Working Paper 9007

Optimal Financial Structure and Bank Capital Requirements: An Empirical Investigation

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July 1990

Abstract

This paper presents an empirical analysis of the determinants of the leverage ratios (the book value of liabilities divided by the total of the book value of liabilities and the market value of equity) for 232 bank holding companies for December 1986, June 1987, and December 1987. Many theoretical models of bank behavior assume that bank capital requirements will be binding, and empirical research has generally shown that almost all banks will meet capital guidelines. However, if the optimal leverage ratios differ among banks, then banks' responses to changes in capital requirements or to changes in factors that influence their optimal leverage ratio may vary in a cross section. The theoretical framework is a variant of the one developed in Bradley, Jarrell, and Kim (1984). The optimal leverage ratio balances the tax advantage of debt with the costs of bankruptcy. In addition to considering nondebt tax shields and tax rates as determinants of the optimal ratio, we analyze the simultaneity between leverage and investment in municipal securities (munis). Previous research indicates that banks utilize munis to minimize tax liabilities.

I. Introduction

The impact of bank capital regulation has reemerged as a topic of debate since the establishment of risk-based capital guidelines. Capital requirements are intended both to control excessive risk-taking and to limit the exposure of the deposit-insurance fund. Capital regulation may be rationalized as a necessary part of a system of bank regulation that involves fixed-rate deposit insurance. However, it is unclear whether capital guidelines have been successful in meeting their objectives. Even if most banks meet or exceed the guidelines, at least in a book-value sense, guidelines may affect market leverage and have a perverse impact on risk-taking. For example, banks may resort to accounting gimmicks to meet the guidelines, or they may redefine products or activities to circumvent them. In addition, a focus on market-value measures of capital adequacy, or on the extent to which banks maintain capital cushions, may be more appropriate for assessing the exposure of the deposit-insurance fund. Although all of these factors may be examined by regulators, their links with capital regulation are unclear.

On the surface, capital guidelines would seem to be effective, since the vast majority of banks increase their (book-value) capital ratios in order to meet the requirements. However, this need not imply that the guidelines are effective, because market influences may affect the capital decision. For example, in a system of partial deposit insurance, it is difficult to separate regulatory influences from market influences, since the interests of the insurer and the uninsured depositors are similar. Then, if regulators and depositors react to similar information, an increase in capital requirements followed by an actual increase in capital ratios does not necessarily indicate the effectiveness of regulation. Similarly, if market-equity values incorporate a deposit-insurance subsidy that varies inversely with the capital-asset ratio, then an increase in capital will have a smaller impact on the market-value measure of capital adequacy than on the narrower book measure. Furthermore, market-equity values include the value of growth options that are not captured by book-equity measures.

In the absence of regulation, the optimal leverage ratio for a bank may be below, above, or equal to the guidelines. To some extent, optimal leverage ratios for banks may be determined as for nonfinancial corporations, that is, by a tax advantage for debt interacting with expected bankruptcy and agency costs. Thus, tax rates, nondebt tax shields, and proxies for debt-related costs (such as variance of cash flow) may affect capital ratios. There may be influences unique to banks as well, such as economies of scale in the provision of deposit services. In addition, agency problems are introduced by capital regulation and deposit insurance. The possibility of a deposit-insurance subsidy and the existence of government guarantees may also encourage lower capital ratios. Some theoretical analyses of bank behavior assume that capital guidelines will always be binding. However, even if in practice the incentives to increase leverage are great enough relative to the costs that banks are at the capital guidelines, market influences may affect the response of leverage to changes in regulations. In other words, capital positions may influence bank portfolio decisions.

In this paper, we analyze the impact of capital regulation by considering a model of a bank that responds to both market and regulatory forces in its choice of optimal market leverage ratio (the book value of liabilities divided by the total of the book value of liabilities and the market value of equity). The model is a variant of that developed by Bradley, Jarrell, and Kim (1984).

In the absence of capital regulation, the optimal leverage ratio balances the tax advantages of debt against the expected costs of debt. Variations in nondebt tax shields, tax rates, and the variance of bank return affect the optimal leverage ratio in the simple model. In the presence of capital requirements, the expected cost of violating the guidelines is part of the expected cost of leverage. Our model allows for the possibility of deposit-insurance subsidies or other government guarantees, which may be reflected in market leverage ratios. Although portfolio composition is taken as a given, riskiness is allowed to influence the bank's leverage decision. The model implies that the market leverage ratio will vary with tax rates, tax shields, variance of return, and municipal bond holdings (munis). It is important to note that the response of leverage to market influences will also vary with capital position. Munis are included in the analysis because they are closely related to bank tax liability.

We utilize balance-sheet data on 232 bank holding companies from December 1986 to December 1987, and estimate a two-equation simultaneous system between leverage and munis using an instrumental variables technique. The capital ratio relative to the overall average is a determinant of the response of leverage to changes in tax rates, nondebt tax shields, and loan-loss provisions. The variance of bank returns is also assumed to influence the response of leverage. A variety of balance-sheet proxies for the variance are considered, following the suggestions of Kuester and O'Brien (1989). Results provide some support for considering taxes, capital regulation, munis, and risk in analyzing bank leverage decisions.

II. Related Literature

A. Optimal Financial Structure for Financial Institutions: Theory

The theory of optimal financial structure for nonfinancial institutions may not be directly applicable to financial intermediaries such as banks. For nonfinancial corporations, there is a consensus that optimal structure balances the tax advantage to debt against leverage-related costs. The ability of corporations such as banks to deduct interest on debt encourages leverage and makes relevant nondebt tax shields such as depreciation, tax credits, and munis. Leverage-related costs arise due to the possibility of bankruptcy and agency problems associated with conflicts among creditors, stockholders, and managers. In the case of banks, problems include conflicts involving the Federal Deposit Insurance Corporation (FDIC) and other regulators.

The theory of optimal financial structures for financial intermediaries differs from the theory for nonfinancial firms for at least three reasons. First, incomplete markets seem to be necessary to explain the existence of intermediaries. Second, the role of deposits seems to make the separation of operating and financial decisions unlikely. Third, the role of regulatory forces is harder to ignore.

A wide body of research has attempted to analyze the role of informational asymmetries and the resulting contracts in order to explain the existence of intermediaries (see Boyd and Prescott [1986] and Diamond [1984]). The "finance" approach is somewhat distinct. Hart and Jaffee (1974) made an early attempt to apply finance theory to intermediaries. Sealey (1983, 1985) discusses conditions under which shareholder unanimity obtains given a particular type of market incompleteness, and reviews the link between unanimity and separation of operating and financial decisions. 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 between operating and financial decisions exists, and that this even applies to analysis of the impact of taxation on leverage decisions.

As discussed in Santomero's (1984) survey of approaches to modeling bank behavior, most analyses of bank-capital structure assume that the leverage choice is made conditional on asset choices. Orgler and Taggart (1983) provide one such approach, showing that economies of scale in the provision of deposit services can help to determine intermediaries' optimal choice of leverage. If 100 percent of all bank debt can be viewed as insured, then the option pricing framework can be utilized to examine capital-structure issues. In fact, the conclusions of theoretical analyses of the impact of bank capital requirements are closely tied to the treatment of deposit insurance and government guarantees. This may not be surprising, given the findings of Buser, Chen, and Kane (1981), who view capital regulation as imposing an implicit risk-related insurance premium that discourages banks from exploiting a subsidy implied by flat-rate deposit insurance.

Koehn and Santomero (1980) analyze the impact of increased capital requirements on the portfolio choices of banks that are risk-averse expected utility maximizers and conclude that portfolio reshuffling would unambiguously increase the probability of bankruptcy. Lam and Chen (1985) and Kim and Santomero (1988) are examples of similar approaches. Keeley and Furlong

(1987) point out that these approaches ignore the impact of changes in leverage and portfolio risk on the deposit-insurance subsidy, clarifying these effects within a value-maximization framework. Osterberg and Thomson (1988) show that the impact of capital requirements is closely related to the extent to which deposit insurance is mispriced. The option pricing framework has also been utilized by Pyle (1986) and Marcus (1984) to show how the impact of capital requirements depends on closure policy and other aspects of regulation.

B. Optimal Financial Structure for Financial Institutions: Evidence

Distinguishing market forces from regulatory forces is a major difficulty in discerning the effectiveness of capital guidelines. Peltzman (1970) finds that the guidelines have no effect on bank capital, while Mingo (1975) reaches the opposite conclusion. Dietrich and James (1983) point out that, under interest-rate ceilings, banks can influence risk-adjusted returns on debt by augmenting capital. In that case, under partial deposit insurance, both regulators and uninsured depositors benefit from higher capital, so it is crucial to develop distinct measures of regulatory and market influences. Dietrich and James conclude that the guidelines have no distinct influence.

Marcus (1983), Wall and Peterson (1987), and Keeley (1988a, 1988b) look at bank holding companies rather than at independent banks. Wall and Peterson consider the reaction of equity values to distinguish between two regimes, one in which capital ratios are higher than the requirements and thus are influenced by market forces, and another in which the ratios are at their regulatory minimum. Their evidence suggests that most banks are influenced by regulation.

Marcus 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.

