Bank Capital Requirements and Leverage: A Review of the Literature

by William P. Osterberg

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Introduction

Recognition of the extensive losses inflicted on the Federal Savings and Loan Insurance Corporation (and thus indirectly on the taxpayers) by the thrift industry crisis has led to increased scrutiny of the safety and soundness of commercial banks and other financial institutions. It has become obvious that some of the factors responsible for excessive risk-taking by savings and loans may also be relevant to commercial banks. In particular, the current system of fixed-rate deposit insurance and supervision and regulation interacts in complex ways with the market forces that may ordinarily discipline banks. An understanding of these interactions is crucial to financial institution reform.

This article reviews the literature relevant to assessing one proposed regulatory reform — increased capital requirements for banks. The arguments for higher capital requirements rely primarily on the premise that they will strengthen market discipline, and secondarily on the desire to provide a greater cushion for the deposit insurance agency. In theory, increased capital requirements can at least partially compensate for the weakening of market discipline that may result from the continued presence of fixed-rate deposit insurance. However, the magnitude of the impact of past changes in capital requirements on banks' capital decisions is unclear, mainly because market forces also affect such decisions.

Any analysis of the impact of capital requirements must take into account the current system of fixed-rate deposit insurance. The presence of non-risk-related insurance premiums and government guarantees influences the capital decision by blunting the effect that increased capital-asset ratios would otherwise have on banks' cost of funds. The current system complicates identifying the impact of changes in required capital-asset ratios, because the subsidy itself may be influenced by the ratios and other factors.

Fixed-rate insurance is also widely viewed as subsidizing risk-taking, thus providing a rationale for capital regulation. In the absence of government guarantees, shareholders would need higher levels of capital as a buffer against losses in order to avoid risk-related increases in their cost of funds. These guarantees thus lead to a substitution of deposits for equity, thereby lowering capital ratios.

Although this distortion has led to reform proposals that emphasize reductions in the scope of government guarantees, proposals to increase capital requirements continue to emerge despite the introduction of risk-based requirements. This has occurred in part because changes in capital requirements are seen as relatively easy to implement. In addition, as noted above, capital requirements may induce shareholders to evaluate risk more carefully and to submit to the market's evaluation when they attempt to raise capital.

On the surface, capital requirements seem to be effective, because almost all banks increase their capital-asset ratios (book value) after the requirements are increased. However, other factors may influence the ratios, especially if they are calculated in terms of book value. For example, suppose that the regulatory standards were increased in response to a general market perception that capital is inadequate. In this case, the subsequent adjustment may be partly due to banks' desire to avoid an increase in the risk premium in their cost of funds. Clearly, in order to disentangle such influences, investigators must have a model of the factors that determine bank capital-asset ratios.

The remainder of this paper is organized as follows. Section I reviews the theoretical literature on the determination of banks' capital structure. Section II covers a closely related topic, the impact of capital requirements on portfolio risk. Section III presents a model of a bank's choice of capital structure. Section IV analyzes the model's implications for the impact of market and regulatory forces on bank leverage.[1] Section V reviews the empirical findings on the effects of capital requirements, contrasting various results in terms of the implications presented in section IV. Section VI presents suggestions for future research and concludes.

I. Optimal Capital Structure Theory for Financial Institutions

I first discuss the theoretical findings relevant to nonfinancial corporations, since to some extent these may extend to banks, and then review the limited number of analyses of how and why the capital structure decisions of banks may differ from those of nonfinancial institutions.[2] I then focus on specific analyses of banks' capital structure, most of which assign a prominent role to deposit insurance.

The literature analyzing the capital structure decisions of nonfinancial corporations is so broad as to defy easy description.[3] However, one of the strongest conclusions to emerge from the empirical studies is that optimal capital structure is influenced by the tax code, possibly in combination with leverage-related costs. For example, the ability of corporations to deduct interest on debt may encourage an increase in leverage. On the other hand, higher levels of non-debt tax shields, such as depreciation and tax credits, may reduce optimal leverage by increasing the probability that not all interest expenses will be deductible. Taxes on personal equity and interest income may also decrease the net tax advantage of debt and optimal leverage.

Leverage-related costs include the expected costs of bankruptcy, and agency costs associated with conflicts among creditors, stockholders, and managers. The direct costs of bankruptcy are minimal (mainly involving administrative and legal fees), but agency costs, which include any decrease in firm value associated with contractual arrangements to protect one party from actions taken by another party with conflicting interests, can be significant. Bond covenants that restrict cash-flow usage may impose agency costs. However, such covenants may be a part of optimal contracts reconciling bondholders with stockholders.

