2] In this formulation, capital is the difference between the economic values of assets and liabilities, exclusive of the benefits of any real or perceived guarantee of deposits.

discussed in Section 3. Section 4 describes the data, addresses some issues relating to the values of key parameters, and discusses details of the estimation. Section 5 contains the key results, and Section 6 concludes.

2. CONTINGENT CLAIM MODEL OF A BANK

An important consideration in using bank share prices as a source of information on underlying asset values is the fact that market participants may believe bank deposits have the benefit of a government guarantee. The nature of the government backing is most obvious in countries with explicit deposit insurance or deposit guarantee structures, such as the United States, United Kingdom, Japan and Germany. This is not the case in Australia. The Commonwealth Bank and the State Banks are guaranteed by the Commonwealth and appropriate State governments respectively. However, for Australian private banks any deposit "guarantee" is implicit only in the depositor protection provisions of the Banking Act. The central bank does not guarantee bank deposits. However, in interpreting bank share prices, what matters are market *perceptions* regarding the safety of deposits, not legal differences between the Australian system and more explicit deposit insurance frameworks. Market participants almost certainly believe that depositors would be protected from financial loss, whether as a result of preemptive action by the supervisor, or by compensation payments. As in virtually all countries, the ultimate perceived guarantor probably is the central government. Indeed, theoretical models that imply a stabilising role for deposit guarantees (for example, Diamond and Dybvig (1983)) imply that guarantees must come from a central government with general taxation authority to be sufficiently credible.

The fact that banks are perceived to be supported by the central bank enables banks to pay a rate of interest on deposits that is approximately equal to the risk-free rate, since depositors bear no risk of default.[3] The consequent savings in interest expenses, or reduction in the cost of funds, produces additional real value for banks and constitutes a “shadow asset” whose value will be recognised by the market and

[3] Of course, the deposits are not actually riskless, because the real return on nominal deposits can fluctuate unexpectedly. However, short-term Commonwealth Government securities typically are regarded as approximately risk-free; guaranteed bank deposits are risk-free in the same sense and in roughly the same degree.

incorporated into share prices. This value is added to whatever value comes from ordinary banking assets net of liabilities. The effect on share prices and share volatility of the market-perceived guarantee must be filtered out to make share price information useful for policy purposes.

But the value of the depositor protection powers of the central bank is not merely a nuisance in using market information; it is of considerable interest itself. Note that any financial claim must have two sides: if the depositor protection constitutes a valuable asset for the bank, it must be a liability for some other party, and that other party is the body the market perceives to be the deposit guarantor. Many countries recognise this liability explicitly as a contingent liability of a deposit insurance fund. Kane and Kaufman (1992) note that in Australia "an implicit 'completing' and taxpayer-financed fund of contingent reserves may be said to exist whether or not a non zero explicit client-institution-supported deposit-insurance scheme also exists" (page 25). The size of this "completing" fund is a legitimate concern of public policy. As Kane and Kaufman further note, "The credit enhancements that this completing fund creates ... may be characterized as implicit deposit insurance." Hence many of the tools originally developed for analysis of explicit deposit insurance are applicable to the Australian case as well.

Merton (1974) applied contingent-claim techniques to the general problem of valuing the debt and equity of levered firms; in Merton (1977), the same techniques were applied specifically to banks with guaranteed deposits. Following Merton's initial theoretical work, Marcus and Shaked (1984) implemented a similar model using US bank holding company data to derive empirical estimates of bank capital, asset volatility, and the size of the US deposit insurance liability. In these models, banks have ordinary banking assets with market value A_T, and total liabilities maturing with B_T dollars due at date T. Banks are monitored for solvency by banking supervisory authorities at discrete intervals. We take the present date to be t=0, and the next monitoring date to be t=T, at which time the bank is closed if assets do not equal or exceed liabilities. These assumptions imply a value of equity E_T at date T:

$$E_T = \begin{cases} A_T - B_T & if \;\; A_T \geq B_T \\ 0 & if \;\; A_T < B_T \end{cases} \tag{1}$$

At any time prior to T, the total market value of a bank's equity is equal to the discounted value of this payoff structure. Equity in the model is a contingent claim (a positive payoff to equity is contingent upon the bank being solvent at T), and its discounted value at any earlier point in time can be calculated using the same valuation techniques used in pricing other contingent claims, such as options.

Levonian (1991a) modified this contingent-claim model of banks to incorporate positive bank "charter" value.[4] For Australian banks, the parallel concept might be termed "licence" value. We model licence value as a fraction ϕ of liabilities, and as being received by bank equity holders at date T only if the bank is not closed by its supervisors.[5] Licence value is taken to be net licence value, that is, the value of a banking licence net of costs, such as the below market rates earned on non-callable deposits which must be held with the Reserve Bank.

The licence value allows banks to make use of special privilege accorded to financial institutions called "banks", which have real or perceived advantages, as sources of both credit and payments services, for which customers are willing to pay a premium (evidence supporting the uniqueness of banks is presented in Bernanke (1983)). This premium is over and above the benefit received by a bank from the "guarantee" of its deposits.[6] Because the supply of licences is limited, the positive value conferred by a licence is not necessarily competed away. The freeing of entry restrictions into the Australian market since 1985 may have reduced the licence value. However, remaining regulatory constraints, the fixed costs incurred in

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4 The model presented by Levonian (1991a) is a generalisation of Merton's and two others, Marcus (1984) and Ronn and Verma (1986). The differences between the various models are summarised by Levonian.

