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CONTENTS

IMPROVED METHODS OF TREATING CRITICAL ISSUES IN REGULATING AND SUPERVISING BANK SAFETY AND SOUNDNESS

P. A. V. B. Swamy, Thomas J. Lutton and
Philip F. Bartholomew

ABSTRACT

This paper provides a basic reference to the development of the safety and soundness of banks as a concept, the utility of stochastic coefficient estimation as a means to measure risks, and to the development of capital adequacy evaluation and portfolio selection procedures that permit regulators and banks to estimate the key ratios of equity to assets and return on assets before interest and taxes to the interest rate on liabilities on a full market value accounting basis.

I. INTRODUCTION

Banks were managing risk before there were modern risk management tools and such well developed disciplines as statistics, economics, finance, and computers. Technological changes, computers, and recent refinements in statistics and finance set the stage for a more explicit study and quantification of risk. The measurement of risk requires probability distributions of future returns on financial assets because risk is uncertainty about those returns. From

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the perspective of individual banks, the potential loss or risk is borne by their owners or stockholders. From the regulators' view the potential loss may be viewed from many additional perspectives including uninsured creditors, the Bank Insurance Fund (BIF), industries, tax payers, and the local community.

This paper is written from the perspective of regulator, one who monitors bank activities, balance sheets, and income statements. While often relying on imperfect information and limited data, bank regulators must determine when a bank, as a whole, appears to be taking excessive risks. Regulators and their examiners have often had to rely on recent and past developments and trends in the condition and performance of banks to impute the "riskiness" of banks. Since 1982, regulatory agencies have used CAMEL ratings as measures of the financial condition of banks after examination.[1] Examiners use their judgment, often based on peer group analyses, recent rates of return on book value equity capital, or rates of return on assets, and other measures of performance including non-performing loans, and loan growth ratios to classify banks. Unfortunately, reliance on book values often muddles views of risks. Risks after all are potential future losses associated with current and past decisions and book values are poor indicators of future losses.

We have developed a quantitative approach to assessing the safety and soundness of banks without relying on book values. We believe that this approach is theoretically sound and yet practical.

The remainder of this paper is divided into ten sections and two appendices. Section 2 develops the concept of whole bank return based on the ratio of the true value of net income to the correct value of equity. Section 3 formulates the conditions under which deposit insurance could be completely eliminated without increasing default risk to bank depositors. Section 4 uses an exact nonlinear equation between whole bank return and its determinants to estimate market values of capital-to-assets ratios and the ratio of return on assets before interest and taxes to the interest rate on liabilities. Section 5 explains how leverage ratios and fiscal and monetary policies affect the performance of banking institutions and how problem banks can be identified using the correct value of the ratio of return on assets to the interest rate on liabilities. Section 6 utilizes the relationship between return on equity and its determinants and its time differences to construct new measures of two types of whole bank risk and their components. One of these components provides a measure of interest-rate risk. Comparisons of this measure with the measures of interest-rate risk adopted by the federal banking agencies and the previous studies are given in Appendix A to the paper. There is another measure known as "Value at Risk" given in the finance literature. It is used to measure market risk which represents the uncertainty of future earnings resulting from changes in variables, such as prices of assets, interest rates, etc. A comparison of our measure of interest-rate risk with Value at Risk is given in Appendix B to the paper. Section 6 also shows how the unknown correct values of whole bank risks and their components can be estimated from the relevant book values and how these risks can be used to identify potential problem banks. Section 7 establishes connections among the safety and soundness of banks, whole bank risks, equity-to-assets ratios, and capital adequacy. If the risks inherent in bank assets can be estimated, then the level of capital that is required to absorb these risks can be determined. An extended version of the capital asset pricing model is used in Section 8 to make such measurements. Section 9 explains how banks can use the estimates of the extended version to simultaneously maximize their portfolio return and minimize their portfolio risk by finding optimal proportions of an active portfolio of mispriced assets and a passive (or the market index) portfolio. Section 10 discusses further applications of the extended version, while Section 11 concludes.