The theory of optimal financial structures for financial intermediaries differs somewhat from the theory for nonfinancial firms. First, in analyzing capital structure for either financial or nonfinancial firms, it is convenient to assume that operating and financing decisions can be separated. This assumption is harder to defend for financial intermediaries. The existence of complete markets, which makes separation

■ 1 Leverage is often defined as the ratio between debt and equity, measured in book or market values. In the model presented here, the bank chooses the level of promised payments to depositors, given an exogenous asset portfolio. This is equivalent to choosing the debt-to-equity ratio directly. In Osterberg and Thomson's (1990) empirical study, the measure of leverage is the ratio between the book value of debt and the total of the book value of debt and the market value of equity. This is close to another often-analyzed measure of leverage, the debt-to-asset ratio.

■ 2 In this section, we review the theoretical analyses relevant to understanding the impact of changes in bank capital requirements. Because few analyses of bank capital structure are available (relative to the number that deal with the capital structure of nonfinancial institutions), it is not useful to attempt to categorize various approaches. In addition, the dissimilarities in approach prevent the development of a general model to which all others specialize.

■ 3 Among several useful surveys is one by Harris and Raviv (1990), who categorize the forces that may influence capital structure into desires to 1) ameliorate conflicts of interest, 2) convey private information to markets, 3) influence product or input markets, and 4) affect corporate control contests. The authors exclude tax-driven theories that they admit are of great empirical importance. Although few analyses of the capital structure of banks consider these four forces, several take into account taxes and other considerations discussed here.

more likely, makes it difficult to explain the existence of intermediaries: If markets were complete, lenders and borrowers could transact without them. In addition, deposits seem to play a role in both the real and financial decisions of banks, because deposits are not only an input into banks' production, but a component of debt in their capital structure. Another reason that analyses of banks' capital structure differ is that regulatory forces aimed directly at capital structure (for example, capital-asset ratios) must be considered.

Although most studies of the impact of capital requirements on banks do not view these institutions as fundamentally different from nonfinancial entities, many others have examined the role of informational asymmetries and contracts in explaining the existence of intermediaries. Early examples are Boyd and Prescott (1986) and Diamond (1984). Sealey (1985) analyzes a model of incomplete markets and intermediaries, showing the conditions under which shareholder unanimity holds and under which unanimity implies separation. Sealey (1983) examines a model of incomplete markets in which economies of scale in the provision of deposit services influence bank leverage. Chen, Doherty, and Park (1988) utilize an option-pricing framework to analyze the capital structure decisions of depository financial intermediaries in the presence of deposit insurance, reserve requirements, liquidity effects, and taxation. They conclude that no clear separation exists between operating and financial decisions, and that this finding even applies to analyses of the impact of taxation on leverage decisions.

As noted in Santomero (1984), most studies of bank capital structure assume that real and financial decisions can be separated, and try to explain leverage choice conditional on a given portfolio of assets. One example is Orgler and Taggart (1983), who show how personal and corporate taxes, reserve requirements, and economies of scale influence intermediaries' optimal leverage. Applications of the option-pricing framework also assume that portfolio composition is held constant. Pyle (1986) shows that the use of book values in capital regulation is inappropriate when combined with closure rules that deviate from an economic solvency condition.

The conclusions of theoretical analyses of the impact of capital requirements are closely related to the treatment of deposit insurance and government guarantees. If deposit insurance is underpriced and unresponsive to risk, then stockholders are being subsidized by the insurer, and the size of the subsidy is a function of portfolio risk and leverage. This subsidy has a direct impact on banks' responses to changes in capital requirements. Buser, Chen, and Kane (1981) examine how the combination of capital regulation and flat-rate deposit insurance jointly influences bank leverage. They note that because capital regulation encompasses more than just numerical standards for capital-asset ratios, such regulation can be seen as imposing an implicit risk-related insurance premium that discourages banks from exploiting the subsidy implied by flat-rate deposit insurance.

II. The Impact of Capital Requirements on Portfolio Composition

Although most studies of bank capital structure assume a given portfolio of assets, several authors have examined the impact of capital requirements on portfolio risk, assuming that leverage is at the regulatory maximum.[4] An overall assessment of the impact of capital requirements on bank capital structure would have to allow for possible feedback from variation in portfolio changes.

Koehn and Santomero (1980) conclude that increased numerical capital requirements lead banks that are risk-averse expected utility maximizers to reshuffle their portfolios so as to increase the probability of bankruptcy. Lam and Chen (1985) and Kim and Santomero (1988) use similar approaches. Keeley and Furlong (1987), who employ a value-maximization framework, point out that Koehn and Santomero ignore the impact of changes in leverage and portfolio risk on the deposit insurance subsidy. Osterberg and Thomson (1988) show how the impact of capital requirements on portfolio shares is altered by allowing the cost of funds to be influenced by leverage.