5 The main motivation for assuming that licence value is proportional to liabilities is technical modelling convenience. It seems likely that the value is positively related to bank size. If the value were related to assets in the model rather than liabilities, then the licence value would be stochastic since assets are stochastic. This would introduce an additional element of random fluctuation into the value of shares, which would complicate the theoretical development without substantially adding to the analysis. Moreover, the assumption also is appropriate to the extent that the value of the licence reflects the opportunity to use deposits as a low cost source of funds.

6 We use the term guarantee throughout the paper for simplicity and because of its use in overseas literature. As noted previously, there is no formal guarantee of deposits with privately owned banks in Australia.

establishing a new bank and the switching costs customers must pay to move from one bank to another institution ensure that some positive licence value remains.

Levonian also allowed for a degree of flexibility in the regulatory closure threshold. In Merton (1977), banks are closed if they are insolvent at date T. However, in reality regulators have some discretion regarding closure, and the regulatory closure threshold need not be the point of actual insolvency. Banks may be closed when net worth is positive, or may be allowed to continue operating with negative net worth. Levonian showed that if supervisors follow a rule of closing banks when their capital ratios are less than c, then the value of shareholders' equity at the monitoring date T is:

$$E_T = \begin{cases} A_T - B_T + f\,B_T & if \quad k_T \geq c \\ 0 & if \quad k_T < c \end{cases} \tag{2}$$

where c is not necessarily equal to zero, and the capital ratio is defined as:

$$k_T \equiv \frac{A_T - B_T}{A_T} \tag{3}$$

(A minor difference between this model and (1) is that the closure rule is stated in terms of the capital ratio rather than in terms of the relationship between assets and liabilities. Note that if c=0, then k<c implies A<B.) As (2) indicates, banks remaining open at date T experience a lump-sum increase in value from the rents conferred by a banking licence, where ϕB_T is the value of those rents.[7]

As in most applications of contingent-claim methods, assets are assumed to follow a stochastic process given by:

$$d_A = m_A A(t)dt + s_A A(t)dz \tag{4}$$

where μ_A is the expected instantaneous periodic rate of return on assets, *t* is a time index, dz is the differential of a Wiener process, and σ_A is the instantaneous standard deviation of the rate of return on assets, or asset volatility. Let the date t=0

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[7] In a multiperiod setting, ϕB would reflect the discounted value of the future stream of rents as well.

represent the present, and let unsubscripted variables denote present values. Using standard methods for valuing contingent claims (see Smith (1976)), the present value of equity with date T payoff as given in (2) is:

$$E = A\,N(x) - B\,N\left(x - s_A\sqrt{T}\right) + fB\,N\left(x - s_A\sqrt{T}\right) \tag{5}$$

where

$$x \equiv \frac{In\left(\frac{(1-c)A}{B}\right) + \frac{s_A^2 T}{2}}{s_A\sqrt{T}} \tag{6}$$

and N( ) is the cumulative standard normal distribution function. Equity is essentially a call option on assets, plus an additional lump sum equal to the expected present value of the licence. The first two terms in (5) represent the standard option value; the third term is the present value of the licence ϕB weighted by a factor that is closely related to the probability that the bank will remain open.[8]

Cordell and King (1992) point out that (5) and (6) must be modified for banks that pay cash dividends to shareholders. Dividends reduce assets and hence reduce the value of the contingent claim, but also transfer value directly to shareholders in the amount of the dividend. If annual dividends are paid at the rate γ at date t=T, Cordell and King show that (5) and (6) should be rewritten:

$$E \equiv (1-g)A\,N(x) - B\,N\left(x - s_A\sqrt{T}\right) = f\,B\,N\left(x - s_A\sqrt{T}\right) + g\,A \tag{5'}$$

$$x \equiv \frac{In\left(\frac{(1-c)(1-g)A}{B}\right) + \frac{s_A^2 T}{2}}{s_A\sqrt{T}} \tag{6'}$$

(Note that γ is the rate of dividend payments relative to assets, not equity.)

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8 The factor $N(x - \sigma_A\sqrt{T})$ is actually the probability that the bank would remain open in a world of risk-neutral investors, that is a world in which the assets of the bank earn the risk-free rate of return.

With this theoretical framework for reference, the central issue of this paper can be posed more explicitly. Both k and σ_A are measures of banking risk. A type of risk that might be called “financial risk” has increased if the market value capital ratio k defined in (3) has decreased. Risk that might be called “operating risk” has increased if the volatility of bank assets σ_A has increased.[9]

However, it is entirely possible that changes in financial risk and operating risk might conflict in sign, if k and σ_A both increase or both decrease. A third and more comprehensive measure of risk that can be used to remove any ambiguity is the value of the deposit guarantee, which we will denote V. The deposit guarantee liability is a contingent claim, and can be calculated explicitly, again using standard contingent-claim valuation methods, once values for A and σ_A have been obtained. Overall banking risk has increased if the size of this contingent liability borne by the public sector has increased. This measure of risk incorporates both of the first two types of risk, so that the net impact of changes in risk can always be assessed from changes in V. The separate measures of financial risk and operating risk remain useful, providing an indication of the source of any changes in banking risk. We turn now to a more rigorous expression of the value of the depositor protection liability.

For ease of exposition we assume that the market expects virtually all creditors of the banks in our sample (described below) to be protected from losses in the event of a failure;[10] hence, we model the contingent liability under the assumption that the claim covered by the deposit guarantee is B, even though not all liabilities are deposits.[11] If deposits were guaranteed, the payout under the guarantee may take the form of direct restitution to depositors. Alternatively, a purchaser may be

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9 The volatility of bank liabilities does not enter the model because we assume for simplicity that liabilities are riskless. Interest rates on liabilities may fluctuate, but if rates move because the liabilities are repriced frequently, then the present value of the liabilities is roughly constant, and the risk is minimal. Emprically, any risk arising from bank liabilities should be reflected in share price volatility and hence in our measured asset volatility.