Keeley (1988a) looks at the response of bank holding companies to the increased capital requirements of the 1980s. Although capital-deficient banks increased their ratios more than did capital-sufficient banks in order to meet the guidelines in a book-value sense, market ratios increased for both classes of banks. However, the possibility of regulatory subsidies or taxes can influence the response of market-value capital ratios to increased capital guidelines, since the value of the subsidy to the bank can vary with leverage or asset risk. Keeley (1988b) claims that increased competition erodes the value of bank charters and thereby raises the incentives to increase leverage or to reduce capital ratios. Charter values should be reflected in market capital ratios, but not necessarily in book ratios.

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 focus on large banks affiliated with bank holding companies. They argue that tax considerations are not important in analyzing the capital structure of banks affiliated with holding companies, since 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 financial data for 11,000 banks and find strong evidence for market influences on leverage: Tax rates, risk, and nondebt tax shields significantly influence leverage. Gelfand and Hanweck use munis as their proxy for nondebt tax shields.

Prior to the Tax Reform Act of 1986 (TRA), banks had an advantage in the purchase of munis. Before August 7, 1986, they could deduct a portion of the interest expense associated with the purchase of these securities. In studies using a pre-TRA sample period, muni holdings seem to be related to taxable income, tax shields, and relative yields. Osterberg (1990) provides recent evidence regarding the determinants of banks' holdings of munis.

III. The Model

In this section, we set up a single-period model of optimal capital structure for a regulated banking firm that is an extension of the Bradley, Jarrell, and Kim (BJK [1984]) model of optimal capital structure for the nonregulated firm. We thus allow for both market and regulatory forces to influence bank leverage. Risk, in terms of the variance of returns, is assumed given, although it can influence the leverage decision. We also cannot control for the influence of regulatory subsidies, such as may be implied by fixed-rate deposit insurance. As in BJK, we assume that

1. Investors are risk-neutral.
2. The personal tax rate on returns from bank debt is t_{pb}.
3. The personal tax rate on equity and the marginal corporate tax rate are constant and t_{ps} and t_c, respectively.
4. All taxes are based on end-of-period wealth.
5. The firm's end-of-period tax liability can be reduced through nondebt tax shields, ϕ, which include investment tax credits and accelerated

depreciation. We also allow banks to shelter income from taxation by holding municipal debt.

6. Unused tax credits cannot be transferred across time or firms.
7. Positive costs associated with financial distress are incurred if banks cannot meet their end-of-period promised payments to depositors, $\hat{Y}$.
8. The end-of-period value of the bank before taxes and debt payments is $\tilde{X}$. If $\tilde{X}$ is less than $\hat{Y}$, then the the costs of financial distress reduce bank equity value by a factor of k.

In addition, we make the following assumptions:

9. Banks face an end-of-period capital requirement of $\delta = \hat{Y}d$.
10. In states of the world where $\tilde{X}-\hat{Y}$ is less than δ, a regulatory penalty reduces the return to stockholders by a constant fraction, λ.
11. All bank liabilities are <u>uninsured</u> deposits that mature at the end of the period.
12. The capital constraint, δ, is binding at end-of-period values of $\hat{X}$ where the tax shields, ϕ, are being fully utilized by the bank.

The reader is referred to BJK for a discussion of assumptions 1 through 8. Assumptions 9 and 10 are made to incorporate the effects of a regulatory capital requirement on the capital-structure decision of a bank. As in Buser et al. (1981), bank regulators use their regulatory powers to levy a tax or penalty on banks that fail to meet minimum capital requirements. Assumption 11 allows us to isolate the effects of capital requirements on optimal capital structure independent of the effects of deposit insurance. Thomson (1987) shows that assumption 11 is equivalent to assuming 100 percent deposit insurance when the insurance is fairly priced. To determine the sensitivity of the results to assumption 10, appendix A presents the model with 100 percent of bank liabilities covered by fixed-rate deposit insurance, where the deposit-insurance premium is zero. Finally, assumption 12 is made largely for convenience and ease of exposition. The alternative would be to assume that δ is binding for values of $\tilde{X}$ where $\phi > (\tilde{X}-\hat{Y})t_c$. As shown in appendix B, results of the analysis are not materially affected by this assumption.

Given the above assumptions, cash flows accruing to the bank's stockholders and depositors in each state at the end of the period are

$$(1) \qquad \tilde{Y}_s = \begin{cases} (\tilde{X} - \hat{Y})(1 - t_c) + \phi & \tilde{X} \geq \hat{Y} + \frac{\delta - \phi}{1 - t_c} \\ (1 - \lambda)[(\tilde{X} - \hat{Y})(1 - t_c) + \phi] & \hat{Y} + \frac{\phi}{t_c} \leq \tilde{X} < \hat{Y} + \frac{\delta - \phi}{1 - t_c} \\ (1 - \lambda)(\tilde{X} - \hat{Y}) & \hat{Y} \leq \tilde{X} < \hat{Y} + \frac{\phi}{t_c} \\ 0 & \tilde{X} < \hat{Y} \end{cases}$$

$$(2) \qquad \tilde{Y}_b = \begin{cases} \hat{Y} & \hat{Y} \leq \tilde{X} \\ \tilde{X}(1 - k) & 0 < \tilde{X} < \hat{Y} \\ 0 & \text{otherwise,} \end{cases}$$

where

$\tilde{Y}_s$, $\tilde{Y}_b$ = gross end-of-period cash flows accruing to stockholders and depositors of the bank, respectively,

$\hat{Y}$ = total end-of-period promised payment to depositors,

ϕ = total end-of-period after-tax value of nondebt tax shields if they are fully utilized,

k = cost of financial distress per dollar of end-of-period firm value,

δ = regulatory capital requirement at the end of the period,

λ = regulatory penalty (or tax) per dollar of end-of-period equity, and

d = parameter indicating the proportionate response of the capital requirement to an increase in debt, $\hat{Y}$.

In equation 1, regulators impose a tax of λ on the end-of-period equity of the firm if $\tilde{X}$ is below $\hat{Y}+(\delta-\phi)/(1-t_c)$, that is, if equity is insufficient to meet the capital requirement $\tilde{X}(1-t_c)+\phi-\hat{Y} < \delta$. As in BJK, nondebt tax shields exceed income taxes when $\tilde{X}$ is less than $\hat{Y}+\phi/t_c$. Equation 2 gives the end-of-period pre-tax flows to the depositors.

Under the assumption of risk neutrality, the after-tax values of the bank's equity (S) and deposits (B) at the beginning of the period are

$$(3)\quad S = \frac{E(\tilde{Y}_s)}{E(\tilde{r}_s)} = \frac{(1-t_{ps})}{r_0}\Big[\int_{\hat{Y}+\frac{\phi}{t_c}}^{\alpha} [(\tilde{X}-\hat{Y})(1-t_c)+\phi] f(\tilde{X})d\tilde{X} - \int_{\hat{Y}+\frac{\phi}{t_c}}^{\hat{Y}+\frac{\delta-\phi}{1-t_c}} \lambda[(\tilde{X}-\hat{Y})(1-t_c)+\phi] f(\tilde{X})d\tilde{X}$$

$$+ \int_{\hat{Y}}^{\hat{Y}+\frac{\phi}{t_c}} (1-\lambda)(\tilde{X}-\hat{Y}) f(\tilde{X})d\tilde{X} \Big]$$

$$(4)\quad B = \frac{E(\tilde{Y}_b)}{E(\tilde{r}_b)} = \frac{(1-t_{pb})}{r_0}\Big[\int_{\hat{Y}}^{\alpha} \hat{y} f(\tilde{X})d\tilde{X} + \int_0^{\hat{Y}} \tilde{X}(1-k) f(\tilde{X})d\tilde{X} \Big],$$

where

S,B = the market value of the bank's stock and deposits, respectively,

$E(\tilde{r}_s)$, $E(\tilde{r}_b)$ = one plus the expected pre-tax rate of return on stocks and deposits, respectively,

r_0 = one plus the rate of return on a risk-free tax-exempt bond, and

$f(\tilde{X})$ = probability density of $\tilde{X}$.

Following BJK, the market value of the banking firm is the sum of equations 3 and 4, the market value of its equity and deposits.

$$(5)\quad V = \frac{1}{r_0}\Bigg[\int_{\hat{Y}+\frac{\phi}{t_c}}^{\alpha} \{(1-t_{ps})[(\tilde{X}-\hat{Y})(1-t_c)+\phi]+(1-t_{pb})\hat{Y}\}f(\tilde{X})d\tilde{X}$$

$$- \int_{\hat{Y}+\frac{\phi}{t_c}}^{\hat{Y}+\frac{\delta-\phi}{1-t_c}} \lambda(1-t_{ps})[(\tilde{X}-\hat{Y})(1-t_c)+\phi]f(\tilde{X})d\tilde{X}$$

$$+ \int_{\hat{Y}}^{\hat{Y}+\frac{\phi}{t_c}} [(1-t_{ps})(1-\lambda)(\tilde{X}-\hat{Y})+(1-t_{pb})\hat{Y}]f(\tilde{X})d\tilde{X} + \int_{0}^{\hat{Y}} (1-t_{pb})(1-k)\tilde{X}f(\tilde{X})d\tilde{X} \Bigg]$$

The first integral in equation 5 is the expected value of the bank over the range of $\tilde{X}$ where the bank fully utilizes its nondebt tax shields. The second integral is 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. The third integral is the expected value of the bank over the range of $\tilde{X}$ where nondebt tax shields are no longer fully utilized. The last integral is the expected value of the bank when $\tilde{X}$ is not large enough to meet promised payments to depositors and k percent of the firm value is lost to financial distress.