II. WHOLE BANK RETURN – THE BASIS OF WHOLE BANK RISK

According to a definition given in the finance literature, risk is uncertainty about future rates of return on financial assets. To quantify that uncertainty, we need to know the probability distributions of returns that hold in the future. But those distributions are usually unknown. We can only estimate them by using past data and use the estimated distributions to quantify uncertainty about future returns. Such a procedure does not yield accurate results unless the estimated distributions have close connections with the real-world sources of uncertainty we are trying to quantify. These sources are many, which is why the nature of risk varies depending on the source of the underlying uncertainty.[2] Our aim is to find a measure that captures the effects of all sources of uncertainty to which each bank is exposed. We call such a measure whole bank risk. This measure should, of course, be consistent with the measures of the individual types of risk facing each bank. Usually, the individual types of risk will have some sources of uncertainty in common and as a result, their measures will be correlated with one another. For this reason, we cannot sum the values of individual types of risk and obtain a meaningful measure of the overall risk. Moreover, it is not possible to list all the sources of uncertainty each bank faces. Another difficulty is that all banks may not be affected by the same sources of uncertainty. To resolve these difficulties, we will first develop the measures of whole bank risk and then decompose them into individual types of risk in a consistent manner.

The ratio of a bank's net income to its equity is known as the rate of return on equity (ROE).[3] This ratio is not useful if its numerator and denominator are measured with error. Only when these measurement errors are not present, we call ROE 'whole bank return.' We indicate below how the true values of ROE should be viewed. From the finance notion of risk it follows that whole bank risk may be viewed as uncertainty about future values of whole bank return.

A. Incorrect Measurements

One valuation of net income and equity adopted in the reports of condition and income (Call Reports) is given by the following two equations:

$$\begin{aligned}\text{Net income} = {} & \text{Interest income} - \text{Interest expense} + \text{Noninterest income}\\ & - \text{Noninterest expense} - \text{Loan loss provision}\\ & + \text{Net securities gains} + \text{Extraordinary income after taxes}\\ & - \text{Total income taxes} \qquad (1)\end{aligned}$$

$$\text{Equity}_b = \text{Assets}_b - \text{Liabilities}_b \qquad (2)$$

where all the variables vary over time, the time subscript is suppressed for convenience, and b indexes book values. The data set we have on the variables in Eqs (1) and (2) consists of observations on a large number of individual banks for all quarters in the period 1984 to present.

Are Eqs (1) and (2) suitable to measure whole bank return? Our answer is: 'no.' The reasons are: (i) the variables in Eq. (1) cover both on- and off-balance sheet items, but those in Eq. (2) cover only on-balance sheet assets and liabilities, and (ii) even those on-balance sheet items the latter equation covers are valued in book value terms at historical prices that do not reflect current market prices. Consequently, Eq. (2) is seriously deficient. However, contingent assets and liabilities are off-balance sheet items and their approximate market values can be calculated by using the method given in Saunders (2000, pp. 262–264). The definitions of Assets_b and Liabilities_b may improve if the approximate market values of contingent assets and liabilities are added to Assets_b and Liabilities_b, respectively. Quite possibly, the variables in Eq. (1) are also measured with error. However, compared to the variables in Eq. (2) they may be more accurately measured.

B. Limitations of the Option Pricing Models of Equity

To rectify the deficiencies of Eq. (2), we consider market value accounting without ignoring off-balance sheet items. Such an accounting is considered for the most common case where the liability of shareholders is limited to their investment in a bank's stock. That is, if the market value of a bank's assets gets below that of its liabilities, then its shareholders have the option of defaulting on their debt repayment and turning any remaining assets of the bank over to the debtholders. There are both benefits and costs redounding to shareholders as a result of the shield of limited liability. The benefit is measured by the value of the option open to shareholders to 'put' the assets of their bank to creditors at a price which is equal to the face value of the bank's obligations. The cost is measured by the premium that fully informed creditors require for accepting the risk entailed by this option. Accordingly, the value of equity including the net benefit of limited liability may be expressed as

