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CAPITAL REQUIREMENTS AND OPTIMAL BANK PORTFOLIOS: A REEXAMINATION

by William P. Osterberg and James B. Thomson

William P. Osterberg and James B. Thomson
are economists at the Federal Reserve Bank
of Cleveland.

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ABSTRACT

Previous studies of the impact of capital requirements on bank portfolio decisions typically assume that the deposit rate paid by banks is not a function of the riskiness of the bank's portfolio. Such studies conclude that stiffer capital requirements decrease portfolio risk but may increase the probability of bankruptcy. These studies have utilized the mean-variance framework (Koehn and Santomero), the state-preference framework (Kareken and Wallace), and the Capital Asset Pricing Model (Lam and Chen).

In this study, we utilize the cash flow version of the Capital Asset Pricing Model to show how the impact of capital requirements depends on the response of deposit rates to bank leverage and portfolio risk. Following Merton (1977), we model the deposit insurance premium as a put option. Allowing deposit rates to vary with risk and leverage mitigates agency problems that appear in previous studies as incentives to increase bank risk and maximizes the value of the deposit-insurance subsidy. We find that the variance of earnings and the incentive to increase leverage are reduced with risk- and leverage-related interest rates. However, the impact of increased capital requirements on portfolio behavior is generally ambiguous.

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I. Introduction

Many studies have analyzed the impacts of bank regulation on bank behavior. Some have argued that federal deposit insurance and capital requirements, which were designed to improve the safety of the banking system, may instead create perverse incentives for bank behavior. Most proposals to redesign the regulatory system consider mechanisms to force banks to "pay" for increased risk. Proposals for either risk-based capital requirements or risk-based deposit insurance have been presented, and there have been both theoretical and empirical analyses of the two systems (see Avery and Belton [1987] and Hanweck [1984]). Increases in capital requirements are another possible regulatory response.

Theoretical analyses of the impact of increased capital requirements typically assume that bank borrowing rates are unaffected by bank risk. The combination of Regulation *Q*, which governs deposit-rate ceilings, and fixed-rate deposit insurance premiums implies that explicit deposit costs are unaffected by bank risk. Fixed-rate deposit insurance premiums, of course, have perverse incentive effects. Not only do low-risk banks subsidize high-risk banks, but the deposit insurance agency also provides a subsidy. Fixed-rate deposit insurance creates incentives for banks to engage in risky behavior to maximize the deposit insurance subsidy.

This view of banks as attempting to maximize the deposit insurance subsidy is discussed by Keeley and Furlong (1987) and Kane (1986). With

fixed-rate deposit insurance, the impact of the subsidy on portfolio behavior is not diminished by an increase in the deposit insurance premium, as would be the case if the insurance agency were to adjust its rates when the bank engaged in more risky behavior.

On the other hand, there is a growing body of literature discussing "correct pricing" of deposit insurance. Initially, Merton (1977) showed how deposit insurance can be viewed as a put option[*], and others (Marcus and Shaked [1984], Osterberg and Thomson [1987], Pennacchi [1987], Pyle [1986], and Ronn and Verma [1986]) have indicated how a correctly priced insurance premium would vary with changes in bank leverage or portfolio variance. In this paper we analyze the impact of increased capital requirements on bank portfolio decisions if deposit costs increase with leverage and portfolio variance.

Analyses of the impact of increased capital requirements that utilize the mean-variance framework (see Koehn and Santomero [1980]) conclude that increased capital requirements will reduce portfolio risk. These studies view banks as utility maximizers. Koehn and Santomero contend that banks will respond to the imposition of higher capital requirements by reshuffling their portfolios. Banks with relatively risky portfolios will tend to shift toward even riskier portfolios, while safe banks will shift in the same direction to a lesser extent. Thus, portfolio reshuffling tends to partially offset the intended effects of the increased capital requirement.

In addition, it is possible that increased capital requirements may increase the probability of bankruptcy. These studies assume that deposit

rates are constant and thus unaffected by bank risk. They also ignore the subsidy provided by the insurer. In effect, the subsidy reduces the net cost of deposits.