The optimal leverage decision involves choosing the end-of-period promised payment to depositors, $\hat{Y}$, to maximize the value of the bank. The partial derivative of V with respect to $\hat{Y}$ is $V_{\hat{Y}}$ $(\partial V/\partial \hat{Y})$.

$$(6)\quad V_{\hat{Y}} = \frac{(1-t_{pb})}{r_0}\Big[1 - F(\hat{Y}) - k\hat{Y}f(\hat{Y}) \Big] + \frac{(1-t_{ps})}{r_0}\Big[-(1-t_c)\{1-F(\frac{\phi}{t_c}+\hat{Y})\} - \{F(\hat{Y}+\frac{\phi}{t_c}) - F(\hat{Y})\} - \lambda\Big(\{F(\hat{Y}+\frac{\phi}{t_c}) - F(\hat{Y})\} + (1-t_c)\{F(\hat{Y}+\frac{\delta-\phi}{1-t_c}) - F(\hat{Y}+\frac{\phi}{t_c})\} + [\delta + \frac{d(\delta-\phi)}{1-t_c}]f(\hat{Y}+\frac{\delta-\phi}{1-t_c}) \Big) \Big],$$

where $F(\cdot)$ is the cumulative probability density function of $\tilde{X}$. If $\lambda = 0$, then the last term in equation 6, $\lambda(\cdot)$, is zero and the resulting equation is identical to equation 6 in BJK. The first two components of $\lambda(\cdot)$ make up the expected after-tax regulatory penalty associated with issuing the last dollar of deposits. The last component of $\lambda(\cdot)$ is the marginal increase in the cost of equity capital from issuing the last dollar of deposits, $[\delta+d(\delta-\phi)/(1-t_c)]f(\hat{Y}+(\delta-\phi)/[1-t_c])$. Because all of the components of $\lambda(\cdot)$ are positive, the optimal leverage for a bank facing a possible capital penalty is less than it would be for the same bank without a capital constraint.

The effects of fixed-rate deposit insurance on a bank's optimal leverage can be seen by relaxing assumption 11 and assuming that 100 percent of deposits are insured. Subtracting equation 6 from $V_{\hat{Y}}$ in the fully insured case gives us $(1-t_{pb})[F(\hat{Y}) + k\hat{Y}f(\hat{Y})]/r_0$, which is positive. Under fixed-rate deposit insurance, the optimal $\hat{Y}$ for insured banks is greater than for uninsured banks for two reasons. First, with deposit insurance, the probability that depositors will not be paid in full, $F(\hat{Y})$, is zero.

Second, because the costs of financial distress are borne by the FDIC, the leverage-related costs, $k\hat{Y}f(\hat{Y})$, do not factor into the bank's capital-structure decision.

IV. Comparative Statics

Equation 6, the first-order necessary condition (FOC) for leverage, gives the optimal capital structure for a bank given d, ϕ, λ, k, t_c, t_{ps}, t_{pb}, and σ, where σ is the standard deviation of $\tilde{X}$ and we assume $\tilde{X} \sim N(\bar{X},\sigma^2)$. Differentiating the optimality condition (6) with respect to the above exogenous variables indicates how each affects optimal bank leverage.

Equation 7 gives the impact of a change in the capital requirement on the optimality condition for leverage.

$$(7) \quad V_{\hat{Y}d} = -\frac{\lambda(1-t_{ps})}{r_0(1-t_c)} f\left(\hat{Y}+\frac{\delta-\phi}{1-t_c}\right)\left[2\delta - \phi - \left(\hat{Y}\delta + \frac{\delta(\delta-\phi)}{1-t_c}\right)\frac{[\hat{Y}+\frac{\delta-\phi}{1-t_c}-\bar{X}]}{\sigma^2}\right] \gtrless 0$$

Equation 7 is negative whenever $\bar{X} \geq \hat{Y}+(\delta-\phi)/(1-t_c)$. That is, an increase in the capital requirement (through an increase in d) reduces leverage when the bank, on average, expects to be able to meet capital requirements. However, if capital requirements are set at a level a bank does not expect to be able to meet, on average, then the bank may actually increase its leverage in response to an increase in d.

The effect of an increase in nondebt tax shields, ϕ, on the optimality condition (6) is

$$(8)\quad V_{\hat{Y}\phi} = -\frac{1-t_{ps}}{r_0}\left[\,(1+\lambda)f(\hat{Y}+\frac{\phi}{t_c}) + \lambda f(\hat{Y}+\frac{\delta-\phi}{1-t_c})[1+\frac{d}{1-t_c} - (\delta+\frac{d(\delta-\phi)}{1-t_c})\frac{[\hat{Y}+\frac{\delta-\phi}{1-t_c}-\bar{X}]}{\sigma^2}\,\right] \gtrless 0.$$

Equation 8 is positive when $\bar{X} \geq \hat{Y}+(\delta-\phi)/(1-t_c)$. This may seem to be counter-intuitive. In the BJK model, an increase in ϕ reduces leverage. However, there is ambiguity here because the capital requirement is based on the after-tax value of equity, which includes the value of the shields, and 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.

Equation 9 shows that an increase in the regulatory penalty, λ, reduces bank leverage. Equation 10 demonstrates that an increase in the costs of financial distress, k, also reduces optimal leverage.

$$(9)\quad V_{\hat{Y}\lambda} = -\frac{1-t_{ps}}{r_0}\left[\,(1-t_c)(F(\hat{Y}+\frac{\delta-\phi}{1-t_c}) - F(\hat{Y}+\frac{\phi}{t_c})) + (\delta+\frac{d(\delta-\phi)}{1-t_c})f(\hat{Y}+\frac{\delta-\phi}{1-t_c})\,\right] < 0$$

$$(10)\quad V_{\hat{Y}k} = -(\frac{1-t_{pb}}{r_0})[\hat{y}f(\hat{Y})] < 0$$

The effects of changes in the various tax rates on the optimal level of debt are shown in equations 11, 12, and 13. In equation 11, the response of bank leverage to an increase in the marginal corporate tax rate is positive when $\bar{X} \geq \hat{Y}+(\delta-\phi)/(1-t_c)$. In other words, if expected end-of-period income is large enough to meet capital requirements, then an increase in t_c reduces the optimal level of debt. The ambiguous sign for $V_{\hat{Y}t_c}$ when $\bar{X}<\hat{Y}+(\delta-\phi)/(1-t_c)$ arises because the capital constraint is assumed to be binding when the bank's net tax bill is positive. There are two separate effects. First, an increase in t_c raises the value of the interest deduction on debt, which induces the bank to issue more deposits. Second, there is a reduction in the after-tax value of equity, which increases the probability that the capital constraint will be violated and also reduces leverage. When the bank does not expect to meet its end-of-period capital requirements, the sign of $V_{\hat{Y}t_c}$ depends on which effect dominates.

$$(11)\quad V_{\hat{Y}t_c} = \frac{1-t_{ps}}{r_0}\Big\{1-F(\hat{Y}+\frac{\phi}{t_c})) + \lambda(F(\hat{Y}+\frac{\delta-\phi}{1-t_c}) - F(\hat{Y}+\frac{\phi}{t_c})) + \frac{\phi(1-\lambda)}{t_c}f(\hat{Y}+\frac{\phi}{t_c})$$
$$+ \Big((1+\frac{d}{1-t_c})\frac{\lambda(\delta-\phi)}{1-t_c} - \frac{\lambda}{\sigma^2}[\delta+\frac{d(\delta-\phi)}{1-t_c}](\hat{Y}+\frac{\delta-\phi}{1-t_c}-\bar{X})\Big)f(\hat{Y}+\frac{\delta-\phi}{1-t_c})\Big] \gtrless 0$$

When λ equals zero (see BJK), equation 12 is unambiguously negative at the optimal level of debt. In addition, when all of the bank's deposits are insured, $V_{\hat{Y}t_{pb}}$ is unambiguously negative. However, for positive λ and no deposit insurance, equation 12 is negative for values of $\hat{Y}$ where the probability that $\hat{Y}$ is less than $\tilde{X}$ exceeds the marginal expected leverage-related costs. As in BJK, $V_{\hat{Y}t_{ps}}$ is unambiguously positive.

$$(12)\quad V_{\hat{Y}t_{pb}} = -\frac{1}{r_0}[1 - F(\hat{Y}) - k\hat{Y}f(\hat{Y})] \gtrless 0$$

$$(13)\quad V_{\hat{Y}t_{ps}} = \frac{1}{r_0}\Big[(1-t_c)(1-F(\frac{\phi}{t_c}+\hat{Y})) + (F(\hat{Y}+\frac{\phi}{t_c}) - F(\hat{Y})) + \lambda\Big((F(\hat{Y}+\frac{\phi}{t_c}) - F(\hat{Y})) + (1-t_c)(F(\hat{Y}+\frac{\delta-\phi}{1-t_c}) - F(\hat{Y}+\frac{\phi}{t_c})) + (\delta + \frac{d(\delta-\phi)}{1-t_c})f(\hat{Y}+\frac{\delta-\phi}{1-t_c}) \Big) \Big] > 0$$