$$A_{t+j} - Le^{-r_f(s-j)} = c_{t+j} - p_{t+j} \quad (j = 0, 1, \ldots, s) \tag{3}$$

where t indexes time; A_t (or L_t) denotes the bank's on- and off-balance sheet assets (or liabilities) that are valued in market value terms at current prices on a market-to-market basis; for convenience in this discussion, we assume that all the liabilities are zero-coupon debt and come due at the same time, $t+s$; t or $t+0$ is the current period; s is the time period to expiration; $L_{t+s} = L$ is the zero-coupon equivalent of liabilities (or a contract amount of obligations) due at $t+s$; that is, interest and principal due on the liabilities at $t+s$ will be L; r_f is the risk free rate on debt of equivalent maturity; c_{t+j} with $j<s$ is the value before expiration of a European call option on the assets of the bank with an exercise price equal to L; the value of c_{t+j} at expiration is $c_{t+s} = \max(0, A_{t+s} - L)$; p_{t+j} with $j<s$ is the value before expiration of a European put option on the assets of the bank with an exercise price equal to L; and the value of p_{t+j} at expiration is $p_{t+s} = \max(0, L - A_{t+s})$. The models for c_{t+j} and p_{t+j} with $j<s$ can be derived under certain assumptions (see Bodie, Kane & Marcus, 1993, pp. 681, 689).

Option pricing models of default risk write Eq. (3) as $c_{t+j} = A_{t+j} - L_{t+j}$ with $L_{t+j} = Le^{-r_s(s-j)} = Le^{-r_f(s-j)} - p_{t+j}$, where r_s is the yield-to-maturity on the risky debt L. Imbedded in Eq. (3) is the restriction that $A_{t+j} - Le^{-r_s(s-j)}$ is non-negative because c_{t+j} is non-negative. Therefore, this equation cannot be used if equity is negative.

The positions of the shareholders and the creditors can be viewed either in terms of calls or in terms of puts. These two viewpoints can be related in terms of the put-call-parity relationship given by Eq. (3); for a complete treatment of these viewpoints, see Ross, Westerfield and Jaffe (1996, Chap. 21). Kopcke (1995, p. 41) has shown that c_{t+j} is the value of the bank's equity with limited liability and p_{t+j} is the expected value of creditors' potential losses due to a collapse of the value of the bank's assets, provided that all banks operate within competitive financial markets wherein investors have homogeneous opinions in the sense that they all assess the potential returns on all assets much the same. This value of creditors' potential losses equals the premium creditors would require for accepting the shareholders' put option if there were no deposit insurance. The following results are due to Merton: (i) the market value at time t of the risky liabilities made by creditors to the bank is $Le^{-r_s s} = A_t - c_t$; (ii) $r_s - r_f = -\frac{1}{s}\log\left(\frac{A_t - c_t}{L}\right) - r_f$ is an equilibrium default risk premium that the bank should be charged; and (iii) creditors should adjust the required risk premium as the bank's leverage ratio ($Le^{-r_f s}/A_t$) and asset risk change (see Saunders, 2000, pp. 237, 415).

The difference $A_t - L_t$ is called the market value net worth of the bank, which can be negative. Unlike Eq. (2), $A_t - L_t$ takes account of the bank's value as a going concern. In an efficient capital market, a positive price for the stock of a bank means that the bank's net worth is positive and is equal to the market value of its shares outstanding.[4]. If markets are not efficient and r_s is not constant, then $A_t - Le^{-r_s s}$ may not be equal to $A_t - L_t$. The formula $-\frac{1}{s}\log\left(\frac{A_t - c_t}{L}\right) - r_f$ does not yield accurate estimates of the risk premium if $A_t - Le^{-r_s s}$ is not equal to the bank's market value net worth at time t.