While the mean-variance analyses focus on utility-maximizing behavior, other approaches examine value-maximizing behavior. Kareken and Wallace (1978) utilize the state-preference framework. Although they assume that the deposit rate does not increase with bank risk, the presence of fixed-rate deposit insurance creates the incentive to increase leverage. Since the subsidy from the guarantor increases with leverage, the cost of deposits, net of the insurance subsidy, decreases with leverage. In addition, banks may have an incentive to increase asset risk. These results have been used to justify restrictions on asset choice and leverage.

Lam and Chen (1985) utilize a cash flow version of the Capital Asset Pricing Model (CAPM) to analyze the impact of increased capital requirements on bank behavior when Regulation Q is removed. This framework distinguishes between internal risk and external risk. Internal risk is characterized by the variance of asset returns net of interest costs; external risk refers to covariation of net asset returns with the market. Thus, in the absence of Regulation Q, interest costs may covary with asset rates of return as well as with the rate of return on the market portfolio. However, deposit rates do not covary with the total risk of the bank. So, although deposit rates are stochastic, they do not vary in a manner that would necessarily reduce the liability of the deposit insurer. In this case, the effects of tighter capital requirements on internal risk and total bank risk are ambiguous.

II. Agency Problems, Deposit Insurance, and Capital Requirements

Any analysis of the impact of capital requirements must consider the incentives to increase leverage (that is, to lower the capital ratio) facing the banking firm. We contend that incorrectly priced deposit insurance creates an agency problem that is responsible for an incentive for increased leverage. The failure to resolve this agency problem makes capital requirements binding.

The optimal financial structure of banks in the absence of fixed deposit rates or deposit insurance is determined by the same factors that influence the financial structure of nonfinancial entities (see Sealey [1985] for a dissenting view). Conflicts of interest among managers, stockholders, and bondholders (depositors) are the essence of agency problems and are one likely factor in explaining financial structure (see Pyle [1986]). In theory (see Smith and Warner [1979]), financial contracts such as bond covenants can be written so as to resolve such conflicts. Maximizing the value of equity and maximizing the total value of debt and equity then lead to equivalent behavior.

Previous analyses of the impact of capital requirements on bank portfolio behavior do not make explicit the factors that determine bank leverage. In the mean-variance analysis of Koehn and Santomero, deposit costs are fixed, although there is no explicit deposit insurance. In the state-preference analysis of Kareken and Wallace, deposit rates are fixed and some deposits are insured. In the stochastic deposit-rate case of Lam and Chen, there is no deposit insurance. In all of these cases, the capital requirement is assumed to be binding. Excluded from these analyses are discussions of the factors

that give the bank the incentive to increase leverage. We do not propose an agency-theoretic explanation of financial structure in the absence of deposit insurance. However, the literature on agency problems and financial structure gives us some insight into how correctly priced deposit insurance alters the impact of capital requirements on bank behavior.

Given the assumptions of the option-pricing model of Merton (1977), in the absence of Regulation Q and deposit insurance, the rate paid on bank deposits increases with portfolio variance and leverage. In fact, as shown by Thomson (1987), the market-determined risk premium built into deposit rates would be equal to the insurance premium that reduces the value of the FDIC's claim to zero. In an earlier paper (Osterberg and Thomson [1987]) we show that if deposit insurance is priced correctly, the value of the bank is unaffected by the presence of deposit insurance.[1] This premium is the "fair" or correctly priced premium that eliminates the incentive problems created by fixed-rate insurance.

We propose that one likely rationale for the result in earlier analyses that the capital constraint is binding is the implicit assumption of incorrectly priced deposit insurance. If the deposit insurance premium is fixed at any rate, including zero, then the subsidy provided by the insurer to the equity-holders increases with portfolio variance and leverage. If deposit insurance is correctly priced, and in the absence of other factors that would determine financial structure, we can see no reason for the capital constraint to be binding.

