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Bank Capital Requirements and Capital Structure

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Abstract

This paper studies the impact of capital requirements, deposit insurance and tax benefits on a bank's capital structure. We find that properly regulated banks voluntarily choose to maintain capital in excess of the minimum required. Central to this decision is both tax advantaged debt (a source of firm franchise value) and the ability of regulators to place banks in receivership stripping equity holders of firm value. These features of our model help explain both the capital structure of the large mortgage Government Sponsored Enterprises and the recent increase in risk taking through leverage by financial institutions.

Journal of Economic Literature Classification: G21, G28, G32, G38, M48

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1. Introduction

The current financial crisis illustrates that highly leveraged capital structures are a significant source of risk for financial institutions and for society as a whole.[1] Banks, as financial intermediaries, are different than other firms. Significantly, banks have the unique benefit of being able to issue federally insured debt; but they also bear the cost of capital regulations, including the threat of being placed in receivership and wiping out the investment of the shareholders. Banks also manage financial, rather than physical, assets implying lower bankruptcy costs than industrial firms. This paper examines how these special characteristics influence the optimal capital structure of banks.

Earlier studies of bank capital structure have generated conflicting predictions. First, traditional moral hazard theory has been applied to predict that banks with deposit insurance will choose extremely high levels of leverage (Keeley 1980, Marshall and Prescott 2000, Gueyie and Lai 2003)[2] because the insurance premium does not reflect or adapt to the underlying risk of the insured's activities.[3] Meanwhile, casual observation of banks' choices of capital structure indicates that banks do not operate with capital ratios equal to the regulated minimum. The insurance premium paid by banks for deposit insurance is only one component of the total regulatory cost associated with deposit insurance and other studies that consider these regulatory costs generally predict that banks will not choose high leverage. Buser, Chen and Kane (1981) point out that banks face significant costs that are not explicitly priced attributable to regulations, investment restrictions and monitoring. Merton (1978) develops a contingent claims model of

[1] Since the seminal work of Modigliani and Miller (1958), many papers including Jensen and Meckling (1976), Myers and Majiluf (1984), Myers (1984), and Fama and French (2002) have examined the capital decisions of forward looking firms using models that balance the benefits and costs of additional debt.
[2] Another explanation for banks choosing high leverage is offered by Diamond and Rajan (2000) and Diamond (2001) who consider the optimal capital structure of banks as the result of the tradeoff between liquidity creation, costs of bank distress, and the ability to force borrower repayment.
[3] Insured deposits represent one of the lowest cost capital sources for banks and, in recent years, most solvent banks have paid almost no premium for their insurance.

bank leverage that includes explicit regulatory costs for insolvent banks. He shows that this regulatory burden can be significant enough to create a preference for equity among solvent banks. Based on Merton's model, Marcus (1984) explicitly examines bank capital structure under capital regulation and argues that "for solvent banks, increases in capital are wealth-increasing, while for sufficiently insolvent banks, capital withdrawals increase owner's wealth."

These results are unsatisfying in the sense that for solvent banks (and most operating banks are solvent), these models suggest the opposite corner solution (all equity financing) than did the moral hazard models, and both corner solutions are clearly inconsistent with actual bank capital choices. The purpose of the Merton and Marcus papers was to demonstrate the importance of the regulatory burden associated with deposit insurance for bank capital decisions. The Merton and Marcus models, however, exclude consideration of a significant benefit—the value of possible future insurance payments. Accordingly, while the models above demonstrate the importance of either moral hazard or capital regulation, they do not support policy-motivated analyses because their predictions are at odds with empirical regularities.

In the one exception to this pattern, Elizdale and Repullo (2007) develop a model of bank capital structure where banks enjoy a franchise value associated with borrowing at the risk free rate, but if the bank experiences a loss, the owners must infuse additional capital sufficient to reset its capital to the optimal start of period ratio, or if the loss is severe enough, the bank is closed by the regulator or owners.[4] However, Elizdale and Repullo's (2007) model allows banks to freely recapitalize every period undoing the additional risk of dissolution created by a series of negative shocks. Under their model, banks are not required to plan ahead for the risk associated with the possibility of multiple periods of negative shocks that slowly erode a bank's capital

[4] The bank's profitability each period is stochastic representing the loss from bad loans, and the authors numerically solve the resulting Bellman equation for various parameterizations of the problem. The authors also derive a limited number of comparative static results.

position. The recent financial crisis emphasizes the importance of considering models that do not allow for the recapitalization of financial firms in response to negative shocks.