III. THE IMPOSSIBILITY OF ACCURATELY PRICING AND THE CONSEQUENCES OF MISPRICING LIMITED LIABILITY

When the liabilities of banks are insured by an agency like the Federal Deposit Insurance Corporation (FDIC), creditors' expected losses (p_{t+j}) become the insurance agency's expected losses. A proper premium for this liability insurance equals the expected value of the insurer's potential losses due to the insolvency of insured banks. Although insurance rates for depository institutions nominally vary with their supervisors' rating of their risks, the actual premiums are set according to rules that could be inconsistent with each institution's expected losses (see Spong, 1994, pp. 117–118). If a deposit insurer charges a bank the premiums that are less than the expected losses of the bank's creditors, then the bank owners would earn a rent which increases the value of their equity (see Kopcke, 1995, p. 44). Part of the limited liability that is voluntarily absorbed by uninsured creditors other than the deposit insurers is not added to Eq. (3) because these creditors are paid by shareholders through higher interest rates.

If it is possible for regulators to enforce the rule that the market value of capital held by every bank is always above zero and if the markets for financial instruments are always liquid, then every bank will have adequate capital to repay all of its obligations at any time in future. Under these conditions, the owners of any bank will have no incentive to exercise their put option, the FDIC's losses will be at a minimum, and the BIF maintained by the FDIC will be well protected. There is no need for the BIF to exist in this case.

The above conditions under which the BIF can be abolished without increasing default risk to bank depositors cannot be enforced because A_t and L_t in Eq. (3) are not observable. Without knowing the market values of both on- and off-balance sheet assets and liabilities, it is not possible to guarantee that the market value of every bank's capital is always positive.

To predict the deposit insurer's losses, one should accurately forecast the probability that $A_{t+s} - L_{t+s} > 0$. Such forecasting is difficult because the true distribution of $A_{t+s} - L_{t+s}$ is unknown. This distribution cannot be directly estimated from past data, since the market values of nontraded assets and liabilities other than their book values are not observable in any period. This situation is further complicated by the fact that the market values of contingent assets and liabilities are unknown. The expected value of the insurer's potential losses cannot be accurately determined, knowing only the distribution that is derived from the past book values of on-balance sheet assets and liabilities under dubious assumptions.[5]

From the above discussion we can conclude that there are no accurate data to directly determine the proper premium for liability insurance without making what could be inappropriate assumptions. In subsequent sections of this paper, we show what can be done with the available data. This work is based on a generalized errors-in-variables model that is more appropriate than the option pricing models of default risk in the presence of measurement errors.

IV. ESTIMATION OF MARKET VALUES FROM A MODEL OF WHOLE BANK RETURN

Let us now replace A_t and L_t by more suggestive symbols like Assets_c and Liabilities_c, respectively, where c indexes true or correct values. The definitions of these correct values follow from the definitions of A_t and L_t which are given below Eq. (3). The correct value of equity, Equity_c, is equal to the difference between Assets_c and Liabilities_c. We consider the ratio of the true value of net income (i.e. net income measured without error) to Equity_c as a measure of whole bank return. We denote this ratio and its numerator by ROE_c and

Net income$_c$, respectively. ROE$_c$ is related to return on assets (ROA) which has more than one definition. ROA can be defined either narrowly as $\text{R1OA}_c = \frac{\text{Net income}_c}{\text{Assets}_c}$ or broadly as $\text{R2OA}_c = \frac{\text{EBIT}_c}{\text{Assets}_c}$, where EBIT$_c$(= Net income$_c$ + Interest expense$_c$ + Total income taxes$_c$) denotes earnings before interest and taxes. The relationship between ROE$_c$ and R2OA$_c$ can be written as

$$\text{ROE}_c = (1 - \text{Tax rate}_c)[\text{IOL}_c + (\text{R2OA}_c - \text{IOL}_c)\text{LR}_c], \tag{4}$$