III. The Model

Following Lam and Chen, we use the cash flow version of the CAPM to model the banking firm. We modify their model to allow for an endogenously determined cost of deposits., and we make the usual assumptions necessary for the CAPM to hold. In addition, we assume that bankruptcy costs and taxes are zero and that the bank is operated by its owners.[2] The owners seek to maximize the value of bank equity, V, where

$$(1) \quad V = \frac{1}{R}\{E(\tilde{\pi}) - \lambda CV(\tilde{\pi},\tilde{M})\},$$

and R = one plus the risk-free rate;

$\tilde{M}$ = aggregate cash flow of all firms in the market;

$\tilde{\pi}$ = cash profit of the bank;

$CV(\tilde{\pi},\tilde{M})$ = covariance between the cash profit of the bank and the aggregate cash flow of all firms (systematic risk within the CAPM framework);

λ = market price of risk-bearing services.

Suppose that there are N risky assets in which the bank can invest. Let A_j and $\tilde{r}_j$ be the amount invested in asset j and the uncertain return on asset j, respectively. Furthermore, the bank issues only insured deposits, D, and a fixed amount of capital, K. The bank pays its deposit guarantor (henceforth, the FDIC) a premium of g per dollar of deposits. Its expected cash profits at the end of the period are

$$(2)\quad E(\tilde{\pi}) = \sum_{j=1}^{n} \tilde{r}_j A_j - (R+g)D.$$

Following Lam and Chen, we partition $\lambda CV(\tilde{\pi},\tilde{M})$ into internal portfolio risk and external risk by separating the aggregate cash flows $\tilde{M}$ into $\tilde{\pi}$ and $\tilde{W}$, where $\tilde{W}$ is the aggregate cash flows in the market excluding the bank. This allows us to isolate the risk of the asset portfolio (internal risk) from market risk in the maximization problem. Equation (1) can now be expressed as

$$(3)\quad V = \frac{1}{R}\left[E(\tilde{\pi}) - \lambda CV(\tilde{\pi},\tilde{W}) - \lambda CV(\tilde{\pi},\tilde{\pi}\right], \text{ with}$$

$$CV(\tilde{\pi},\tilde{W}) = \sum_{j=1}^{n} A_j \sigma_{j,w},$$

$$CV(\tilde{\pi},\tilde{\pi}) = \sum_{i=1}^{n}\sum_{j=1}^{n} A_i A_j \sigma_{i,j},$$

and $\sigma_{i,j}$ = covariance between rates of return on asset i and j;

$a_{j,w}$ = covariance between rates of return on asset j and cash flows of all other firms.

The deposit insurance premium, g, varies with the bank's leverage and asset portfolio decisions (internal risk). Since the bank knows how its choices influence g, it knows what g results from its asset portfolio and capital structure decisions.

One covenant imposed on the bank by the FDIC in exchange for its deposit guarantees is the minimum ratio of deposits to capital, $C \equiv D/K$.

A second restriction is the balance-sheet constraint that sources of funds must equal uses of funds. Thus, the problem facing the bank is to maximize V with respect to A_j and **D**, subject to

$$(4) \quad \sum_{j=1}^{n} A_j = D + K \quad \text{and}$$

$$(5) \quad D \leq CK \text{ (where } \mathbf{D} = CK \text{ when the capital constraint is binding).}$$

Let **7** and γ_1 be the Lagrangian multipliers associated with (4) and (5), respectively, and let L be the Lagrangian function. The first-order conditions of the constrained maximization problem are:

$$(6) \quad \frac{\partial L}{\partial A_k} = \frac{1}{R}\left[\tilde{r}_k - \frac{\partial g}{\partial A_k}D - \lambda\left(\sigma_{k,w} + 2\sum_{i=1}^{n} A_i\sigma_{i,k}\right)\right] - \gamma = 0 \qquad (k = 1,2,\ldots,n),$$

$$(7) \quad \frac{\partial L}{\partial D} = \frac{1}{R}\left[-R - g - \frac{\partial g}{\partial D}D\right] + \gamma - \gamma_1 = 0,$$

$$(8) \quad \frac{\partial L}{\partial \gamma} = \sum_{j=1}^{n} A_j - D - K = 0,$$

$$(9) \quad \frac{\partial L}{\partial \gamma_1} = D - CK \leq 0,$$

$$(10) \quad \gamma_1 \frac{\partial L}{\partial \gamma_1} = 0.$$

Adding equations (6) and (7) and solving for γ_1 yields

$$(11) \quad \gamma_1 = \frac{1}{R}\left[\tilde{r}_k - \frac{\partial g}{\partial A_k}D - \frac{\partial g}{\partial D}D - \lambda\left(\sigma_{k,w} + 2\sum_{i=1}^{n} A_i\sigma_{i,k}\right)\right] \quad (k = 1,2,\ldots,n).$$