10 While the Banking Act is concerned only with Australian depositors, if the general practice were to support a failing bank, transfer its entire operations to another institution, or assist a merger, then all depositors, both foreign and domestic, would effectively be covered.

11 Note that although this assumption may overstate the true magnitude of the liability, it will not affect the analysis of changes in banking risk, which is the main focus of this paper, provided the degree of overstatement does not change significantly during the sample period.

located for the failed institution; the acquirer receives the assets and the licence of the failed bank, and assumes all of the liabilities. If the liabilities assumed exceed the combined value of the assets and the licence, the deposit guarantor makes up the difference. Thus, the deposit guarantor pays the acquirer B - (ϕB + A) = (1 - ϕ)B - A if that difference is positive, and otherwise pays nothing.

Whether the deposit guarantee obligation is discharged through a direct payment to depositors or through an assisted acquisition, the payout by the guarantor is:

$$V_T = \begin{cases} (1-f)B_T - A_T & \text{if} \quad B_T > A_T + fB_T \\ 0 & \text{if} \quad B_T \leq A_T + fB_T \end{cases} \tag{7}$$

Again using standard contingent-claim valuation techniques, the value of the contingent payout in (7) is:

$$V_T = (1-f)B\,N\left(y + s_A\sqrt{T}\right) - (1-g)AN(y) \tag{8}$$

where

$$y = \frac{In\left(\dfrac{(1-f)B}{(1-g)A}\right) - \dfrac{s_A^2 T}{2}}{s_A\sqrt{T}} \tag{9}$$

The value of this contingent liability borne by the deposit guarantor is a comprehensive measure of banking risk.

3. COMPUTING ASSET VALUES AND ASSET VOLATILITY

Assuming that the value of bank equity is determined as in (5') above, it is possible to work backward from the share prices of publicly traded banks to infer the market value of assets and asset volatility. Given values for bank liabilities B, the regulatory monitoring interval T, the capital ratio closure threshold c, and the licence value ratio ϕ, the two remaining unknowns in (5') are the value of assets A and the volatility of assets σ_A. Obviously, a single equation cannot be solved for two unknowns; a second independent equation is needed.

Marcus and Shaked (1984) suggest applying Itô's Lemma to the expression for the value of equity, to yield a second equation relating to volatility of equity and the volatility of assets. They follow Merton (1974) in deriving the relationship:

$$\sigma_E = \sigma_A \frac{\partial E}{\partial A}\frac{A}{E} \tag{10}$$

In the present case, differentiation of (5') yields:

$$\frac{\partial E}{\partial A} = (1-\gamma)\,N(x) + \frac{\theta B N'\left(x - \sigma_A\sqrt{T}\right)}{A\sigma_A\sqrt{T}} + \gamma \tag{11}$$

where N'( ) is the standard normal density function, and $\theta = 1/(1-c) - (1-\phi)$. Using (11), the expression in (10) can be rewritten as:

$$\sigma_E = \frac{(1-\gamma)AN(x)\sigma_A\sqrt{T} + \theta BN'\left(x-\sigma_A\sqrt{T}\right) + \gamma A\sigma_A\sqrt{T}}{E\sqrt{T}} \tag{12}$$

Equation (12) depends on all of the same variables as equation (5'). If σ_E is observable, then under identical assumptions regarding the parameters of the model, this equation also has A and σ_A as the only unknowns, and (5') and (12) can be solved simultaneously for values of the two unknown variables.

4. DATA, ASSUMPTIONS AND METHODS

4.1 Data

Our sample is comprised of eleven banks that were listed on the Australian Stock Exchange between January 1983 and March 1992. This includes the three major private banks and, from September 1991, the Commonwealth Bank. The banks included in our sample account for about 55 percent (80 percent following the inclusion of the Commonwealth Bank) of all deposits repayable in Australia. This group of banks does not, however, include the state banks which have been most troubled in recent times. The remainder of the banks omitted from our sample are primarily wholly owned subsidiaries of foreign banks. For more details see the Data Appendix.

4.2 The Value of a Banking Licence

The value of a banking licence is likely to be seen in non market interest rate spreads. On the liability side a bank licence may enable banks to set a rate on their liabilities which is less than the rate on government securities. Similarly, on the asset side, the licence may allow banks to earn a rate of return on bank loans in excess of the rate required on the open market for securities of comparable risk. Using an alternative formulation of the contingent claim model presented in equation (5), Levonian (1991b) demonstrates that the licence value can be approximated by

$$f \approx \frac{D}{1-k} + \left(r_f - r_d\right) \tag{13}$$

where Δ is the loan spread - the rate of return on loans held by the bank minus the required rate of return for assets with the same level of risk, r_f is the rate on government securities, r_d is the average cost of banks' liabilities, and k denotes the capital ratio.

The spread r_f - r_d was proxied by the difference between the rate on 26-week Treasury Notes and a measure of banks' weighted average cost of funds (see the Data Appendix). Investigation of a number of loan spreads leads us to postulate that Δ is about 0.015 to 0.02 on average. Combining the interest spreads with values of k between 2 and 12 percent produces estimates of ϕ in the range of 0.05 and 0.06. Since substantial approximation error is likely these estimates should be taken only as a rough guide of the licence value ratio. Although not strictly comparable, this is somewhat higher than the range of licence value ratios calculated for US banks by Levonian (1991b).