Finally, the optimal level of deposits is a function of the variability of $\tilde{X}$. Equation 14 shows that an increase in σ has an ambiguous effect on optimal leverage. The sign of $V_{\hat{Y}\sigma}$ depends upon the proximity of $\hat{Y}$, $\hat{Y}+(\delta-\phi)/(1-t_c)$, and $\hat{Y}+\phi/t_c$ to the mean of $\tilde{X}$, as well as on the magnitudes of k, ϕ, d, and λ.

$$(14)\quad V_{\hat{Y}\sigma} = \frac{1-t_{pb}}{r_0\sigma}\Big[(\hat{Y}-\bar{X}) - k\hat{Y}((\frac{\hat{Y}-\bar{X}}{\sigma})^2-1) \Big] f(\hat{Y}) + \frac{1-t_{ps}}{r_0\sigma}\Big[((1-\lambda)t_c-2\lambda)(\frac{\phi}{t_c}+\hat{Y}-\bar{X})f(\hat{Y}+\frac{\phi}{t_c}) - (1-\lambda)f(\hat{Y})(\hat{Y}-\bar{X}) + \lambda f(\hat{Y}+\frac{\delta-\phi}{1-t_c})((1-t_c)(\hat{Y}+\frac{\delta-\phi}{1-t_c}-\bar{X}) - (\delta+\frac{d(\delta-\phi)}{1-t_c})[\Big(\frac{\hat{Y}+\frac{\delta-\phi}{1-t_c}-\bar{X}}{\sigma}\Big)^2-1] \Big] \gtrless 0$$

V. Municipal Securities and Optimal Leverage

In the model presented above, the level of nondebt tax shields influences the optimal $\hat{Y}$, since such shields substitute for the interest deduction allowable on bank debt. Munis provide an alternative with which banks can reduce tax payments. Gelfand and Hanweck (1987) use munis as proxies for nondebt tax shields, but this study views munis as substitutes for nondebt tax shields (such as investment tax credits and foreign tax credits) and allows for the simultaneous determination of muni holdings and leverage. Previous analyses of muni holdings support the view that banks adjust their muni portfolios to minimize tax liability given other nondebt tax shields (see Neubig and Sullivan [1987]). In fact, the interest-expense ratio, which is related to the level of debt, is a factor in determining muni holdings in such analyses.

To see how the factors influencing optimal leverage would influence muni demand, suppose the return $\tilde{X}$ were split between taxable returns ($\tilde{X}_T$) and tax-exempt returns ($\tilde{X}_M$). Then, if the proportion going into munis, $m = \tilde{X}_M/\tilde{X}_T$, were chosen so as to eliminate tax liability ($[\tilde{X}_T - \hat{Y}]t_c = \phi$), the share of munis would clearly be a function of nondebt tax shields, the corporate tax rate, total returns, and leverage:

$$(15)\ m = \tilde{X}/(\phi/t_c + \hat{Y}).$$

Unfortunately, the model we present assumes that portfolio composition is given. However, Osterberg (1990) suggests that the determinants of muni demand include income/assets, the difference between the yield on munis relative to taxable investments and a break-even ratio, the interest-expense ratio, and loan-loss provisions. In the next section, we propose an empirical model of the choice of leverage (LEV) that differs from previous analyses by considering simultaneity between LEV and muni holdings.

VI. An Empirical Model

The general structure of our empirical model is given in equations 16 and 17.

(16) LEV = L(m, t_c, ϕ, loan-loss provisions, σ, λ) + e_L

(17) m = m(LEV, t_c, ϕ, loan-loss provisions, σ, income, relative yield minus break-even ratio) + e_m

The actual capital requirement (d in our model) is excluded from the empirical analysis because the primary capital-asset ratio did not vary from 0.055 during our sample period. In each equation, we distinguish between ϕ and loan-loss provisions. Loan-loss provisions, which did not appear in our theoretical model, seem to be deductions from net income on financial statements. However, loan-loss provisions have been shown to be determinants of muni holdings and to sometimes signal asset quality. The penalty for violating the capital guideline, λ, is assumed to influence leverage but not muni demand. Here, we are implicitly assuming that $\lambda = k$, the cost of financial distress.

Income, given the availability of various tax shields, influences muni demand, but only indirectly influences leverage. The yield on munis relative to taxable investments minus a break-even ratio influences muni demand. The relative yield may also incorporate variations in personal tax rates, t_{pb} and t_{ps}, which are not included directly. Variance, σ, is allowed to influence both endogenous variables, and may impact muni demand by affecting uncertainty of income. e_L and e_m are residuals. The econometric specifications of the two equations are seen in equations 18 and 19.

(18) $LEV = \beta_{01} + \beta_{1m}m + \underline{\beta}_{1x}X_1 + \underline{\beta}_{1\lambda}\lambda X_1 + e_1$

(19) $m = \beta_{0m} + \beta_{11}LEV + \underline{\beta}_{mx}X_m + e_m$

where X_1 includes t_c, ϕ, and loan-loss provisions, and X_m includes t_c, ϕ, loan-loss provisions, income, and relative yield minus break-even ratio.

In order to capture some of the nonlinear interactions predicted by our comparative statics results, both the standard deviation of return, σ, and the regulatory penalty, λ, enter interactively. The standard deviation of return enters via the coefficients attached to X_1 and X_m. Each coefficient i in the vectors $\underline{\beta}_{1x}$ and $\underline{\beta}_{mx}$ is parameterized as

(20) $\beta_i = \alpha_i + \underline{\delta}_i\underline{q}$,

where $\underline{q}$ is a vector of risk proxies. Thus, risk influences the responses of LEV and m to other market determinants. This allows us to distinguish between the influences of risk and a regulatory penalty, although the possibility that a regulatory subsidy influences LEV cannot be ruled out.

The regulatory capital penalty influences the response of LEV to the market determinants in $\underline{\beta}_{1\lambda}$: t_c, ϕ, and loan-loss provisions. Thus, the impact of each determinant of LEV in X_L has three components: the direct effect, an effect that depends on the bank's risk, and an effect that depends on regulation.

VII. Data and Estimation

We utilize balance-sheet information supplied by Kuester and O'Brien (1989) for 232 bank holding companies for December 1986, June 1987, and December 1987. Twenty-six respondents from the sample were deleted because data were unavailable for items required to calculate some of our proxies. (Detailed information on our data manipulations is given in appendix C.) This section briefly describes the construction of our variables.

LEV is measured as the ratio between the book value of debt and the total of the market value of equity (see Kuester and O'Brien, p.14, for the construction of the market value of equity) and the book value of debt. m is calculated as the book value of munis divided by total assets. The variable for loan-loss provisions is measured as the ratio between loan-loss provisions and total assets, which we refer to as "llp." ϕ is measured as the total of investment tax credits and foreign tax credits divided by total assets. t_c is the highest corporate income-tax bracket in the state of incorporation. The calculations of income and relative yield minus the break-even ratio are described in more detail in appendix C. We note that the relative yield employed is a national-average ratio rather than a state-specific ratio. The list of variables considered as proxies for σ is given in appendix D. Our q variables are all calculated as the difference between the particular balance-sheet ratio for holding company i at time j, and the mean ratio for all banks over the three periods. This allows us to interpret the α's as responses of the dependent variable to the independent variables at the mean of the risk measures.

Our proxy for λ, the regulatory penalty, is calculated as the difference between the holding company's primary capital-asset ratio and the average ratio for all holding companies at the same time. This peer-group-standard approach is similar to that of Marcus (1983). In effect, the response of LEV to changes in t_c, ϕ, and loan-loss provisions is dependent on the holding company's capital-asset ratio relative to its peers.

We utilize iterative three-stage least squares (3SLS) for all three reporting periods both separately and combined. Initially, all of the X's and the products of the q's with the X's were considered as instruments. However, employing the collinearity diagnostics suggested by Belsley, Kuh, and Welsch (1980), we found excessive collinearity. (Our procedure is described in appendix D.) As a result, we exclude a subset of the products of q's with the X's.

VIII. Results

Panels A and B of table I contain the 3SLS estimation results (using SHAZAM) for our model for each separate year and for the pooled sample. Panel A contains the results from the leverage equation, and panel B contains the results from the muni equation. A comparison of our 3SLS results with those obtained using ordinary least-squares (OLS) indicates significant simultaneity bias in the OLS results and lends support to our simultaneous equations approach.

As expected, the coefficient on m in panel A is negative and significant in all four regressions. Since munis can substitute for interest expenses in shielding income, higher levels of munis will be associated with less leverage. Similar reasoning explains the negative sign on LEV in the m equation for the entire sample. However, it is somewhat puzzling that the coefficient on m for the December 1986 reporting period is smaller in absolute value than it is for the other periods, because TRA reduced the demand for munis after 1986. It is possible that portfolio rebalancing by banks in reaction to TRA introduced noise into the relationship between m and LEV in the December 1986 regressions, thereby reducing the measured relationship between them. The positive and insignificant coefficient on LEV in panel B for December 1986 is consistent with this explanation.