A binding capital constraint (assumed from here on) implies that

$\gamma_1 > 0$, or that equity value could be increased with a looser capital requirement. Expression (6) implies that the marginal expected returns from each risky asset are equal. γ_1 equals risk-adjusted return on assets less the cost of deposits. Changes in leverage and portfolio composition also affect 7,.

We assume that the FDIC views deposit insurance as a put option on the bank. Thus, we utilize Merton's (1977) put option formulation, which indicates how g varies with portfolio variance and leverage. We do not assume, however, that the deposit guarantor correctly prices the insurance so as to drive the net value of the FDIC's claim to zero (see Osterberg and Thomson [1987]). Since the deposit guarantee is not correctly priced, the agency problem is not completely resolved, and the stockholders still have incentives to increase the leverage of the portfolio and the portfolio risk (hence the binding capital constraint). However, we assume that the FDIC does not make relative pricing errors in setting g. That is, we assume that the FDIC can measure risk correctly and that it charges the same premium to all banks with the same risk profile. Moreover, the premium is an increasing function of asset portfolio risk and leverage.

Assuming g is set according to an option-valuation formula allows us to sign $\frac{\partial g}{\partial D}$ and $\frac{\partial g}{\partial A_k}$. Let $\frac{\partial g}{\partial D} = 6 \geq 0$ and $\frac{\partial g}{\partial \sigma^2} = \rho \geq 0$. By the chain rule $\frac{\partial g}{\partial A_k} = \frac{\partial \sigma^2}{\partial A_k} \cdot \frac{\partial g}{\partial \sigma^2}$, and therefore, $\frac{\partial g}{\partial A_k} = 2\rho \sum_{i=1}^{n} A_i \sigma_{i,k} \geq 0$. Substituting CK, 6, and

$2\rho \sum_{i=1}^{n} A_i \sigma_{i,k}$ into equation (11) and rearranging gives us

$$(12) \quad 2[X + \rho CK] \sum_{i=1}^{n} A_i \sigma_{i,k} + R\gamma_1 + CK6 = \bar{r}_k - R - g - \lambda \sigma_{k,w}, \qquad (k = 1,2,\ldots,n).$$

As in Lam and Chen, the right side of equation (12) represents the expected spread associated with investing in asset k adjusted for external risk. Note that the risk-based deposit insurance premium affects portfolio decisions through g's effect on the risk-adjusted spread and through the ρ and 6 terms on the left side of (12).

To derive the optimal portfolio shares, A_k^*, we solve the N + 1 equation system of equations comprised of equations *(4)* and (12) for the N + 1 unknowns (the N asset shares and the multiplier γ_1). Following Lam and Chen, the solution for optimal asset shares from this system of equations is

$$(13) \quad A_k^* = [2(\lambda + \rho CK)]^{-1}\{\sum_{j=1}^{n} v_{k,j}[\bar{r}_j - \lambda \sigma_{I,w}] - \frac{\sum_{j}^{n} v_{k,j}}{\sum_{i=1}^{n}\sum_{j=1}^{n} v_{i,j}} \sum_{i=1}^{n}\sum_{j=1}^{n} v_{i,j}[\bar{r}_j - \lambda \sigma_{j,w}]\}$$

$$+ (1 + C)K \frac{\sum_{j=1}^{n} v_{k,j}}{\sum_{i=1}^{n}\sum_{j=1}^{n} v_{i,j}} \qquad (k = 1,2,\ldots,n),$$

and the solution for γ_1 is

$$(14)\quad \gamma_1 = \frac{[2(\lambda + \rho CK)]^{-1}\sum_{i=1}^{n}\sum_{j=1}^{n} v_{i,j}[\tilde{r}_j - R - g - \lambda\sigma_{j,w} - CK\delta] - (1 + C)K}{[2(\lambda + CK\rho)]^{-1}\sum_{i=1}^{n}\sum_{j=1}^{n} v_{i,j}},$$

where $v_{i,j}$ is the ijth element of the inverse variance-covariance matrix of the asset shares A_j.