While the model assumes that the licence value is constant over time, it may be expected that the process of deregulation, in particular the entry of new banks into the Australian market, would have eroded bank licence values in the face of increased competition. Consistent with this the cost of funds spread exhibits a negative trend. However, it has been observed that the spread between the loan rate and other rates has increased over the past few years[12] (such spreads do not include risk premia, which make interpretation of these spreads as a reflection of licence value difficult). These trends in interest rates coincided with a downward trend in operating costs which may have stemmed the erosion of banks' licence value in the face of deregulation. Thus it is likely that in total licence value has not exhibited any significant trend during the 1980s.

Given the differences in size, geographical location and business strategies across the banks in our sample it is likely that there are, in fact, interbank differences in ϕ. However, it is not possible to measure ϕ for each individual bank with the data available. Hence the licence value ratio is assumed to be identical across all banks in the sample.

4.3 The Closure Threshold

Solutions for the system of equations could not be obtained for some banks at closure thresholds above -0.02. This suggests that closure thresholds greater than -0.02 are not consistent with the data; that is, stock market participants regard bank closure as being extremely unlikely at any positive level of capital or even at small negative values of capital. This suggests that c = -0.02 should be considered a maximum value for the assumed closure threshold.

Levonian (1991a and 1991b) argues that a lower bound on c exists, related to the licence value ratio. Levonian notes that the value E_T realised by shareholders in (2) can never be negative, since they can always exercise their right as corporate owners with limited liability to walk away from a losing proposition. Thus it must be true that banks are closed at capital ratios above the level at which the licence value would be completely offset by negative net worth; that is, at the closure point $k=c$, it must also be true that $A-B+\phi B \geq 0$. Rewriting this restriction using the definition of the capital ratio, the closure threshold must satisfy $c \geq -\phi/(1-\phi)$. If the closure threshold were set lower, banking supervisors or the deposit guarantor would be forced to inject funds to induce banks with $c < k < -\phi/(1-\phi)$ not to close voluntarily. The injection would have to be large enough to bring the capital ratio back up to the minimum level of $-\phi/(1-\phi)$.

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[12] See, for instance, Reserve Bank of Australia (1992).

Licence values in the range of 0.05 to 0.06 imply a minimum closure threshold of about -0.06. Consistent with this, analysis of the final annual report of the State Bank of Victoria gives a capital-asset ratio of about -0.06 when considering the State Bank group as a whole (0.02 for the State Bank alone) in the absence of government assistance.

4.4 Estimation

In the light of the previous discussion of the licence value and closure threshold four cases are considered:

	Early Closure	Late Closure
Licence Value Relatively Low	Case 1 $c = -0.02$, $\phi = 0.05$	Case 2 $c = -0.05$, $\phi = 0.05$
Licence Value Relatively High	Case 3 $c = -0.05$, $\phi = 0.06$	Case 4 $c = -0.06$, $\phi = 0.06$

In case 1 the banking licence value is low, and a bank is closed when it is insolvent as judged by market value, that is, when the market value of the bank's assets falls below the book value of its liabilities, but the value of the banking licence has not been exhausted. In case 2 the banking licence value is also low, and banks are closed when their licence value has been exhausted, that is, when the market value of the bank's assets falls below liabilities by an amount equal to the value of the banking licence. The banking licence value is relatively high, and banks are closed before their licence value has been exhausted in case 3. Finally, for case 4 the banking licence value is high, and banks are closed when their licence value has been exhausted.

In each of these cases the monitoring interval is set equal to one year.[13] The market value of bank liabilities is assumed to be equal to book value. Actual dividends

[13] It is possible that regulators might systematically vary the monitoring interval and closure threshold according to the condition of each bank. The maximum closure threshold at which solutions could be obtained varied across time and between banks, suggesting that this is in fact the case. Variation of the monitoring interval between three months and one year made no noticeable difference to the results. The weighted average of asset volatility increases a little as the monitoring time increases, as does the market capital - asset ratio.

paid by each bank semi-annually are used to compute the dividend rate, hence it is assumed that market participants perfectly forecast future dividends.[14] The standard deviation of rates of return on equity is estimated from share prices over the past 52 days, using daily data.

The system of equations was solved using the GAUSS 1.49B procedure for solving non-linear equations. The algorithm employed is a modification of Broyden's secant method (Edlefsen and Jones (1986), Dennis and Schnabel (1983)), which combines Broyden's method with Newton's method, Newton's method being used when Broyden's approximation does not move towards the system's solutions.

5. RESULTS

The effect of the share market crash in October 1987 dominates the results and swamps all other movements in our derived series.[15] This effect was also observed in work done with US data (Levonian (1991b) and Schellhorn and Spellman (1991)). The graphical results are presented omitting the last six months of 1987 so that other variation may be discerned. Although the contingent claim model assumes that the stock market is always efficient, there are grounds for considering the crash to be an anomalous event that should be excluded from the analysis.

5.1 Capital

Looking first at the banking sector as a whole, weighted averages are constructed to combine the individual bank results at each time period, with each bank weighted by its share of the total market value of assets in the sample. Graph 1, presents the weighted average market capital ratio for each case. The estimated capital ratio rose from below zero in early 1983 to a peak of about 2.5 percent in late 1988. The capital ratio declined a little until early 1991 and, since then, recovered to about two percent as of March 1992.

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[14] Special dividends, such as those paid out at the time of the introduction of dividend imputation, are excluded when calculating the dividend rate.