In the leverage equation, the coefficient on t_c is negative and significant for all of the regressions. The average effect of a higher corporate income-tax rate is a reduction in leverage. In our model, the sign of the relationship is ambiguous because, while a higher tax rate increases the value of the interest deduction, it also decreases the value of equity and thus increases the probability of violating the guidelines. The interactive term involving the regulatory penalty and t_c should have captured the latter effect. Our result on the average effect of t_c differs from that of Marcus (1983), who found that the expected sign on his measure of the tax incentive increased leverage. However, we divide the influence of t_c into three separate channels.

The coefficient on ϕ is negative and significant in the pooled regression and supports the DeAngelo and Masulis (1980) hypothesis that nondebt tax shields are a substitute for interest tax shields. However, the coefficient on ϕ is insignificant, with a sign that differs between subperiods. Our theory implies that an increase in ϕ may not always reduce leverage if nondebt tax shields can be used to meet capital guidelines. Of course, in our estimation, ϕ is allowed to influence m directly and via its interaction with risk, and then to influence LEV through three separate channels.

The interactive effect of t_c and regulation on LEV is only significant for the first subperiod. We note that, for nonregulated firms, BJK found a positive and significant relationship between nondebt tax shields and leverage.

Finally, the positive sign on the coefficient of loan-loss provisions is consistent with banks' use of these provisions to signal the true quality of their asset portfolio and the income-smoothing hypothesis (see Greenwalt and Sinkey [1988]); it is inconsistent with the view of provisions as alternative shields. Since 1987, net charge-offs have been the more appropriate measure of bad-debt deductions. Prior to that time, the deduction included an addition to the bad-debt reserve. However, the negative and significant sign on provisions in the muni equation for the entire sample and for December 1986 may capture any role of provisions as a proxy for the bad-debt deduction.

Risk directly affects leverage interactively with t_c, ϕ, and loan-loss provisions. Risk also influences LEV indirectly through m, since the second equation contains interactive risk measures. While some of the coefficients on the interactive risk measures for both the leverage and muni equations are significant, we have no interest in the individual interactions. Table II indicates that we reject the restriction that the interactive risk measures are jointly zero at the 1 percent significance level. In other words, the response of leverage to a change in m, t_c, ϕ, or loan-loss provisions is a function of the risk of the institution.

All three interactive regulatory penalty measures are significant for the entire sample. Only the interaction of bank capital standards with ϕ is insignificant for any of the subperiods. Table II indicates that we reject the restriction that the coefficients on the regulatory penalty measures are jointly zero at the 1 percent significance level in all sample periods. In other words, the response of leverage to changes in tax provisions or to other market determinants depends on the bank's capital position relative to its peers. The magnitude of the coefficients on the interactive terms relative to the direct effects suggests that the response of leverage to a change in t_c, ϕ, or loan-loss provisions is larger (smaller) for banks with high (low) capital relative to their peers.

In the muni equation, the positive signs for income and yield are as expected. Higher income requires more munis as shields. Purchases of munis after 1986 reduced tax benefits, but nonetheless, banks increased their muni holdings that year, apparently in anticipation of a need to shelter income. Although only significant in December 1986, higher nondebt tax shields or provisions reduce muni demand. The results for June 1987 and December 1987 indicate that banks located in states with high corporate tax rates have lower muni holdings. This is somewhat surprising, since these banks would be expected to have a greater demand for all types of shields. We note, however, that our yield minus break-even ratio does not incorporate state-specific information.

IX. Conclusion

Using a modified version of the BJK optimal-capital-structure model, we show how regulatory and market influences may interact in the determination of bank leverage. The influence of capital regulation on leverage may be nonlinear, depending on market determinants such as tax rates, tax shields, and variance of returns.

The theoretical analysis yields some surprising conclusions. First, increased capital requirements may not reduce leverage, and banks not expecting to meet the guidelines may respond perversely. Second, higher levels of nondebt tax shields may not reduce a bank's leverage if such shields can help to meet the guidelines. Third, a change in the corporate tax rate may have an unexpected influence on leverage through altering the probability that a bank will meet capital guidelines.

Empirically, we allow for nonlinearity by modeling the influence of market determinants on leverage as operating directly, indirectly with risk, and indirectly with regulation. Our results demonstrate that it is important to control for the endogeneity of the muni holdings of banks. To do this, we set up a two-equation system and use 3SLS. This differs from the approach of Gelfand and Hanweck (1987), who use munis as proxies for tax shields. Our results show that both book capital regulation and portfolio risk influence the market leverage of banks. We cannot claim to have addressed Keeley's (1988b) concern and controlled for the influence of risk on a regulatory subsidy. However, contrary to the results of Wall and Peterson (1988b), our results provide important support for considering market influences on bank leverage. Tax rates, nondebt tax shields, and loan-loss provisions impact the leverage decisions of banks.

Table I
Iterative 3SLS Estimation of LEV, m System

sample	all	Dec. 1986	June 1987	Dec. 1987
variables				
Panel A: Dependent Variable-LEV				
intercept	0.983	0.948	0.961	0.975
	(.066)**	(.006)**	(.008)**	(.007)**
m	-0.875	-0.345	-0.700	-0.640
	(.091)**	(.063)**	(.091)**	(.086)**
t_c	-0.359	-0.436	-0.321	-0.297
	(.043)**	(.059)**	(.073)**	(.066)**
ϕ	-13.614	8.308	1.277	-15.876
	(6.456)**	(13.65)	(28.02)	(27.48)
llp	1.570	2.421	2.649	1.929
	(.270)**	(.530)**	(.495)**	(.467)**
interactive risk measures:				
$q5*t_c$	2.348	0.814	3.572	2.707
	(0.724)**	(1.22)	(1.22)**	(1.00)**
q5*llp	-1.559	19.01	2.548	11.706
	(9.758)	(14.87)	(19.56)	(13.57)
q6*llp	-14.593	68.035	-20.95	18.657
	(8.181)*	(29.08)**	(10.98)*	(21.55)
$q7*t_c$	-11.435	1.303	-16.87	-3.340
	(3.442)**	(4.83)	(4.80)**	(7.843)
$q9*\phi$	749.78	2462.3	2670.3	-2413.2
	(961.2)	(1003.1)**	(5221.6)	(3689.7)
$q11*t_c$	-0.344	-0.174	-0.329	-0.349
	(0.115)**	(.169)	(.214)	(.169)**
$q11*\phi$	13.001	15.590	-8.644	163.34
	(49.58)	(59.55)	(103.7)	(157.38)
$q14*t_c$	-0.002	0.070	0.011	0.019
	(.052)	(.074)	(.096)	(.082)
$q14*\phi$	39.602	76.321	-3.219	-18.300
	(15.99)	(25.90)**	(45.18)	(62.479)
q14*llp	0.501	-0.231	1.587	-0.120
	(0.470)	(.770)	(1.131)	(.885)
$q15*t_c$	0.105	0.010	0.077	0.043
	(.083)	(.122)	(.167)	(.122)
$q20*t_c$	0.038	0.053	0.369	0.026
	(.231)	(.294)	(.451)	(.359)
$q20*\phi$	55.069	273.79	-77.06	164.34
	(85.01)	(162.4)*	(189.8)	(219.1)

Table I (continued)

interactive regulatory penalty measures:				
$qr*t_c$	-8.058	-10.407	-5.204	-7.524
	(.868)**	(1.253)**	(1.596)**	(1.601)**
$qr*\phi$	-85.578	1375.3	24.201	-2286.7
	(347.4)	(731.6)*	(874.5)	(1727.5)
qr*llp	19.43	11.669	31.509	26.911
	(3.94)**	(6.727)*	(9.184)**	(9.959)**
Total observations	696	232	232	232

Table I (continued)
Iterative 3SLS Estimation of LEV, m System

sample	all	Dec. 1986	June 1987	Dec. 1987
variables				
Panel B: Dependent Variable-m				
intercept	0.215	-0.406	0.380	0.249
	(.079)**	(.161)**	(.139)**	(.152)
LEV	-0.183	0.451	-0.367	-0.217
	(.084)**	(.167)	(.148)**	(.160)
t_c	-0.082	-0.068	-0.141	-0.181
	(.045)	(.070)	(.077)*	(.069)**
ϕ	-8.835	-29.679	-29.925	-19.823
	(5.714)	(10.72)**	(27.52)	(22.12)
llp	-0.407	-3.948	0.606	-0.847
	(.218)*	(.906)**	(.432)	(.557)
income	1.332	4.511	2.423	2.165
	(.275)**	(.939)**	(.644)**	(.547)**
yield	0.109	0.199	0.268	0.184
	(.016)**	(.074)**	(.075)**	(.077)**
interactive risk measures:				
q1*yield	0.024	-1.280	0.706	0.633
	(.069)	(.156)**	(.158)**	(.130)**
q2*yield	0.083	-0.358	0.155	0.099
	(.100)	(.277)	(.178)	(.154)
q5*t_c	0.798	1.273	-0.078	-0.587
	(.884)	(1.975)	(1.61)	(1.76)
q5*llp	-19.789	-37.395	-44.485	-22.941
	(10.00)**	(21.96)*	(2.31)**	(20.04)
q5*income	-4.466	-10.462	51.605	-8.655
	(6.247)	(22.63)	(17.80)**	(14.12)
q5*yield	0.258	0.881	5.303	-1.724
	(.636)	(2.50)	(2.41)**	(3.14)
q6*llp	-11.226	-110.1	-9.790	52.443
	(7.907)	(61.36)*	(11.53)	(25.82)**
q6*yield	-0.252	2.523	2.383	3.689
	(1.033)	(3.96)	(2.17)	(1.85)**
q7*t_c	-8.128	-24.067	-13.230	-17.576
	(3.378)**	(11.29)**	(5.95)**	(9.15)**
q7*yield	-7.239	22.525	-2.012	-17.211
	(2.241)**	(11.76)*	(4.64)	(7.83)**