where

$$\text{Tax rate}_c = \frac{\text{Total income taxes}_c}{\text{Net income}_c + \text{Total income taxes}_c},\ \text{IOL}_c = \frac{\text{Interest expense}_c}{\text{Liabilities}_c},$$

and

$$\text{LR}_c = \frac{\text{Assets}_c}{\text{Equity}_c}.$$

The last ratio here is a measure of the bank's degree of financial leverage and is called the leverage ratio in Bodie, Kane and Marcus (1993, p. 592). Note that it is also the reciprocal of capital-to-assets ratio. The ratio IOL$_c$ measures the cost of funds. Replacing the correct values in Eq. (4) by the corresponding book or observed values gives an equation that is derived in Bodie, Kane and Marcus (1993, pp. 590–593).

Equation (4) can be estimated by writing each of the variables which appear in the numerator and denominator of its ratios as a difference between the corresponding observed value and measurement error. To do so, we need the following notation:

$$\begin{aligned}\text{Assets}_b &= \text{Assets}_c + \epsilon_a,\ \text{Liabilities}_b = \text{Liabilities}_c + \epsilon_l,\ \text{Equity}_b \\ &= \text{Equity}_c + \epsilon_a - \epsilon_l,\ \text{Net income} = \text{Net income}_c + \epsilon_{ni},\ \text{Tax rate} \\ &= \text{Tax rate}_c + \epsilon_{tr},\ \text{Interest expense} = \text{Interest expense}_c + \epsilon_{ie},\ \text{EBIT} \\ &= \text{EBIT}_c + \epsilon_{ebit},\end{aligned}$$

where the variables without a subscript and the variables with subscript b are the observables in Eqs (1) and (2) and the ϵs are measurement errors. Inserting these definitions into Eq. (4) gives

$$\frac{\text{Net income} - \epsilon_{ni}}{\text{Equity}_b - \epsilon_a + \epsilon_l} = (1 - \text{Tax rate} + \epsilon_{tr}) \times \left[\frac{\text{Interest expense} - \epsilon_{ie}}{\text{Liabilities}_b - \epsilon_l} + \left(\frac{\text{EBIT} - \epsilon_{ebit}}{\text{Assets}_b - \epsilon_a} - \frac{\text{Interest expense} - \epsilon_{ie}}{\text{Liabilities}_b - \epsilon_l} \right) \times \frac{\text{Assets}_b - \epsilon_a}{\text{Equity}_b - \epsilon_a + \epsilon_l} \right]. \tag{5}$$

Defining $\text{ROE}_b = \frac{\text{Net income}}{\text{Equity}_b}$, $\text{R2OA}_b = \frac{\text{EBIT}}{\text{Assets}_b}$, $\text{LR}_b = \frac{\text{Assets}_b}{\text{Equity}_b}$, and $\text{IOL}_b = \frac{\text{Interest expense}}{\text{Liabilities}_b}$, we can write Eq. (5) as

$$\frac{u_{ni}\text{ROE}_b}{u_{a-1}} = u_{tr}(1 - \text{Tax rate}) \left[\frac{u_{ie}\text{IOL}_b}{u_l} + \left(\frac{u_{ebit}\text{R2OA}_b}{u_a} - \frac{u_{ie}\text{IOL}_b}{u_l} \right) \frac{u_a\text{LR}_b}{u_{a-1}} \right], \tag{6}$$

where

$$u_{ni} = 1 - \frac{\epsilon_{ni}}{\text{Net income}},\ u_{a-1} = 1 - \frac{\epsilon_a - \epsilon_l}{\text{Equity}_b},\ u_a = 1 - \frac{\epsilon_a}{\text{Assets}_b},\ u_{tr} = 1 + \frac{\epsilon_{tr}}{1 - \text{Tax rate}},$$

$$u_{ie} = 1 - \frac{\epsilon_{ie}}{\text{Interest expense}},\ u_{ebit} = 1 - \frac{\epsilon_{ebit}}{\text{EBIT}},\ \text{and } u_l = 1 - \frac{\epsilon_l}{\text{Liabilities}_b}.$$