[15] During the last six months of 1987 the capital-asset ratio fluctuated between -3.4 and 1.1 percent and asset volatility reached a peak of about five percent.

Because of the use of the weighted average, the secular pattern of the capital-asset ratio is most heavily influenced by the three largest banks in the sample. Individual bank results vary considerably, with some banks' capital-asset ratio rising greatly over the 1980s, and others remaining static or falling slightly.

The market capital-asset series varies considerably over time. To determine the source of this variation the change in the market capital asset-ratio was decomposed into movements attributable to changes in equity, licence value and the contingent deposit guarantee liability, each relative to assets.[16] The results showed that movements in the market capital-asset ratio were dominated by fluctuations in the ratio of shareholder equity to assets, with about 95 percent of movement in the capital ratio attributable to movements in market equity. Changes in the ratio of aggregate market equity to assets was then broken up into components attributable to changes in the number of shares on issue, changes in the share price and changes in aggregate bank assets. This decomposition showed that most of the movement in the equity to asset ratio was due to movements in share prices, reflecting market revaluation of banks' capital, rather than active changes in bank capital through share issuance.

However, a number of banks, including the three major private banks, have made some large capital raisings, particularly in the latter half of the decade. Some of the increase in bank capital may have been brought about by various regulatory requirements introduced through the 1980s. Prior to the adoption of the BIS risk-based capital adequacy requirements in 1988 established banks were required to hold capital equal to at least 6.5 percent of total assets, while new entrants, such as building societies converting to bank status and foreign banks taking up a banking licence in Australia, were required to observe a higher capital-asset ratio. In practice, new entrants tended to hold capital well above the required minimum. Hence, the entry of newer banks into our sample may account for some of the increase in the weighted average market capital-asset ratio since 1985. Moreover, while most banks were well placed to comply with the BIS risk-based standards, the introduction of those standards may have led some banks to issue more equity. It is

[16] Equity is equal to the number of shares on issue multiplied by the share price, whereas capital (the numerator of the capital-asset ratio) is the difference between the market value of assets and book liabilities.

likely that some portion of the measured variation in capital ratios is due to these regulatory changes.

5.2 Asset Volatility

Graph 2, shows the weighted average asset volatility across all banks in our sample. Asset volatility displays a slight upward trend over the 1980s. This may simply reflect the entry of new, smaller, banks into our sample. The most noticeable feature of our results is the large upward spike in implied asset volatility in mid-to-late 1988. This may be associated with the tightening of monetary policy (as reflected in increasing short term interest rates, such as the official cash rate) which began about April 1988. Less pronounced increases in asset volatility beginning in late 1983 and early 1984 also coincide with increased short term rates. In comparison with results found for the US (see, for example, Levonian (1991b)), Australian banks do not appear to be noticeably more risky than US banks.

Again, the pattern of asset volatility is greatly influenced by the three largest banks in the sample. The patterns for individual banks differ to some degree. However, in no case is there a significant increase in bank riskiness over the sample period.

While we are concerned with measuring absolute risk rather than systematic risk, the finding that the variance of bank assets has not increased over the 1980s is consistent with the results of Harper and Scheit (1991). Harper and Scheit use the Capital Asset Pricing Model to assess changes in the stock market's perceptions of the riskiness of banks, relative to the total share market, over the 1980s. They find that banks' systematic risk has not increased since deregulation. This is in contrast to the widespread perception that banks have become riskier since deregulation, as evidenced by increases in banks' provisions for bad and doubtful debts as a percentage of assets (see, for instance, Ackland and Harper (1990)).

One reason for our finding might be that deregulation has enabled banks to limit risk by holding more diverse portfolios. For instance, banks' holdings of foreign currency assets and liabilities more than doubled as a proportion of total Australian dollar assets and liabilities between 1984 and 1992. It may also be that risk management techniques have become more sophisticated, or that banks are taking increasing advantage of newly developed hedging instruments.

5.3 The Deposit Guarantee Liability

Annual averages of the sum, across banks, of the liability that would arise in the event that the public sector undertook to guarantee deposits are presented in Table 1. As noted above, calculation of the insurer's contingent liability assumes that all liabilities, not just deposits, are insured. Apart from a couple of large values associated with the share market crash and the sharp escalation of asset volatility in 1988 the public sector liability is negligible, particularly in comparison to results obtained for the US (Levonian (1991b)). This is probably partly a reflection of the fact that banking licence value is considerably higher in Australia than in the US. Movements in asset volatility appear to be offset by increases in bank capital, so that the deposit insurance liability is, in effect, covered by shareholders' capital.

5.4 Varying c and f

Comparing the results for the four cases enables investigation of the sensitivity to changes in the assumed values of c and ϕ. Graphs 1 and 2 show that altering the closure threshold and the licence value makes little difference to the pattern of movements in asset volatility and market capital-asset ratios over time, although the level of the two measures is affected to some degree. Variations in the assumed closure threshold (comparing case 1 with case 2, and case 3 with case 4) had essentially no impact on estimated capital-asset ratios. Increasing the licence value from five to six percent causes a discrete drop in the market capital-asset ratio of about one percent. This is to be expected as the capital ratio is defined exclusive of the licence value. Since a higher licence value should make bank stock more valuable, all else equal, a given market value of equity can only be consistent with a lower market value of assets, and hence, a lower market value of bank capital. Given that varying ϕ, in particular, does affect the results noticeably, a degree of caution is warranted when interpreting the results.