■ 4 Flannery (1989) shows why insured banks may have a preference for safe individual loans but still prefer risky overall portfolios. Capital adequacy standards and loan examination procedures are key elements of his analysis. Lucas and McDonald (1987) study the impact of capital regulation on bank portfolio choice when banks have private information about loan quality.

EQUATIONS (1) AND (2)

$$(1)\quad \tilde{Y}_s = (\tilde{X} - \hat{Y})(1 - t_c) + \varphi \qquad \text{if } \tilde{X} \geq \hat{Y} + \frac{\delta - \varphi}{1 - t_c}$$

$$= (1 - \lambda)[(\tilde{X} - \hat{Y})(1 - t_c) + \varphi] \qquad \text{if } \hat{Y} + \frac{\varphi}{t_c} \leq \tilde{X} < \hat{Y} + \frac{\delta - \varphi}{1 - t_c}$$

$$= (1 - \lambda)(\tilde{X} - \hat{Y}) \qquad \text{if } \hat{Y} \leq \tilde{X} < \hat{Y} + \frac{\varphi}{t_c}$$

$$= 0 \qquad \text{if } \tilde{X} < \hat{Y}$$

$$(2)\quad \hat{Y}_b = \hat{Y} \qquad \text{if } \hat{Y} \leq \tilde{X}$$

$$= \tilde{X}(1 - k) \qquad \text{if } 0 < \tilde{X} < \hat{Y}$$

$$= 0 \qquad \text{otherwise,}$$

where

$\tilde{X}$ = end-of-period value of bank assets,
$\tilde{Y}_s, \tilde{Y}_b$ = gross end-of-period cash flows accruing to bank stockholders and depositors, respectively,
$\hat{Y}$ = total end-of-period promised payment to depositors,
φ = total end-of-period after-tax value of nondebt tax shields when fully utilized,
λ = regulatory penalty,
δ = capital requirement,
k = cost of financial distress to depositors, and
d = proportion between δ and $\tilde{Y}$ (a capital requirement proxy).

III. A Model of Market and Regulatory Influence on Bank Capital Structure

To aid in this review, I present a model in which market and regulatory influences on banks' capital structure are intertwined. The model also provides a limited synthesis of the theoretical literature. However, influences that could explain the existence of intermediaries, such as the presence of incomplete markets, are not incorporated. The only factor included that distinguishes banks is capital regulation. In addition, the model maintains the separation of real and financial decisions by holding constant the bank's asset portfolio and return variance. Although I initially assume that there is no deposit insurance, such insurance is easily introduced (see Osterberg and Thomson [1990] and the following discussion).[5]

Equations (1) and (2) describe the uncertain outcomes facing stockholders and depositors. I view the bank as attempting to maximize the total of the values of equity and deposits, each of which depends on the uncertain outcomes and their associated probabilities.

Pre-tax returns to stockholders depend on the uncertain end-of-period value of bank assets, $\tilde{X}$. The first line of equation (1) indicates the return when income (asset values) is high enough that the capital guideline is not violated. I assume in this case that all nondebt tax shields can be utilized ($\tilde{X} > \hat{Y} + \varphi / t_c$); however, the results are not significantly affected by this assumption. In the second case, when income is high enough to use all the shields but the capital requirement is not met ($\tilde{X}[1 - t_c] + \varphi - \hat{Y} < \delta$), regulators impose a tax of λ on stockholder returns. In the third case, income is positive but insufficient to utilize nondebt tax shields, and the guidelines are not met.

5 This model is a variant of the one developed by Bradley, Jarrell, and Kim (1984), hereafter referred to as BJK. Detailed assumptions underlying the model are given in appendix 1.

Equation (2) indicates the end-of-period pretax flows to depositors. A crucial distinction between stockholders and depositors is readily apparent: Depositors only receive $\hat{Y}$, even if income greatly exceeds promised payments. On the other hand, if income is positive but insufficient to meet promised payments, the bank is in financial distress and incurs real costs that reduce the return to depositors by the fraction k.

The bank is assumed to know 1) the relevant tax rates, 2) the amount of nondebt tax shields, 3) the required capital-asset ratio, d, 4) the regulatory response, embodied in λ, 5) the costs of financial distress, 6) the average income, $\tilde{X}$, and 7) the standard deviation of income, φ. The bank chooses $\hat{Y}$ to maximize the market value of its debt plus equity (see appendix 1).