Setting $g = g$, $\rho = 0$, and $\delta = 0$ in equations (13) and (14) gives the results for the case of fixed-rate deposit insurance premiums. The fixed-rate equations are identical to Lam and Chen's equations (14) and (15) and are analogous to Koehn and Santomero's risk-free deposit case when $\tilde{g} = 0$. Note that γ_1 is smaller under risk-based deposit insurance than under fixed-rate deposit insurance.[3] In other words, the capital requirement has less impact on portfolio composition for banks paying risk-based premiums' than for banks paying fixed-rate premiums. This is consistent with our hypothesis that with correctly priced deposit insurance (that is, a full resolution of the agency problem), asset portfolio decisions are independent of capital structure decisions.

As in Lam and Chen, the optimal asset share is a function of the expected asset returns adjusted for outside risk weighted by the elements of the inverse of the variance-covariance matrix.[4] By rearranging (13), A_k^* is shown to be a function of γ_1 and the price of risk-bearing, λ. In fact, our fixed-rate deposit insurance result is identical to Lam and Chen's result when Regulation Q prevails.

When variable-rate deposit insurance is introduced into the model, A_k^* is also a function of the insurance-premium risk adjustment, ρ

Through ρ, risk-based deposit insurance reduces the influence of the term in parentheses in expression (13) on A_k^*. More interesting, however, A_k^* is not a function of the deposit insurance premium, g, and the deposit insurance leverage adjustment, 6. This implies that the portfolio decision is independent of the response of the insurance premium to a change in leverage and of the level of the premium.[4] On the other hand, A_k^* is a function of the change in the cost of deposit insurance due to a change in the risk of the bank's portfolio, ρ. This is consistent with our maintained hypothesis that agency problems induced by fixed-rate deposit guarantees are the source of Lam and Chen's and Koehn and Santomero's indeterminate results on the impact of a change in the capital requirement on the probability of default.[5]

IV. The Joint Effects of Risk-Based Deposit Insurance Premiums and Changing Capital Requirements on Portfolio Behavior

The impact of capital requirements on bank portfolio behavior can be seen by looking at their impact on asset portfolio risk, asset portfolio composition, and bank profitability. The change in A_k^* with respect to C is

$$(15)\quad \frac{\partial A_k^*}{\partial C} = \frac{\rho K}{2(\lambda + \rho CK)^2}\left\{-\sum_{j=1}^{n} v_{k,j}[\bar{r}_j - \lambda\sigma_{j,w}] + \frac{\sum_{j=1}^{n} v_{k,j}}{\sum_{i=1}^{n}\sum_{j=1}^{n} v_{i,j}}\sum_{i=1}^{n}\sum_{j=1}^{n} v_{i,j}[\bar{r}_j - \lambda\sigma_{j,w}]\right\}$$

$$+ K\frac{\sum_{j=1}^{n} v_{k,j}}{\sum_{i=1}^{n}\sum_{j=1}^{n} v_{i,j}} \qquad (k = 1,2,\ldots,n),$$

where, for simplicity, we assume $\frac{\partial \rho}{\partial C} = 0$. For banks with fixed-rate deposit

insurance, the last term on the right side of equation (15) equals A_k^*. The sign of equation (15) is indeterminate because we do not know the signs of $\sum_{j=1}^{n} v_{k,j}[\bar{r}_j - \lambda\sigma_{j,w}]$ and $\sum_{j=1}^{n} v_{k,j}$.[6] Restrictions in the model require the other terms in equation (15) to be positive. The indeterminate sign on equation (15) is consistent with the findings of Lam and Chen. That is, an increase in the capital constraint (a decrease in C) may cause the bank to choose a riskier portfolio. Again, this is because we have not assumed that the deposit guarantor correctly prices the insurance.