Raising the licence value from five to six percent increased asset volatility slightly. Lowering the closure threshold from -0.02 to -0.05 causes estimated asset volatility to be a little higher.

Table 1 demonstrates that earlier assumed closure (that is, higher closure thresholds) reduces the contingent liability, although this effect varies somewhat according to the licence value. Increasing the licence value also reduces the public sector liability. This result follows from the assumption that a bank's licence value is used to offset, to some degree, the payout to depositors following the bank's failure. In both case 2 and case 4, the closure threshold is such that the bank is only closed when the licence value is completely exhausted by the bank's losses. With this late closure assumption higher licence values reduce risk to the insurer, but only by a very small amount. The sensitivity of the contingent liability to assumptions about c and ϕ make it inappropriate to attach much weight to the specific dollar amounts of the liability. However, the pattern over time is roughly similar across the four cases.

5.5 Correlation Between Risk and Capital

Regulatory guidelines phased in from August 1988 explicitly require banks to raise more capital as they move into riskier areas of activity. Graph 3 shows a scatter plot of the annual averages of asset volatility against the market capital-asset ratio for each bank and each year using the estimates derived under case 3. (Three outlying observations have been omitted for clarity.) It can be seen that, with the exception of 1987 which includes the effect of the share market crash, there is an overall positive relation between the two variables. To investigate the relation between risk and capital we regress the capital-asset ratio on asset volatility using cross section and time series data separately. Since estimation is by way of ordinary least squares, the results are only a measure of simple, contemporaneous correlation. Research in progress by the authors conducts more informative tests of the relationship between risk and capital, pooling the data across banks and across time and using vector autoregression estimation to determine the causal relation between the two variables, rather than simply considering contemporaneous correlation.

Table 2 presents the results of regressing the capital-asset ratio against estimated asset volatility for each year using a cross section of annual averages of individual bank results. Apart from 1987, 1989 and 1991 all estimates of the coefficient on the market capital-asset ratio are significantly positive, implying that at any given point in time banks with riskier assets tend to maintain higher capital ratios. The 1987 share crash was an exception in that increased variation in equity values, and hence measured asset volatility, was associated with a large fall in market value. Measured capital fell as a result of the rapid fall in banks' share prices, at the same time that asset volatility rose, reversing the positive relationship found for other dates.

Table 3 shows time series regressions for each bank. Here the nature of the relation between asset volatility and bank capital is less clear. In four cases out of eleven the relation is significantly positive, while in another four cases the coefficient is found to be strongly negative. However, inspection of the data reveals that the instances of negative and insignificant results are largely the result of the high asset volatility combined with low (or even negative in some cases) market capital levels during late 1987. Thus it does appear that, for each bank, an increase in the riskiness of the bank's assets generally is associated with an increase in the bank's capital.

6. CONCLUSION

This paper has presented a contingent claim model of a bank which allows us to use share price data to derive estimates of the variability of the rate of return on bank assets, the economic value of bank capital and the contingent liability that might be thought to be associated with the deposit protection conditions of the Banking Act.

Apart from the isolated incident of the 1987 share market crash, the deposit protection liability was found to be negligible during the sample period. The riskiness of banks, as measured by the volatility of the rate of return on assets, was not found to have increased significantly over the past ten years. Banks' market capital-asset ratios have risen during this time.

Investigation of the correlation between asset volatility and the capital-asset ratio across time and across banks suggests that increases in the riskiness of banks' assets are accompanied by increases in bank capital. We intend to investigate this issue further by testing the nature of the causal relation between these two variables using a vector autoregressive framework.

The ambit of this work could be extended by looking at the riskiness of building societies. Although only one building society, the Co-operative Building Society, has been listed on the Australian Stock Exchange for any length of time, shares in a number of societies are traded through the building societies themselves or through select brokers.

Table 1: Total Contingent Payout Annual Averages ($ Million)

Year	Case 1	Case 2	Case 3	Case 4
1983	0.10	0.60	0.49	0.59
1984	0.11	1.20	0.94	1.19
1985	1.00	2.40	2.04	2.38
1986	0.44	1.62	1.37	1.60
1987	722.99	900.51	862.14	895.26
1988	30.94	50.04	46.51	49.75
1989	2.48	3.19	3.06	3.17
1990	0.24	0.59	0.53	0.59
1991	1.24	3.36	2.80	3.33
1992	0.07	0.20	0.18	0.19

Table 2: Regressions across Banks using Annual Averages of Asset Volatility and Market Capital Asset-Ratios. Regression: $s_A = a + bk + e$.

Year	b	Standard Error of b
1983	0.112*	0.006
1984	0.228*	0.019
1985	0.562*	0.065
1986	0.371*	0.008
1987	-0.157	0.226
1988	0.373*	0.097
1989	0.388	0.184
1990	0.173*	0.067
1991	0.152	0.070
1992	0.366*	0.066

* Significantly different from zero at the five percent level.

Table 3: Regressions across Time for Each Bank.
Regression: $s_A = a + bk + e$.