Table I (continued)

q9*ϕ	-822.38	-1074.4	-3949.5	-335.84
	(878.3)	(1333.6)	(4770.1)	(3453.5)
q11*t_c	-0.151	0.689	0.235	0.435
	(.115)	(.340)**	(.259)	(.273)
q11*ϕ	17.229	-43.13	-39.449	-104.97
	(47.20)	(70.15)	(95.84)	(138.3)
q11*yield	0.114	-0.552	0.331	0.594
	(.088)	(.352)	(.232)	(.233)**
q14*t_c	-0.059	0.099	-0.031	-0.039
	(.076)	(.187)	(.122)	(.122)
q14*ϕ	7.180	-13.008	-10.761	-59.781
	(15.58)	(33.06)	(35.48)	(57.7)
q14*11p	0.042	2.893	-0.239	0.607
	(.458)	(1.378)**	(1.25)	(1.03)
q14*income	0.113	-2.855	-0.621	-1.871
	(.415)	(1.598)*	(.906)	(.906)**
q14*yield	-0.037	0.478	-0.278	-0.350
	(.038)	(.179)**	(.147)*	(.164)**
q15*t_c	0.149	-0.324	0.449	0.028
	(.137)	(.393)	(.253)*	(.274)
q15*ϕ	-7.287	63.734	6.714	-80.75
	(48.70)	(89.50)	(123.9)	(78.85)
q15*income	-0.333	5.288	-3.317	-2.369
	(.718)	(2.678)*	(1.484)**	(1.71)
q15*yield	0.077	-0.492	-0.340	-0.583
	(.074)	(.349)	(.274)	(.288)**
q20*t_c	0.754	0.887	1.162	0.720
	(.384)**	(1.104)	(.697)*	(.696)
q20*ϕ	170.10	132.42	-5.104	210.56
	(81.93)**	(168.6)	(174.8)	(211.3)
q20*income	-7.740	-18.861	-8.455	-6.557
	(2.213)**	(5.011)**	(4.69)*	(3.37)*
q20*yield	0.280	0.335	0.813	-0.435
	(.183)	(.813)	(.514)	(.585)
q21*yield	0.384	-4.242	1.888	2.127
	(.181)**	(0.413)**	(.411)**	(.373)**
q22*yield	0.265	-4.366	2.419	2.317
	(.231)	(.476)**	(.612)**	(.509)**
q23*income	-4.555	2.161	-3.767	-6.900
	(.960)**	(3.241)	(2.088)*	(2.65)**
q23*yield	-0.260	-1.048	-0.677	-0.746
	(.150)*	(.645)	(.360)*	(.4224)*

* Significant at the 10 percent confidence level.
** Significant at the 5 percent confidence level.
NOTE: Standard errors are in parentheses.
SOURCE: Authors' calculations.

Table II
Hypothesis Tests of the Impact of Capital Standards and Risk

Hypothesis C1: There is no channel through which regulatory capital standards influence leverage, that is, all of the coefficients on the regulatory capital measure equal zero.

Hypothesis R1: There is no channel through which risk influences leverage, that is, all of the coefficients on the risk measures equal zero.

sample	all	Dec. 1986	June 1987	Dec. 1987
C1:				
F-statistic	30.588**	25.327**	5.488**	8.699**
(d.f.)	(3,1332)	(3,404)	(3,404)	(3,404)
Wald Chi-Squared	91.762**	75.981**	16.464**	26.097**
(d.f)	(3)	(3)	(3)	(3)
R1:				
F-statistic	2.709**	6.557**	2.414**	2.154**
(d.f.)	(3,1332)	(31,404)	(31,404)	(31,404)
Wald Chi-Squared	83.966**	203.274**	74.842**	66.759**
(d.f.)	(31)	(31)	(31)	(31)

** Significant at the 1 percent level.
SOURCE: Authors' calculations.

Appendix A

With 100% Fixed-Rate, Zero-Premium Deposit Insurance

Given assumptions 1 through 10 and 12, and that 100 percent of bank liabilities are insured with a flat-rate insurance premium of zero, cash returns to the stockholders and depositors in each state at the end of the period are given by equations 1a and 2a.

$$\text{(1a)} \quad \tilde{Y}_s = \begin{cases} (\tilde{X} - \hat{Y})(1 - t_c) + \phi & \hat{Y} \le \tilde{X} + \dfrac{\phi}{t_c} \\ \tilde{X} - \hat{Y} & \hat{Y} + \dfrac{\delta - \phi}{1 - t_c} \le \tilde{X} < \hat{Y} + \dfrac{\phi}{t_c} \\ (1 - \lambda)(\tilde{X} - \hat{Y}) & \hat{Y} \le \tilde{X} < \hat{Y} + \dfrac{\delta - \phi}{1 - t_c} \\ 0 & \tilde{X} < \hat{Y} \end{cases}$$

$$\text{(2a)} \quad \tilde{Y}_b = \hat{Y}$$

where

$\tilde{Y}_s$, $\tilde{Y}_b$ = gross end-of-period cash flows to 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 if they are fully utilized,

δ = regulatory capital requirement at the end of the period, and

ϕ = regulatory penalty per dollar of end-of-period equity.

The beginning-of-period values of equity (S) and deposits (B) are

$$\text{(3a)} \quad S = \frac{E(\tilde{Y}_s)}{E(\tilde{r}_s)} = \frac{(1-t_{ps})}{r_0}\left[\int_{\hat{Y}+\frac{\phi}{t_c}}^{\infty} [(\tilde{X}-\hat{Y})(1-t_c)+\phi] f(\tilde{X}) d\tilde{X} - \int_{\hat{Y}+\frac{\phi}{t_c}}^{\hat{Y}+\frac{\delta-\phi}{1-t_c}} \lambda[(\tilde{X}-\hat{Y})(1-t_c)+\phi] f(\tilde{X}) d\tilde{X} \right.$$

$$\left. + \int_{\hat{Y}}^{\hat{Y}+\frac{\phi}{t_c}} (1-\lambda)(\tilde{X}-\hat{Y}) f(\tilde{X}) d\tilde{X} \right]$$

$$\text{(4a)} \quad B = \frac{\hat{Y}(1-t_{pb})}{r_0}$$

The total value of the bank is V = S + B.

$$\text{(5a)}\quad V = \frac{E(\tilde{Y}_s)}{E(\tilde{r}_s)} = \frac{(1-t_{ps})}{r_0}\Big[\int_{\hat{Y}+\frac{\phi}{t_c}}^{\infty}[(\tilde{X}-\hat{Y})(1-t_c)+\phi]f(\tilde{X})d\tilde{X} - \int_{\hat{Y}+\frac{\phi}{t_c}}^{\hat{Y}+\frac{\delta-\phi}{1-t_c}}\lambda[(\tilde{X}-\hat{Y})(1-t_c)+\phi]f(\tilde{X})d\tilde{X}$$

$$+ \int_{\hat{Y}}^{\hat{Y}+\frac{\phi}{t_c}}(1-\lambda)(\tilde{X}-\hat{Y})f(\tilde{X})d\tilde{X}\Big] + \frac{\hat{Y}(1-t_{pb})}{r_0}$$

Comparative Statics

The optimal amount of bank debt, $\hat{Y}$, is implied by the first-order condition, $V_{\hat{Y}} = 0$.

$$\text{(6a)}\quad V_{\hat{Y}} = \frac{(1-t_{pb})}{r_0} + \frac{(1-t_{ps})}{r_0}\Big[-(1-t_c)[1-F(\frac{\phi}{t_c}+\hat{Y})] - (1-\lambda)\{F(\hat{Y}+\frac{\phi}{t_c}) - F(\hat{Y})\}$$

$$- \lambda\Big(\,(1-t_c)\{F(\hat{Y}+\frac{\delta-\phi}{1-t_c}) - F(\hat{Y}+\frac{\phi}{t_c})\} + \{\delta + \frac{d(\delta-\phi)}{1-t_c}\}f(\frac{\delta-\phi}{1-t_c}+\hat{Y})\,\Big)\Big]$$