The change in γ_1 with respect to C is

$$(16)\quad \frac{\partial \gamma_1}{\partial C} = -\frac{K[2\delta \sum_{i=1}^{n}\sum_{i=1}^{n} v_{i,j} + 2(\lambda + 2\rho CK) + 2\rho K]}{R\sum_{j=1}^{n}\sum_{j=1}^{n} v_{i,j}} \qquad (k = 1,2,\ldots,n)$$

Setting $\rho = 0$ and $6 = 0$ in (16) gives $\frac{\partial \gamma_1}{\partial C}$ for a bank with fixed-rate deposit insurance. Since ρ and 6 are positive in the risk-adjusted case, $\left|\frac{\partial \gamma_1}{\partial C}\right|$ is greater for banks with risk-adjusted deposit insurance than for banks with fixed-rate deposit insurance. Adjusting deposit-insurance premiums for risk causes deposit costs to move directly with C. Therefore, the risk-adjusted spread moves inversely with leverage. Since γ_1 equates the marginal risk-adjusted spread for all assets in the portfolio, and is inversely related to leverage (holding the cost of deposits constant), risk-adjusted premiums magnify the response of γ_1 to changes in C

To isolate the effects of risk-based deposit insurance on the portfolio allocation decision, let $\beta = \frac{\partial \gamma_1}{\partial C}$ under fixed-rate deposit insurance. Substituting β into equation (15) gives us

$$(17)\quad \frac{\partial A_k^*}{\partial C} = -\frac{\rho K \sum_{j=1}^{n} v_{k,j}[\bar{r}_j - \lambda \sigma_{j,w}]}{2(\lambda + \rho CK)^2} + \frac{\rho K \sum_{i=1}^{n}\sum_{j=1}^{n} v_{i,j}[\bar{r}_j - \lambda \sigma_{j,w}]}{2(\lambda + \rho CK)^2 \sum_{i=1}^{n}\sum_{j=1}^{n} v_{i,j}} \sum_{j=1}^{n} v_{k,j}$$

$$- \beta(2\lambda)^{-1} R \sum_{j=1}^{n} v_{k,j} \qquad (k = 1,2,\ldots,n).$$

The first two terms on the right side of equation (17) represent the effects of risk-based adjustments in the deposit-insurance premium on the portfolio allocation decision. The first term is the joint effect of risk-based deposit insurance and leverage changes on the portfolio adjustment process separate from changes in γ_1. The second term picks up the portfolio adjustment because of changes related to changes in γ_1. The last term in (17) is the effect of a change in C on A_k^* due to the change in γ_1 (controlling for the effects of risk-based deposit insurance). It is the adjustment of asset k's portfolio share resulting from a change in C under fixed-rate deposit insurance. Therefore, the portfolio adjustment process is more complicated for a bank with risk-based deposit insurance than for a bank with fixed-rate deposit insurance.'

To analyze the joint effects of risk-based insurance and changes in capital requirements on internal portfolio risk, we multiply both sides of equation (12) by A_k and sum over all k. Substituting $\sigma_\pi^2 = CV(\tilde{\pi},\tilde{\pi}) = \sum_{i=1}^{n}\sum_{j=1}^{n} A_i A_j \sigma_{i,j}$ and $(1 + C)K = \sum_{j=1}^{n} A_i$ into this expression and solving for the asset portfolio variance yields

$$(18)\quad \sigma_\pi^2 = (2[\lambda + \rho CK])^{-1}\{\sum_{i=1}^{n} A_i(\tilde{r}_i - A_{,}) + [R(1 + \gamma_1) + g + \delta CK](1 + C)K\}.$$

Letting $\alpha_i = \tilde{r}_i - \lambda\sigma_{i,w}$ and plugging A_k^* and γ_1 from (13) and (14) into (18) gives us

$$(19)\quad \sigma_\pi^2 = (2[\lambda + \rho CK])^{-2}\{\sum_{i=1}^{n}\sum_{j=1}^{n} v_{i,j}\alpha_i\alpha_j - \frac{\sum_{i=1}^{n}\sum_{j=1}^{n} v_{i,j}\alpha_i}{\sum_{i=1}^{n}\sum_{j=1}^{n} v_{i,j}}\sum_{i=1}^{n}\sum_{j=1}^{n} v_{i,j}\alpha_j\} + \frac{[(1 + C)K]^2}{\sum_{i=1}^{n}\sum_{j=1}^{n} v_{i,j}}.$$