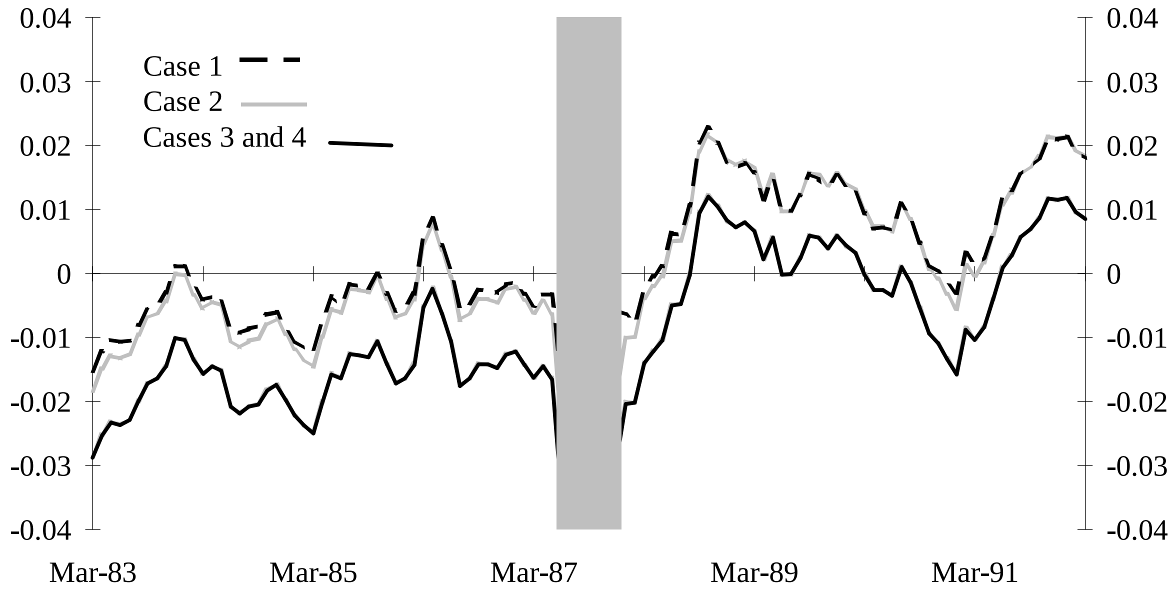
Bank	b	Standard Error of b
ADV	-0.968*	0.103
ANZ	-0.619*	0.103
BOM	0.59*	0.083
BOQ	-0.001	0.078
BOS	0.243*	0.068
CHL	-0.827*	0.022
COM	0.526	0.502
MET	0.052	0.129
NAB	0.152*	0.039
SCB	-0.352*	0.107
WPC	0.427*	0.081

* Significantly different from zero at the five percent level.

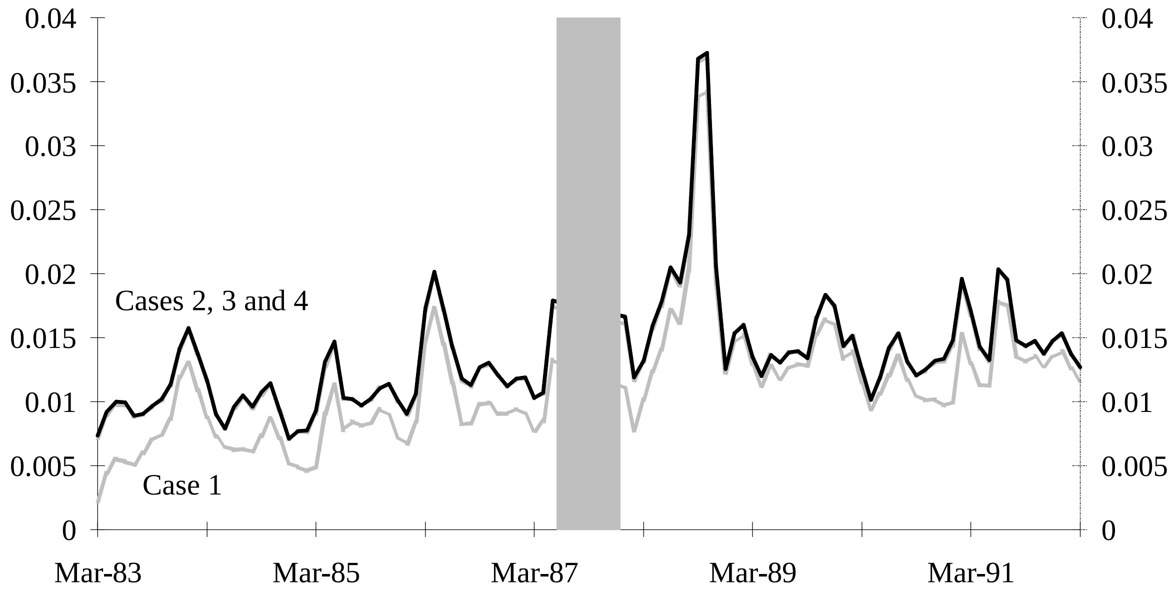
Key:

ADV - Advance Bank
ANZ - ANZ Banking Group
BOM - Bank of Melbourne
BOQ - Bank of Queensland
BOS - Bank of Singapore
COM - Commonwealth Bank of Australia
CHL - Challenge Bank
MET - Metway Bank
NAB - National Australia Bank
SCB - Standard Chartered Bank
WPC - Westpac Banking Corporation