Equations 7a to 14a indicate how the optimal leverage implied by equation 6a responds to d, ϕ, λ, k, t_c, t_{ps}, t_{pb}, and σ [where σ is the standard deviation of $f(\tilde{X})$ and we assume $\tilde{X} \sim N(\bar{X},\sigma^2)$], respectively.

$$\text{(7a)}\quad V_{\hat{Y}d} = -\frac{\lambda(1-t_{ps})}{r_0(1-t_c)}f(\hat{Y}+\frac{\delta-\phi}{1-t_c})\Big[2\delta - \phi - (\hat{Y}\delta + \frac{\delta(\delta-\phi)}{1-t_c})\frac{[\hat{Y}+\frac{\delta-\phi}{1-t_c}-\bar{X}]}{\sigma^2}\Big] \gtrless 0$$

$$(8a)\quad V_{\hat{Y}\phi} = -\frac{1-t_{ps}}{r_0}\Big[\,(1+\lambda)f(\hat{Y}+\frac{\phi}{t_c}) + \lambda f(\hat{Y}+\frac{\delta-\phi}{1-t_c})[1+\frac{d}{1-t_c} - (\delta+\frac{d(\delta-\phi)}{1-t_c})\frac{[\hat{Y}+\frac{\delta-\phi}{1-t_c}-\bar{X}]}{\sigma^2}\,\Big] \gtrless 0$$

$$(9a)\quad V_{\hat{Y}\lambda} = -\frac{1-t_{ps}}{r_0}\Big[\,(1-t_c)\{F(\hat{Y}+\frac{\delta-\phi}{1-t_c}) - F(\hat{Y}+\frac{\phi}{t_c})\} + (\delta+\frac{d(\delta-\phi)}{1-t_c})f(\hat{Y}+\frac{\delta-\phi}{1-t_c})\,\Big] < 0$$

$$(10a)\quad V_{\hat{Y}k} = 0$$

$$(11a)\quad V_{\hat{Y}t_c} = \frac{1-t_{ps}}{r_0}\Big[\,\{1 - F(\hat{Y}+\frac{\phi}{t_c})\} + \lambda\{F(\hat{Y}+\frac{\delta-\phi}{1-t_c}) - F(\hat{Y}+\frac{\phi}{t_c})\} + \frac{\phi(1-\lambda)}{t_c}f(\hat{Y}+\frac{\phi}{t_c})$$

$$+ \Big\{\,(1+\frac{d}{1-t_c})\frac{\lambda(\delta-\phi)}{1-t_c} - \frac{\lambda}{\sigma^2}[\delta+\frac{d(\delta-\phi)}{1-t_c}](\hat{Y}+\frac{\delta-\phi}{1-t_c}-\bar{X})\,\Big\}f(\hat{Y}+\frac{\delta-\phi}{1-t_c})\,\Big] \gtrless 0$$

$$(12a)\quad V_{\hat{Y}t_{pb}} = -\frac{1}{r_0} < \gtrless 0$$

$$(13a)\quad V_{\hat{Y}t_{ps}} = \frac{1}{r_0}\Big[\,(1-t_c)\{1-F(\frac{\phi}{t_c}+\hat{Y})\} + \{F(\hat{Y}+\frac{\phi}{t_c}) - F(\hat{Y})\} + \lambda\Big\{\,\{F(\hat{Y}+\frac{\phi}{t_c}) - F(\hat{Y})\}$$

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

$$(14a)\quad V_{\hat{Y}\sigma} = \frac{1-t_{ps}}{r_0\sigma}\Big[\,\{(1-\lambda)t_c-2\lambda\}(\frac{\phi}{t_c}+\hat{Y}-\bar{X})f(\hat{Y}+\frac{\phi}{t_c}) - (1-\lambda)f(\hat{Y})(\hat{Y}-\bar{X})$$

$$+ \lambda f(\hat{Y}+\frac{\delta-\phi}{1-t_c})\{(1-t_c)(\hat{Y}+\frac{\delta-\phi}{1-t_c}-\bar{X}) - (\delta+\frac{d(\delta-\phi)}{1-t_c})[\,\Big(\frac{\hat{Y}+\frac{\delta-\phi}{1-t_c}-\bar{X}}{\sigma}\Big)^2-1]\,\Big] \gtrless 0$$

Appendix B
Comparative Statics When $\phi/t_c > \delta$

With the additional assumption that the capital constraint is binding in those states of the world where the bank pays no taxes, the returns to bank stockholders and depositors are indicated in equations 1b and 2b, respectively.

$$\text{(1b)}\quad \tilde{Y}_s = \begin{cases} (\tilde{X} - \hat{Y})(1 - t_c) + \phi & \hat{Y} \le \tilde{X} + \dfrac{\phi}{t_c} \\ \tilde{X} - \hat{Y} & \hat{Y} + \delta \le \tilde{X} < \hat{Y} + \dfrac{\phi}{t_c} \\ (1 - \lambda)(\tilde{X} - \hat{Y}) & \hat{Y} \le \tilde{X} < \hat{Y} + \delta \\ 0 & \tilde{X} < \hat{Y} \end{cases}$$

$$\text{(2b)}\quad \tilde{Y}_b = \begin{cases} \hat{Y} & \hat{Y} \le \tilde{X} \\ \tilde{X}(1 - k) & 0 < \tilde{X} < \hat{Y} \\ 0 & \text{otherwise,} \end{cases}$$

where

$\tilde{Y}_s$, $\tilde{Y}_b$ = gross end-of-period cash flows to bank's 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,

k = cost of financial distress per dollar of the end-of-period debt value,

δ = regulatory capital requirement at the end of the period, and

ϕ = regulatory penalty (or tax) per dollar of end-of-period equity.

The beginning-of-period values of stock, deposits, and total bank value are given by equations 3b, 4b, and 5b.

$$\text{(3b)}\quad S = \frac{E(y_s)}{E(r_s)} = \frac{(1-t_{ps})}{r_0}\Big[\int_{\hat{Y}+\frac{\phi}{t_c}}^{\infty} [(\tilde{X}-\hat{Y})(1-t_c)+\phi] f(\tilde{X})d\tilde{X} + \int_{\hat{Y}+\delta}^{\hat{Y}+\frac{\phi}{t_c}} (\tilde{X}-\hat{Y}) f(\tilde{X})d\tilde{X}$$

$$+ \int_{\hat{Y}}^{\hat{Y}+\delta} (1-\lambda)(\tilde{X}-\hat{Y}) f(\tilde{X})d\tilde{X} \Big]$$

(4b) $$B = \frac{E(\tilde{Y}_b)}{E(\tilde{r}_b)} = \frac{(1-t_{pb})}{r_0}\left[\int_{\hat{Y}}^{\alpha} \hat{y} f(\tilde{X}) d\tilde{X} + \int_{0}^{\hat{Y}} \tilde{X}(1-k) f(\tilde{X}) d\tilde{X} \right]$$

(5b) $$V = \frac{E(y_s)}{E(r_s)} = \frac{(1-t_{ps})}{r_0}\left[\int_{\hat{Y}+\frac{\phi}{t_c}}^{\alpha} [(\tilde{X}-\hat{Y})(1-t_c)+\phi] f(\tilde{X}) d\tilde{X} + \int_{\hat{Y}+\delta}^{\hat{Y}+\frac{\phi}{t_c}} (\tilde{X}-\hat{Y}) f(\tilde{X}) d\tilde{X} \right.$$

$$\left. + \int_{\hat{Y}}^{\hat{Y}+\delta} (1-\lambda)(\tilde{X}-\hat{Y}) f(\tilde{X}) d\tilde{X} \right] + \frac{(1-t_{pb})}{r_0}\left[\int_{\hat{Y}}^{\alpha} \hat{y} f(\tilde{X}) d\tilde{X} \quad \int_{0}^{\hat{Y}} \tilde{X}(1-k) f(\tilde{X}) d\tilde{X} \right]$$

Comparative Statics

Optimal leverage for the bank is given by equation 6b.

(6b) $$V_{\hat{Y}} = \frac{(1-t_{pb})}{r_0}\left[1 - F(\hat{Y}) - k\hat{Y}f(\hat{Y}) \right] + \frac{(1-t_{ps})}{r_0}\left[-(1-t_c)[1-F(\frac{\phi}{t_c}+\hat{Y})] \right.$$

$$\left. - [F(\hat{Y}+\frac{\phi}{t_c}) - F(\hat{Y})] - \lambda\left(\delta(1+d)f(\hat{Y}+\delta) + [F(\hat{Y}+\delta) - F(\hat{Y})] \right) \right]$$

Equations 7b to 14b indicate how the optimal leverage responds to changes in d, ϕ, λ, k, t_c, t_{ps}, t_{pb}, and σ, respectively.