Simple algebraic manipulations show that Eq. (6) is expressible in the form

$$\frac{\text{ROE}_b}{(1 - \text{Tax rate})\text{IOL}_b} + \log(\text{LR}_b) = \xi_0 + \xi_1 \frac{\text{R2OA}_b \times \text{LR}_b}{\text{IOL}_b} - \xi_2^* \text{LR}_b, \tag{7}$$

where

$$\xi_0 = \frac{u_{ie}u_{a-1}u_{tr}}{u_l u_{ni}},\ \xi_1 = \frac{u_{ebit}u_{tr}}{u_{ni}},\ \xi_2 = \frac{u_{ie}u_a u_{tr}}{u_l u_{ni}},\ \text{and } \xi_2^* = \xi_2 - \frac{\log(\text{LR}_b)}{\text{LR}_b}.$$

Note that these ξs, like the dependent and independent variables of Eq. (7), are time varying.

If the measurements of variables in Eq. (1) do not contain errors, then $u_{ie} = u_{ni} = u_{tr} = u_{ebit} = \xi_1 = 1$, $\xi_0 = \frac{u_{a-1}}{u_l}$, $\xi_2 = \frac{u_a}{u_l}$, and $\xi_2^* = \frac{u_a}{u_l} - \frac{\log(\text{LR}_b)}{\text{LR}_b}$.

The important point to note here is that both the dependent and the independent variables of Eq. (7) are observable. The time-varying coefficients of this equation can be consistently estimated by using the methodology of Swamy and Tavlas (2000) and the algorithm of Chang, Swamy, Hallahan and Tavlas (2000). Also, note that Eq, (4) from which Eq. (7) is rigorously derived, has the correct functional form, has no omitted explanatory variables, and has no exogenous variables. The derivation of Eq. (7) does not ignore any measurement errors that are present, does not introduce meaningless error terms, and does not inappropriately treat a variable as exogenous. We know of no better alternatives to Eq. (7).

Another advantage of Eq. (7) is that it suggests a way to statistically test the condition that the variables in Eq. (1) are accurately measured. We may know that this condition is true in at least one sample period if for all time periods in a sample period, the estimates of ξ_1 are not significantly different from 1 and the unconstrained estimates of ξ_0 and ξ_2^* are not significantly different from their constrained estimates that satisfy the constraint that $\xi_1 = 1$.

It follows from the definitions of ξs that

$$\frac{\text{Equity}_c}{\text{Assets}_c} = \frac{u_{a-1}\text{Equity}_b}{u_a\text{Assets}_b} = \frac{\xi_0\text{Equity}_b}{\xi_2\,\text{Assets}_b}, \tag{8}$$

$$\frac{\text{R2OA}_c}{\text{IOL}_c} = \frac{u_{ebit}u_1\text{R2OA}_b}{u_a u_{ie}\text{IOL}_b} = \frac{\xi_1\text{R2OA}_b}{\xi_2\text{IOL}_b}. \tag{9}$$

Estimates of the ξs when inserted into (8) and (9), give the implied estimates of the correct value of the capital-to-assets ratio and the correct value of the ratio of R2OA to IOL.

V. LEVERAGE AND POLICY EFFECTS ON WHOLE BANK RETURN AND A METHOD OF IDENTIFYING PROBLEM BANKS

A. Leverage Effects

Since banks are highly leveraged institutions, it may be asked: how is whole bank return (ROE_c) of a bank related to its leverage ratio (LR_c)? The answer given by Eq. (4) is that whole bank return increases with financial leverage if R2OA_c exceeds IOL_c and if $1 - \text{Tax rate}_c$ is positive. This implication of Eq. (4) makes sense: if a bank's R2OA_c exceeds IOL_c, then it earns more on its money than it pays out to creditors. By contrast, the book-value version of Eq. (4)