Equation (3) is the derivative of V with respect to $\hat{Y}$: $V_{\hat{Y}}(\partial V/\partial \hat{Y})$.

$$(3)\quad V_{\hat{Y}} = \frac{1-t_{pb}}{r_0}\left[1 - F(\hat{Y}) - k\hat{Y}f(\hat{Y})\right]$$
$$+\frac{1-t_{ps}}{r_0}\Big[-(1-t_c)\left[1 - F\left(\frac{\varphi}{t_c}+\hat{Y}\right)\right]$$
$$-\left[F\left(\hat{Y}+\frac{\varphi}{t_c}\right) - F(\hat{Y})\right] - \lambda\Big\{\Big[F\left(\hat{Y}+\frac{\varphi}{t_c}\right)$$
$$-F(\hat{Y})\Big] + (1-t_c)\Big[F\left(\hat{Y}+\frac{\delta-\varphi}{1-t_c}\right)$$
$$-F\left(\hat{Y}+\frac{\varphi}{t_c}\right)\Big] + \left[\delta + \frac{d(\delta-\varphi)}{1-t_c}\right]$$
$$\cdot f\left(\hat{Y}+\frac{\delta-\varphi}{1-t_c}\right)\Big\}\Big],$$

where $F(\cdot)$ is the cumulative probability density function of $\tilde{X}$. If banks in fact choose $\hat{Y}$ so as to satisfy equation (3), then this expression indicates how both market and regulatory forces influence bank leverage.

If $\lambda = 0$, the model's implications are consistent with theories of optimal capital structure in which the assumed tax advantage of debt balances the expected cost of bankruptcy (see BJK). These implications are as follows. First, an increase in t_{ps} raises optimal leverage by increasing the cost of equity. Analogous reasoning implies that an increase in t_{pb} reduces optimal leverage. Second, an increase in t_c raises optimal leverage by increasing the tax advantage of debt. For this reason, an increase in φ reduces optimal leverage by increasing the probability that not all interest expenses will be deductible. Third, an increase in k reduces optimal leverage by increasing the expected cost of a bank's inability to make all promised payments.

The model is also consistent with theoretical approaches that assign deposit insurance a role in distorting market discipline. The effect of fixed-rate deposit insurance on optimal leverage can be seen by comparing equation (3) with $V_{\hat{Y}}$ under full insurance (see Osterberg and Thomson [1990]). Optimal leverage is higher with fixed-rate deposit insurance by the amount $(1 - t_{pb})[F(\hat{Y}) + k\hat{Y}f(\hat{Y})]/r_0$. Fixed-rate deposit insurance increases the optimal $\hat{Y}$ by insuring that depositors are always paid in full and by shifting the cost of financial distress from depositors to the Federal Deposit Insurance Corporation. In the context of the model presented above, these two influences are equivalent to assuming that $F(\hat{Y}) = 0$ and $k = 0$. Although this model does not allow the higher leverage to influence bank riskiness, the increase in leverage induced by deposit insurance provides a rationale for capital regulation.

The impact of capital regulation on leverage can be seen by examining the last term in equation (3), $\lambda(\cdot)$. The first two components of $\lambda(\cdot)$ comprise the expected after-tax regulatory penalty resulting from issuing the last dollar of deposits. As equations (1) and (2) demonstrate, the possibility of a regulatory penalty affects the return to equity, which one would expect to be reflected in the rate of return demanded by stockholders and thus in the bank's leverage decision. In fact, the last component of $\lambda(\cdot)$ is the increase in the cost of equity capital that results from issuing one more dollar of deposits, $[\delta + d(\delta-\varphi)/(1-t_c)]f[\hat{Y} + (\delta-\varphi)/(1-t_c)]$. Because all of the components are positive, the possibility of a regulatory penalty reduces a bank's optimal leverage.

IV. The Impact of Regulatory and Market Forces on Optimal Leverage

Although equation (3) clearly shows that both market forces and regulatory variables influence leverage with signs consistent with theory, it is more important for our purposes to note that this expression also implies that the impact of an increase in λ (the regulatory penalty) on leverage depends on market forces entering $\lambda(\cdot)$. Empirical studies of capital requirements vary in their treatment of the influence of such market forces (φ, k, t_c, t_{ps}, t_{pb}, and σ, where σ is the standard deviation of $\tilde{X}$) on $\hat{Y}$.

To show how market influences affect the impact of capital regulation on bank leverage, one can differentiate the optimality condition (equation [3]) with respect to the regulatory variables. The derivatives with respect to the market-force variables are indicated in appendix 2. Further details can be found in Osterberg and Thomson (1990).