If we set $\rho = 0$, equation (19) is the variance of earnings in the fixed-rate deposit case. Note that like A_k^*, σ_π^2 is not a function of δ or g. Furthermore, because ρ is positive, the variance of portfolio earnings for a bank with fixed-rate deposit insurance is greater than the variance of earnings for a bank with risk-based deposit insurance. This result holds for all values of C. The change in σ_π^2 with respect to C is

$$(20)\quad \frac{\partial \sigma_{\pi}^2}{\partial C} = -\rho K(2[\lambda + \rho CK])^{-3}\Big(\sum_{i=1}^{n}\sum_{j=1}^{n} v_{i,j}\alpha_i\alpha_j - \frac{\sum_{i=1}^{n}\sum_{j=1}^{n} v_{i,j}\alpha_i}{\sum_{i=1}^{n}\sum_{j=1}^{n} v_{i,j}}\sum_{i=1}^{n}\sum_{j=1}^{n} v_{i,j}\alpha_j\Big)$$

$$+ \frac{2(1 + C)K^2}{\sum_{i=1}^{n}\sum_{j=1}^{n} v_{i,j}}.$$

As in Lam and Chen, the sign of equation (20) is positive for banks with fixed-rate deposit insurance ($\rho = 0$) and uncertain for banks with risk-based insurance. Therefore, the joint effect of a more restrictive capital constraint and risk-based deposit-insurance premiums may be to increase bank portfolio risk.[8] However, because the value of (19) is greater when banks face fixed-rate premiums than when they face risk-based premiums for all C, risk-based premiums result in less internal risk than do fixed-rate premiums regardless of the sign of (20). Therefore, risk-based deposit-insurance premiums do not introduce any new perverse effects into the analysis.[9]

Bank regulators and some private market bank analysts view the level of profits as an important factor in determining the value of equity. To analyze the impact of a change in the capital requirement on expected profits, we substitute A_k^* from (13) into (2) to yield expression (21).

$$(21)\quad E(\tilde{\pi}) = (2[\lambda + \rho CK])^{-1}\Big\{\sum_{i=1}^{n}\sum_{j=1}^{n} v_{i,j} r_i \alpha_j - \frac{\sum_{i=1}^{n}\sum_{j=1}^{n} v_{i,j} r_i}{\sum_{i=1}^{n}\sum_{j=1}^{n} v_{i,j}} \sum_{i=1}^{n}\sum_{j=1}^{n} v_{i,j}\alpha_j\Big\}$$

$$+ \frac{(1 + C)K\sum_{i=1}^{n}\sum_{j=1}^{n} v_{i,j} r_i}{\sum_{i=1}^{n}\sum_{j=1}^{n} v_{i,j}} - (R + g)CK.$$

If we set $g = \tilde{g}$ and $\rho = 0$, the above expression is the expected profits for a bank with. fixed-rate deposit insurance. As expected, when the risk profile of the bank results in a risk-based premium, g, equal to the fixed rate premium, $\tilde{g}$, profits are lower for the bank paying risk-based premiums than for the bank paying fixed-rate premiums. For both fixed-rate and risk-based insurance, the effect of a change in C on expected profits is ambiguous. Since expected profits are not adjusted for risk, it is possible for a relaxation of the capital constraint to increase the value of the firm and to reduce profits. This result was also found by **Lam** and Chen.

V. Risk-Based Deposit Insurance, Capital Requirements, and Bankruptcy

The only time the FDIC must honor its guarantees is when a bank fails. Therefore, for the FDIC, the impact of changing the capital requirement on the risk of bankruptcy is an important issue. A bank's bankruptcy risk is a function of asset portfolio risk and leverage. An increase in the capital requirement reduces leverage, so an increase in internal risk in response to

increased capital requirements does not necessarily increase bankruptcy risk. Following Koehn and Santomero and Lam and Chen, and we use Chebyshev's Inequality as an upper bound for bankruptcy risk. The probability of failure, P, is

$$(22) \quad P = Pr\{\tilde{\pi} < K\} \leq \frac{\sigma_{\pi}^{2}}{[E(\tilde{\pi}) - K]^{2}}.$$

Holding C constant, the impact of risk-based deposit insurance is to reduce both the numerator and denominator of P. Therefore, the impact of risk-based insurance on default risk is uncertain. On the other hand, a reduction in the variance of earnings should reduce the expected loss to the FDIC when a bank fails. From this standpoint, risk-based deposit insurance produces a desirable result.