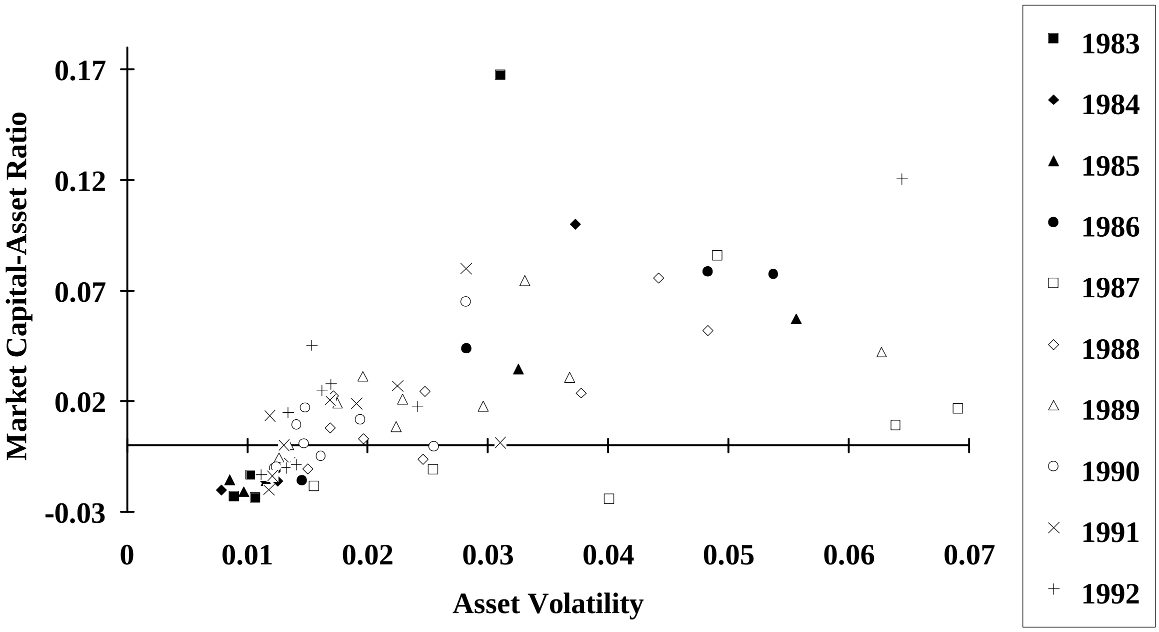
Graph 1: Weighted Average Market Capital-Asset Ratio



Graph 2: Weighted Average Asset Volatility



Graph 3: Annual Averages of Asset Volatility and Market Capital-Asset Ratios



DATA APPENDIX

Interest Rates

Bank Accepted Bills 180 Days - RBA Bulletin, Table F.1.

Treasury Notes 26 Weeks - RBA Bulletin, Table F.1.

Loan Rate - Overdrafts $100 000 and over, maximum rate, RBA Bulletin, Table F.3.

Weighted Cost of Funds - Calculated using RBA Bulletin data and internal RBA data. See Lowe and Rohling (1992).

Equity Share Data

Share Prices - Australian Stock Exchange.

Number of Shares - Series for each bank constructed using infromation from banks' Annual Reports, Australian Stock Exchange Company Files, Jobson's Year Book of Public Companies and the Australian Financial Review. Partly paid shares are included in the total number of shares weighted according to the proportion paid up.

Dividends - Banks' Annual Reports and banks' reports of interim results.

Standard Deviation of Equity - Daily rates of return were calculated from each day's closing share prices. An estimate of the standard deviation was computed for the Wednesday of each week from the proceeding 52 days of returns. Monthly averages of weekly estimates were used for σ_E.

Bank Financial Data

Total Assets - Data from reporting forms submitted by each bank to the Reserve Bank.

The data reported to the Reserve Bank by each bank includes only assets and liabilities within Australia. ANZ, Commonwealth Bank, National Australia Bank and Westpac each hold a significant proportion of their assets and liabilities outside of Australia. Data on foreign assets as a proportion of total assets are contained in the banks' annual and interim reports. The asset data reported to the Reserve Bank were scaled up by those proportions, with linear interpolation used to calculate the proportions between reporting dates.

Total Liabilities - For those banks with Preference Shares (Advance, ANZ, Metway and Westpac) or Redeemable Mortgagor Shares (Advance) on issue these were added to the reported value of total liabilities. Total liabilities were obtained from reporting forms submitted by each bank to the Reserve Bank. Preference Shares and Redeemable Mortgagor Shares were obtained from banks' annual reports and Australian Stock Exchange Company Files. As with total assets, data from annual and interim reports were used to adjust the reported liability figures for foreign liabilities.

Banking Groups

As several banking groups consisted of both a trading bank and a savings bank, these groups have been consolidated together. Subsidiary banks have been added to their parent. Hence the banking groups (and the period for which data were available) are:

Advance (ADV) Sept 85 - March 92	Advance Bank Australia Civic Advance Bank (to July 1990) Canberra Advance Bank (from August 1990)
ANZ March 83 - March 92	Australia and New Zealand Banking Group Australia and New Zealand Savings Bank National Mutual Royal Savings Bank (from April 1990) Town and Country Bank (from October 1991)
Bank of Melbourne (BOM) Oct 89 - March 92	Bank of Melbourne
Bank of Queensland (BOQ) March 83 - March 92	Bank of Queensland Bank of Queensland Savings Bank
Bank of Singapore (BOS) Nov 86 - April 89	Bank of Singapore (Australia)
Commonwealth Bank (COM) Dec 91 - March 92	Commonwealth Bank of Australia Commonwealth Savings Bank Australian Bank Commonwealth Development Bank State Bank of Victoria
Challenge Bank (CHL) July 87 - March 92	Challenge Bank

Metway Bank (MET) Sept 88 - March 92	Metway Bank
National Australia Bank (NAB) March 83 - March 92	National Australia Bank National Australia Savings Bank Australian Resources Development Bank (from October 1989)
Standard Chartered Bank (SCB) June 86 - April 91	Standard Chartered Bank Australia
Westpac (WPC) March 83 - March 92	Westpac Banking Corporation Westpac Savings Bank

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