Equation (4) gives the impact of a change in d on optimal leverage. The ratio d is closely related to a required capital-asset ratio, because it is the minimum level of the end-of-period equity value and because $\delta = \hat{Y}d$.

$$(4) \quad V_{\hat{Y}d} = -\frac{\lambda(1-t_{ps})}{r_0(1-t_c)} f(\hat{Y} + \frac{\delta-\varphi}{1-t_c}) \{2\delta - \varphi - [\hat{Y}\delta + \frac{\delta(\delta-\varphi)}{1-t_c}] (\hat{Y} + \frac{\delta-\varphi}{1-t_c} - \bar{X})/\sigma^2\} \gtrless 0$$

The impact of d on leverage clearly depends on market forces, implying that such forces influence leverage even if a bank fails to meet the guidelines. As discussed below, some studies imply that such banks are influenced only by regulation, while banks meeting the guidelines are influenced only by market forces. No such dichotomy emerges here.

Equation (4) implies that $V_{\hat{Y}d}$ is negative whenever $\bar{X} \geq \hat{Y} + (\delta - \varphi)/(1-t_c)$; that is, an increase in d reduces leverage when the bank expects to meet the capital requirements. However, if a bank does not expect to meet the requirements, an increase in d may induce it to increase leverage and thus move even further below the guidelines.

Equation (5) shows that an increase in the regulatory penalty, λ, reduces bank leverage. Here, as in the response of leverage to d, the impact of capital regulation depends on market factors. Equation (6) shows that an increase in the costs of financial distress, k, also reduces optimal leverage. Although k is referred to above as a market factor, the cost of financial distress can be influenced by regulatory policies pertaining to bank closure.

$$(5) \quad V_{\hat{Y}\lambda} = -\frac{1-t_{ps}}{r_0} \Big[(1-t_c)[F(\hat{Y} + \frac{\delta-\varphi}{1-t_c}) - F(\hat{Y} + \frac{\varphi}{t_c})] + (\delta + \frac{d(\delta-\varphi)}{1-t_c}) f(\hat{Y} + \frac{\delta-\varphi}{1-t_c})\Big] < 0$$

$$(6) \quad V_{\hat{Y}k} = -\frac{1-t_{pb}}{r_0}[\hat{y} f(\hat{Y})] < 0$$

V. Evidence on the Impact of Capital Requirements on Bank Leverage

Separating market forces from regulatory forces has been a major difficulty in ascertaining the effectiveness of capital guidelines. Dietrich and James (1983) criticize earlier studies by Peltzman (1970) and Mingo (1975) for ignoring deposit-rate ceilings in their analyses of the impact of capital requirements. Under such ceilings, banks can influence risk-adjusted returns on bank debt by augmenting capital. However, only under less-than-full deposit insurance would more capital benefit stockholders, by inducing uninsured depositors to accept lower interest rates. Dietrich and James conclude that the guidelines have no effect on bank capital changes.

Although the model presented here does not directly consider the possibility of interest-rate ceilings, capital levels influence the returns to stockholders and thus the rate of return required on equity. The latter can be calculated as the ratio between $E(\hat{Y}_s)$, the expected returns to stockholders, and S, the market value of equity (see appendix 1 and BJK). Equation (1) indicates that returns to stockholders are influenced by several market forces that must be controlled for in any analysis of the impact of capital requirements.

Marcus (1983), Wall and Peterson (1987), and Keeley (1988a, 1988b) examine bank holding companies rather than independent banks. Wall and Peterson apply a switching regression technique to movements of equity values in an attempt to distinguish a regime in which capital ratios exceed the requirements (and are thus influenced by market forces) from a regime in which ratios are at the regulatory limit. They conclude that most banks are influenced by regulation.

The model presented here implies that 1) banks may respond to market forces even if the guidelines are not being met and 2) regulatory forces may influence leverage even if the bank exceeds the guidelines. In addition, equation (4) indicates that banks below the guidelines may actually respond to stiffer requirements perversely.

Keeley (1988a) examines the response of bank holding companies to the increased capital requirements of the 1980s. Although capital-deficient banks increased their book-value ratios more than capital-sufficient banks did, market ratios increased for both classes. However, regulatory subsidies or taxes can influence the response of market-value ratios to increased capital guidelines, because the value of the subsidy may vary with leverage or risk. Keeley (1988b) claims that increased competition erodes the value of bank charters and thus raises incentives to increase leverage or to reduce capital ratios.

Marcus (1983) utilizes a time series cross-sectional approach, measuring regulatory pressure to increase capital by the holding company's capital ratio relative to the average (in terms of book or market value). He finds that the incentive to decrease capital varies positively with the level and variability of interest rates, as well as with the tax disadvantage of equity finance. Regulation seems to have no effect. However, his regulatory measure does not incorporate risk.