Lam and Chen show that the impact of changing the capital requirement on P is

$$(23) \quad \frac{\partial P}{\partial C} = [E(\tilde{\pi}) - K]^{-2}\{\frac{\partial \sigma_{\pi}^{2}}{\partial C} - 2P^{1/2}\sigma_{\pi}\frac{\partial E(\tilde{\pi})}{\partial C}\}.$$

As in Lam and Chen, the sign of expression (23) Is indeterminate for fixed-rate deposit insurance. It is also indeterminate when risk-based deposit insurance is introduced. Our inability to sign (23) for banks with risk-based deposit insurance is at least partially due to our assumption that

the FDIC does not charge banks for the fair value of their insurance. Thus, our risk-based insurance scheme does not remove all of the agency costs associated with underpriced deposit insurance.

VI. Conclusion

Previous analyses of the impact of increased capital requirements on bank portfolio behavior implicitly or explicitly assume that deposit insurance is mispriced. We contend that the mispricing is responsible for the incentive to increase leverage and that correct pricing would make the capital constraint no longer binding. By modifying the cash flow version of the CAPM to incorporate a put option formulation for deposit insurance, we examine the impact of increased capital requirements when deposit rates vary with portfolio risk and leverage.

We find that, with risk- and leverage-related deposit rates, the incentive to increase leverage is smaller than when the deposit rate and insurance premium are fixed. Allowing explicit deposit costs to vary with risk and leverage also reduces the portfolio variance. In addition, asset choice is influenced by the response of the risk premium to increases in portfolio variance.

The impact of increased capital requirements on portfolio behavior, however, is generally ambiguous and broadly similar to the results of Lam and Chen. The impact of increased capital requirements on asset choice is indeterminate, as are the responses of portfolio variance, expected profits, and the probability of bankruptcy. However, our failure to impose correct pricing may be responsible for these indeterminacies. Nonetheless, allowing

deposit rates to vary with portfolio risk and leverage results in reductions in portfolio variance and the incentive to increase leverage. These would seem to be desirable results from a regulator's viewpoint.

Footnotes

1) Correct pricing means that the deposit guarantor charges a deposit insurance premium equal to the risk premium the market would charge for uninsured deposits (see Thomson [1987]).

2) The owner-manager assumption is used to resolve the agency problem that may exist between outside stockholders and managers (see Jensen and Meckling [1976]).

3) This differs from Lam and Chen's stochastic interest-rate case where the capital constraint multiplier may be larger or smaller than the capital constraint multiplier in the deterministic deposit case.

4) The explanation for this result is that g and δ affect the expected risk-adjusted spreads for each asset equally. Therefore, they do not alter the relative risk-return trade-off between the assets.

5) Lam and Chen also get an indeterminate result for the net effect of more stringent capital requirements on overall bank risk in their stochastic deposit case.

If we restrict $A_k^* > 0$ for all k, then $\sum_{j=1}^{n} v_{k,j}[\bar{r}_j - \lambda\sigma_{j,w}] > 0$. However, this restriction does not allow us to sign expression (15).

Lam and Chen get the same result when they relax Regulation Q. The process of portfolio adjustment in response to a change in the binding capital constraint is more complicated in their stochastic deposit-rate case than in the deterministic case.

Separation between capital structure and portfolio decisions does not hold in our model because we do not assume that the deposit guarantor charges banks a premium equal to the fair value of the deposit guarantees.

Even though we do not assume correctly priced deposit guarantees, we do not get perverse effects from risk-based premiums (see Pyle [1983]) because we assume that the FDIC does not make relative pricing errors (that is, it can measure risk and price it consistently).

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