(7b) $$V_{\hat{Y}d} = -\frac{1-t_{ps}}{r_0} f(\hat{Y}\frac{\phi}{t_c}) < 0$$

(8b) $$V_{\hat{Y}\phi} = -\frac{\lambda(1-t_{ps})}{r_0}\left[2[\hat{Y}+\delta] - \delta(\hat{Y}+\delta)\frac{\hat{Y}+\delta-\bar{X}}{\sigma^2} \right] f(\hat{Y}+\delta) \gtrless 0$$

(9b) $$V_{\hat{Y}\lambda} = -\frac{1-t_{ps}}{r_0}\left[\{F(\hat{Y}+\frac{\phi}{t_c})-F(\hat{Y})\} + \delta(1+d)f(\hat{Y}+\delta) \right] < 0$$

(10b) $$V_{\hat{Y}k} = -\left(\frac{1-t_{pb}}{r_0}\right)[\hat{y}f(\hat{Y})] < 0$$

(11b) $$V_{\hat{Y}t_c} = \frac{1-t_{ps}}{r_0}\left[\{1-\{F(\hat{Y}+\frac{\phi}{t_c})\} + \frac{\phi}{t_c}f(\hat{Y}+\frac{\phi}{t_c}) \right] > 0$$

(12b) $$V_{\hat{Y}t_{pb}} = -\frac{1}{r_0}[1 - F(\hat{Y}) - k\hat{Y}f(\hat{Y})] \gtrless 0$$

(13b) $$V_{\hat{Y}t_{ps}} = \frac{1}{r_0}\Big[(1-t_c)[1-F(\hat{Y}+\frac{\phi}{t_c})] + \{F(\hat{Y}+\frac{\phi}{t_c})-F(\hat{Y})\}$$
$$- \lambda\delta(1+d)f(\hat{Y}+\delta) + \lambda[F(\hat{Y}+\delta)-F(\hat{Y})] \Big] > 0$$

(14b) $$V_{\hat{Y}\sigma} = \frac{1-t_{pb}}{r_0\sigma}\left[(\hat{Y}-\bar{X}) - k\hat{Y}\{(\frac{\hat{Y}-\bar{X}}{\sigma})^2-1\} \right] f(\hat{Y}) + \frac{1-t_{ps}}{r_0\sigma}\Big[t_c f(\hat{Y}+\frac{\phi}{t_c})(\hat{Y}+\frac{\phi}{t_c}-\bar{X})$$
$$- (1+\lambda)f(\hat{Y})(\hat{Y}-\bar{X}) + \lambda f(\hat{Y}+\delta)(\hat{Y}+\delta-\bar{X} - \delta(1+d)[\left(\frac{\hat{Y}+\delta-\bar{X}}{\sigma}\right)^2 - 1] \Big] \gtrless 0$$

Appendix C

Data Manipulations and Variable Definitions

Data manipulations

Most of the data were generously supplied to us by Kathleen Kuester and James O'Brien. Except for market values of equity, the original data were reported on Y-9 reports, the Consolidated Financial Statements for Bank Holding Companies. Market values of equity included common stock, preferred stock, certificates, rights, and warrants. Prices used were end-of-month data. See Kuester and O'Brien (1989, p.14) for more detail regarding these calculations. State-specific marginal corporate income-tax rates were taken from Significant Facts About Fiscal Federalism (Advisory Council on Intergovernmental Relations, 1987 and 1988).

We use quarterly balance-sheet (Y-9) data for three periods: December 1986, June 1987, and December 1987. Stock measures are values at the end of each six months. Income-statement items are year-to-date. We divide the December 1986 income numbers in half and replace December 1987 flows by the difference between December and June.

Our final sample includes 232 bank holding companies for the three periods. Suspicious data items for which bank holding companies were removed from the sample include: negative values for investment tax credits, foreign tax credits, tax-exempt lease income, and negative values for loan-loss provisions. In our calculation of q15 (which should be less than 1.0), we replace values exceeding 1.0 with their inverse. In addition, if the denominator of q14 or q15 is zero, we set each ratio equal to zero.

Variable definitions

LEV - total liabilities/total liabilities + market value of equity

m - securities issued by state and political subdivisions/total assets

t_c - marginal corporate tax rate (from Significant Facts About Fiscal Federalism

ϕ - estimated investment tax credit + estimated foreign tax credit/ total assets

llp - loan-loss provisions/total assets

σ - financial ratios listed in appendix D

λ - the difference between bank i's capital-asset ratio at time j and the average ratio for all banks at time j, where the ratio is calculated as equity capital + minority interest in consolidated subsidiaries + mandatory convertible securities + allowance for loan and lease losses/total assets

yield - relative yield minus break-even ratio, where

relative yield - the ratio between the yields on 10-year munis and 10-year Treasuries, and

break-even ratio - 1 - t*[1-b*(id/yield on Treasuries)], where

t - federal marginal corporate tax rate

b - interest expense disallowance ratio

id - interest expense/total assets

income - MAX(0,gti)/total assets, where

gti - income before extraordinary items + income taxes - gains on securities not in trading accounts + loan-loss provisions + interest expense disallowed as a deduction (bid, described below) + net charge-offs + recapture of loan-loss reserves (recapllr, described below) + grossed-up tax-exempt income (gtei, described below)

bid = (b * interest expense * munis * tax-exempt income [described below])/income on munis * total assets

tax-exempt income = income on munis + income on tax-exempt leases + income on tax-exempt loans

gtei = (tax-exempt income) * (1/relative yield - 1)

recapllr = recapture of loan-loss reserves required of some banks by the TRA. For any banks with December 1986 total assets of less than $500 million or with a problem loan ratio in excess of 0.75, this number equals zero.

problem loan ratio = total nonaccrual loans and lease financing receivables + loans 90 days past due but still accruing + restructured loans/ equity capital, where both numerator and denominator are the sum of the December 1986 and December 1987 items so that this is the average ratio for 1987

Banks not meeting either exception must include (recapture) into 1987 income at least 10 percent of December 1986 loan-loss reserves. Banks may recapture more than 10 percent in 1987. We assume that banks will recapture more than 10 percent if such a recapture still leaves them with negative income, that is, if December 1987 net income + 0.10 * December 1986 loan loss reserves < 0 recapture will equal min(-net income, loan-loss reserve), since banks cannot recapture more than the available reserve. We assume that any recapture is split equally between the two halves of 1987.

Appendix D

How We Chose Our Proxies for Risk

In our framework, σ (the standard deviation of $\tilde{X}$) influences $\hat{Y}$ via its interaction with the other independent variables. Thus, our risk proxies appear in multiplicative form. We follow Kuester and O'Brien (1989) and parameterize the coefficient on each independent variable as $\beta_i = \alpha_i + \underline{\delta}_i\underline{q}$, where β_i is the response of the dependent variable to independent variable i, and $\underline{q}$ is the vector of risk proxies, all of which are mean-deleted. As indicated by Kuester and O'Brien, this setup implies that the α_i coefficient can be interpreted as the response of the dependent variable at the mean of the risk measures. This parameterization also implies that each independent variable appears only on the right side and is multiplied by each risk proxy.

We consider 21 proxies for risk, testing for potentially damaging collinearity. First, we apply our diagnostic procedure to the matrix of q's and delete several q's from the subsequent analysis. Note that choosing a principal component would complicate the interpretation of the coefficients. However, with only the non-σ independent variables in the estimating equations, we find there is still too much collinearity among the instruments, which include (1) the intercept, (2) each independent variable appearing in equations 16 and 17, and (3) the product of the remaining q's and the independent variables. Applying the same diagnostics to that instrument matrix leaves us with the variables in table I.

The list of q's initially included 21 variables defined as follows:

q1) proportion of securities held as U.S. Treasuries

q2) proportion of real estate loans to total loans

q3) proportion of loans to domestic commercial and industrial customers

q4) proportion of loans to all types of commercial and industrial customers

q5) proportion of loans to agricultural customers

q6) proportion of loans to foreign governments and official institutions

q7) proportion of loans that are at least 90 days past due and still accruing

q8) proportion of loans that are nonaccrual

q9) proportion between net charge-offs and total loans

q10) proportion between loan-loss provisions and total loans

q11) proportion of securities with a remaining maturity of one year or less

q12) proportion of total assets that reprice or mature within one year

q13) proportion between interest-bearing deposit liabilities that reprice or mature within one year and total interest-bearing deposits

q14) proportion of long-term debt that is repriced within one year

q15) proportion of long-term debt that matures within one year

q20) ratio between noninterest income and the total of interest income and noninterest income q21) = loan-to-total-asset ratio

q22) = proportion of total assets that are liquid

q23) = ratio between volatile liabilities and total assets

q24) = proportion of total assets that are current

q25) = ratio between current liabilities and total assets

The first fifteen variables are similar to those analyzed by Kuester and O'Brien, while the last six are additional proxies for interest-rate risk.

The diagnostic procedure we employ is suggested by Belsley, Kuh, and Welsch (BKW, [1980]). The matrix analyzed includes an intercept and the difference between each q and its mean. As suggested by BKW, all variables are scaled so that they have length equal to one. Although BKW suggest that the variates be analyzed in level form, in our estimation procedure, the q's do not enter in level form; in fact, they only enter after having been multiplied by other variables.

In the first step, we examine the condition indexes: Any index over 30 is associated with a too-harmful linear dependency. In the second step, we examine the matrix of variance decomposition proportions and identify the variables most closely involved in those dependencies. There are 74 indexes over 30. We then calculate the proportions of the variances of each coefficient that are explained by these 74 dependencies and eliminate the 74 variables involving q's that are most closely associated with these dependencies.

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