In the model presented above, d is close to a statutory capital-asset ratio. However, analyzing banks' capital ratios relative to the average may be a more useful way to isolate the impact of capital regulation. There are at least two reasons for this. First, relatively few banks are below the statutory guidelines. Second, evidence suggests that capital regulation is based on a peer-group standard. In fact, a peer-group capital standard may be a useful proxy for the regulatory penalty variable, λ.

The relevance of taxes to the capital structure of banks is discussed in more detail by Wall and Peterson (1988) and Gelfand and Hanweck (1987). Wall and Peterson argue that taxes do not influence the capital structure of banks affiliated with holding companies, because the tax consequences of the parent issuing debt to buy subsidiary equity are similar to those ensuing when the bank itself issues debt. Gelfand and Hanweck examine the financial statements of 11,000 banks and find strong evidence for market influences (tax rates, risk, and municipal securities [munis] as proxies for nondebt tax shields) on leverage.

Osterberg and Thomson (1990) investigate the influence of capital regulation on bank holding company leverage empirically, drawing on the implications of the model presented above. The authors find that market forces influence leverage through three channels: a direct channel, a channel in which market forces interact with risk (σ), and a channel in which market forces interact with capital regulation. In addition, their analysis explicitly allows for the simultaneous determination of leverage and muni holdings. Although the latter may no longer be an important channel through which banks manage their tax liability, this may not have been the case during the period examined (1986-1987).[6] The interactive capital regulation measures, taken as a whole, are significant, as are the interactive risk measures. In addition, muni holdings appear to be significant determinants of leverage, as do market forces.

VI. Conclusions and Suggestions for Future Research

This article reviews the literature relevant to assessing the impact of increased bank capital requirements. Although researchers have suggested various proposals to correct the distorted incentives facing bankers, raising required capital ratios continues to emerge as a possible means of strengthening market discipline. However, previous studies have failed to clarify the impact of numerical guidelines on banks' capital-asset ratios.

The primary difficulty in discerning the influence of such guidelines lies in disentangling the impacts of regulatory and market forces. In order to illustrate the way in which these forces interact, I present a model of a bank's choice of leverage ratio where, in the absence of capital regulation, tax considerations and bankruptcy costs imply an interior solution. When capital regulation is introduced, it becomes clear that the impact of such regulation depends on market forces.

These results may provide useful insight for regulators. For example, the response of bank leverage to capital regulation may depend on

■ 6 Scholes, Wilson, and Wolfson (1990) present evidence that banks' muni holdings responded to changes in the tax code between 1983 and 1987, and that capital regulation seemed to influence banks' timing of capital loss realization. This seems to suggest that capital regulation and the tax code interact in a manner similar to that suggested in this paper.

the market factors considered in this paper, such as tax rates, nondebt tax shields, and muni holdings, not just on the capital position of the bank. This implies that evaluations of banks' leverage and capital-asset ratios should take into account market influences on the leverage decision.

The model may also explain previous empirical findings regarding the impact of capital requirements. Most studies do not control for many of the market influences on banks' capital decisions. The analysis presented here thus implies that theoretical examinations of bank capital structure may further improve our understanding of the influence of capital requirements. In this regard, it may be particularly useful to analyze capital requirements through models that incorporate informational asymmetries and market imperfections to explain the existence of financial intermediaries.

Appendix 1

Detailed Assumptions and Structure of the Model

The main assumptions of the model presented in the text are as follows:

1. Investors are risk-neutral.
2. The personal tax rates on returns from bank debt and bank equity are t_{pb} and t_{ps}, respectively.
3. Bank income is taxed at the corporate rate, t_c.
4. All taxes are levied on end-of-period wealth.
5. The firm's end-of-period tax liability can be reduced through nondebt tax shields, φ, such as investment tax credits and depreciation.
6. Unused tax credits cannot be transferred across time or across firms.
7. If banks cannot meet their end-of-period promised payments to depositors, $\hat{Y}$, costs of financial distress are incurred that reduce bank equity value by a factor of k.
8. The end-of-period capital requirement is $\delta = \hat{Y}d$.
9. If $\tilde{X} - \hat{Y} < (\delta - \varphi)/1 - t_c)$, a regulatory penalty reduces stockholders' returns by a constant fraction λ ($\tilde{X}$ is the end-of-period value of assets).
10. All bank liabilities are *uninsured* deposits.
11. The capital constraint, δ, is not binding unless $\tilde{X}$ is such that the tax shields are being fully utilized.

Assumption 10 allows us to separate the effects of capital requirements from the effects of deposit insurance. Thomson (1987) shows that this is equivalent to assuming 100 percent deposit insurance if the insurance is fairly priced. The case in which all liabilities are covered by fixed-rate, zero-premium deposit insurance is analyzed in appendix A of Osterberg and Thomson (1990). Assumption 11 is made for convenience only; my results are not materially affected by the alternative assumption that δ is binding for values of $\tilde{X}$ where $\varphi > (\tilde{X} - \hat{Y})\, t_c$.

Under the assumption of risk neutrality, and given the uncertain outcomes detailed in the text, the after-tax market value of the banking firm is the sum of the market values of deposits and equity:

$$
\begin{aligned}
(1A)\quad V = \frac{1}{r_0}\Big[& \int_{\hat{Y}+\frac{\varphi}{t_c}}^{\infty} \{(1-t_{ps})[(\tilde{X}-\hat{Y})(1-t_c) \\
& + \varphi] + (1-t_{pb})\hat{Y}\} f(\tilde{X})\, d\tilde{X} \\
& - \int_{\hat{Y}+\frac{\varphi}{t_c}}^{\hat{Y}+\frac{\delta-\varphi}{1-t_c}} \lambda(1-t_{ps})[(\tilde{X}-\hat{Y})(1-t_c) \\
& + \varphi] f(\tilde{X}) d\tilde{X} \\
& + \int_{\hat{Y}}^{\hat{Y}+\frac{\varphi}{t_c}} [(1-t_{ps})(1-\lambda)(\tilde{X}-\hat{Y}) \\
& + (1-t_{pb})\hat{Y}] f(\tilde{X}) d\tilde{X} \\
& + \int_{0}^{\hat{Y}} (1-t_{pb})(1-k)\tilde{X} f(\tilde{X}) d\tilde{X}\Big],
\end{aligned}
$$

where $f(\tilde{X})$ = the probability density of $\tilde{X}$, and r_0 = one plus the rate of return on a risk-free tax-exempt bond.

The four integrals in equation (1A) are, respectively, 1) the expected value of the bank over the range of $\tilde{X}$ where the bank fully utilizes its nondebt tax shields, 2) the expected value of the regulatory tax over the range of $\tilde{X}$ where the bank fully utilizes its nondebt tax shields but fails to meet its capital guideline, 3) the expected value of the bank over the range of $\tilde{X}$ where nondebt tax shields are no longer fully utilized, and 4) the expected value of the bank when $\tilde{X}$ is not large enough to meet promised payments to the depositors and k percent of the firm value is lost to financial distress.

Appendix 2

The Impact of Market Forces on Optimal Bank Leverage

The effect of an increase in nondebt tax shields, φ, on optimal leverage is indicated by equation (2A).

$$\text{(2A)} \quad V_{\hat{Y}\varphi} = -\frac{1-t_{ps}}{r_0}\Big[(1+\lambda)f(\hat{Y}+\frac{\varphi}{t_c}) + \lambda f(\hat{Y}+\frac{\delta-\varphi}{1-t_c})\{1+\frac{d}{1-t_c} - [\delta+\frac{d(\delta-\varphi)}{1-t_c}] \cdot (\hat{Y}+\frac{\delta-\varphi}{1-t_c}-\bar{X})/\sigma^2\}\Big] \gtrless 0$$

If there were no regulatory penalty ($\lambda = 0$), I would obtain the same results as BJK; that is, a higher level of nondebt tax shields would reduce leverage ($V_{\hat{Y}\varphi} < 0$). Here, however, leverage increases if $\bar{X} \geq \hat{Y} + (\delta-\varphi)/(1-t_c)$. This possibility is created by the combination of the capital requirement being based on the after-tax value of equity, which includes the value of the shields, and the fact that the capital requirement is binding when the tax shields are being fully utilized. For high-enough values of $\tilde{X}$, an additional dollar of tax shields reduces the probability that the bank will violate the capital constraint and incur the regulatory penalty.

The effects of changes in the various tax rates on the optimal level of debt are shown in equations (3A), (4A), and (5A). In equation (3A), the response of bank leverage to an increase in the marginal corporate tax rate is positive when $\bar{X} \geq \hat{Y} + (\delta-\varphi)/(1-t_c)$. In other words, if expected end-of-period income is large enough to meet the capital requirements, then an increase in t_c reduces the optimal level of debt. The ambiguous sign for equation (3A) when $\bar{X} \geq \hat{Y} + (\delta-\varphi)/(1-t_c)$ arises because the capital constraint is assumed to be binding when the bank's net tax bill is positive. There are two offsetting effects. First, an increase in t_c raises the value of the interest deduction on debt, which induces the bank to issue more deposits. This is the familiar effect discussed in the finance literature on optimal capital structure for nonfinancial entities. The second effect is a reduction in the after-tax value of equity and an associated increase in the probability that the bank will violate the capital constraint and reduce leverage.

$$\text{(3A)} \quad V_{\hat{Y}t_c} = \frac{1-t_{ps}}{r_0}\Big\{1-F(\hat{Y}+\frac{\varphi}{t_c}) + \lambda[F(\hat{Y}+\frac{\delta-\varphi}{1-t_c}) - F(\hat{Y}+\frac{\varphi}{t_c})] + \frac{\varphi(1-\lambda)}{t_c}f(\hat{Y}+\frac{\varphi}{t_c}) + \Big[(1+\frac{d}{1-t_c})[\frac{\lambda(\delta-\varphi)}{1-t_c}] - \frac{\lambda}{\sigma^2} \cdot [\delta+\frac{d(\delta-\varphi)}{1-t_c}](\hat{Y}+\frac{\delta-\varphi}{1-t_c}-\bar{X})\Big] \cdot f(\hat{Y}+\frac{\delta-\varphi}{1-t_c})\Big\} \gtrless 0$$

If there were no costs of financial distress ($k=0$), equation (4A) would be unambiguously negative at the optimal level of debt. In addition, if all of the bank's deposits were insured, $V_{\hat{Y}t_{pb}}$ would be clearly negative. However, more generally, equation (4A) is negative when the probability that $\hat{Y}$ is less than $\tilde{X}$ exceeds the marginal expected leverage-related costs. This result is similar to the findings of BJK. Note that we have assumed that the costs of financial distress facing the depositors (k) are distinct from the regulatory penalty. As in BJK, $V_{\hat{Y}t_{ps}}$ is unambiguously positive. However, here the response depends on the regulatory penalty, λ.

$$\text{(4A)} \quad V_{\hat{Y}t_{pb}} = -\frac{1}{r_0}[1-F(\hat{Y}) - k\hat{Y}f(\hat{Y})] \gtrless 0$$

(5A) $$V_{\hat{Y}t_{ps}} = -\frac{1}{r_0}\Big\{(1-t_c)[1-F(\frac{\varphi}{t_c}+\hat{Y})]$$

$$+[F(\hat{Y}+\frac{\varphi}{t_c})-F(\hat{Y})]$$

$$+\lambda\Big[[F(\hat{Y}+\frac{\varphi}{t_c})-F(\hat{Y})]$$

$$+(1-t_c)[F(\hat{Y}+\frac{\delta-\varphi}{1-t_c})-F(\hat{Y}+\frac{\varphi}{t_c})]$$

$$+(\delta+\frac{d(\delta-\varphi)}{1-t_c})f(\hat{Y}+\frac{\delta-\varphi}{1-t_c})\Big]\Big\}>0$$

Finally, the optimal level of deposits is a function of the variability of $\tilde{X}$. Equation (6A) shows that an increase in σ has an ambiguous effect on optimal leverage. The sign on $V_{\hat{Y}\sigma}$ depends on the proximity of $\hat{Y}$, $\hat{Y}+(\delta-\varphi)/(1-t_c)$, and $\hat{Y}+\varphi/t_c$ to the mean of $\tilde{X}$, as well as on the magnitudes of k, φ, d, and λ. BJK find that, even without a regulatory penalty, the impact of an increase in σ on $\hat{Y}$ is ambiguous.

(6A) $$V_{\hat{Y}\sigma} = \frac{1-t_{pb}}{r_0\sigma}$$

$$\cdot\{(\hat{Y}-\bar{X})-k\hat{Y}[(\frac{\hat{Y}-\bar{X}}{\sigma})^2-1]\}f(\hat{Y})$$

$$+\frac{1-t_{ps}}{r_0\sigma}\Big\{[(1-\lambda)t_c-2\lambda]$$

$$\cdot(\frac{\varphi}{t_c}+\hat{Y}-\bar{X})$$

$$\cdot f(\hat{Y}+\frac{\varphi}{t_c})-(1-\lambda)f(\hat{Y})(\hat{Y}-\bar{X})$$

$$+\lambda f(\hat{Y}+\frac{\delta-\varphi}{1-t_c})(1-t_c)$$

$$\cdot(\hat{Y}+\frac{\delta-\varphi}{1-t_c}-\bar{X})-[\delta+\frac{d(\delta-\varphi)}{1-t_c}]$$

$$\cdot[(\frac{\hat{Y}+\frac{\delta-\varphi}{1-t_c}-\bar{X}}{\sigma})^2-1]\Big\}\gtrless 0$$

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