Our paper builds upon the general model of firm capital structure developed by Leland (1994) to provide a comprehensive framework of bank capital structure decisions under a deposit insurance system. Leland derives a closed-form expression for the optimal capital structure of a firm that issues risky debt in the presence of bankruptcy costs and tax-advantaged debt. In our model, we consider a scenario where the bank can borrow or take deposits at the risk free rate because those deposits are insured by the government, but the bank faces an insolvency threshold that is established by a regulator where capital regulations require the liquidation of the bank when the capital ratio falls below the threshold.[5,6] Like Elizdale and Repullo (2007), our model also reflects a balancing of benefits and costs that result in an interior solution, but banks in our model, as in Leland's, face a one-time decision concerning capital structure. While this may initially sound unduly restrictive, there are significant frictions that prevent continuous capital rebalancing and most banks are not able to return to the market period after period to recapitalize the bank in response to losses - especially during economic downturns. Our model reasonably represents a world where banks when determining capital structure must plan for adverse economic environments in which capital cannot be easily raised.[7]

We find that there exists an interior optimal capital ratio in banks with deposit insurance, a minimum capital ratio and tax-advantaged debt. That is, banks voluntarily choose to hold

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[5] This case is similar in spirit to both the regulatory burden considered by Elizdale and Repullo (2007) and Leland's model of protected debt.
[6] We extend this model to analyze two capital thresholds: a high "warning" level and a lower insolvency level where the bank is liquidated. We find that the additional warning threshold has only a small impact on the optimal level of leverage, even with substantial warning costs. This finding further emphasizes the importance of the threat of forced liquidation when considering the effectiveness of capital regulation; see Harding, Liang, and Ross (2007).
[7] Unlike Elizdale and Repullo (2007), we find that a bank may choose all equity, i.e. zero debt or deposits in models without tax advantaged debt. This difference does not arise from a fundamental difference between the models, but rather because in our model the regulator liquidation threshold is a policy parameter that can be selected.

capital in excess of the required minimum. This does not mean that minimum capital requirements are ineffective. Rigid capital requirements threaten all banks with the prospect of losing the value of their equity if the bank violates the requirement as the result of random fluctuations in asset values. Accordingly, banks choose capital ratios well above the minimum requirement to maximize the expected value of their equity. If there were no capital requirements, banks would choose a corner solution with very high leverage. Hence the real function of capital requirements is to create a cost of insolvency that replaces bankruptcy costs in the establishment of an optimal firm capital structure.

Tax-advantaged debt is central to the existence of an interior optimal capital ratio. Bankruptcy costs and insurance benefits are small relative to tax benefits and move together with changes in deposits while tax benefits create a large franchise value that is put at risk by capital regulation. This finding is comparable to results of Marcus (1984)[8] and Hellman, Murdock, and Stiglitz (2000)[9] who document an important role for Charter or franchise value in understanding the impact of capital standards on bank risk taking behavior.

The remainder of this paper is organized as follows. Section 2 develops a model of the capital structure of banks, and section 3 analyzes the bank's optimal capital structure. Section 4 considers the implications of this model for regulatory policy, and the last section summarizes the main conclusions.

2. Bank Capital Structure with Deposit Insurance and Capital Regulation

In developing our model of the capital structure of banks, we follow the derivation of Leland (1994). In Leland's framework, a firm's assets are financed with a combination of debt

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[8] Marcus extends his model to consider the value of a bank's charter finding that this extension reinforces his prediction that solvent banks should choose low leverage. Hughes, Lang, Moon and Pagano (2003) find empirical evidence in support of Marcus's proposition about the importance of charter value.

[9] Hellman, Murdock, and Stiglitz focus on the risk arising from the investment portfolio choice of banks. Also see Caprio and Summers (1996) on the importance of franchise value.

and equity. Uncertainty enters the model because the firm's assets are assumed to evolve stochastically. To assure that the stochastic process for the assets is unaffected by the capital structure choices of the firm, debt service payments are made by selling additional equity.[10] This implies that the face value of deposits is static over time. In applying this framework to banks, we assume that banks have only one form of debt — fully insured deposits and that these deposits are deemed by investors to be riskless. Consistent with recent experience in the U.S., we further assume that banks do not pay an insurance premium for deposit insurance.[11] Under these assumptions, banks pay the riskless rate on all deposits. As in Leland, we assume that values evolve continuously and that the firm's capital structure decision is summarized by its choice of a promised continuous payment C.[12]

We assume that the firm's portfolio of assets, V, comprises continuously traded financial securities[13], the market value of which follows a standard geometric Brownian motion process:

$$dV = \mu V dt + \sigma V dW \tag{1}$$

Following Cox, Ingersoll and Ross (1985) and assuming a fixed riskless rate r, a claim, F(V,t), with a continuous payment, C, must satisfy the standard partial differential equation (with boundary conditions determined by payments at maturity and/or time of insolvency):

$$\frac{1}{2}\sigma^2 V^2 F_{VV} + rVF_V + F_t - rF + C = 0 \tag{2}$$

[10] Although this assumption allows firms to raise some capital during an economic downturn, the firms are not able to recapitalize after negative shocks and so face increased likelihood of involuntary closure by regulators.

[11] Incorporating an insurance premium calculated as a fixed percentage of the face value of the insured deposits is straightforward and does not materially change the results discussed here.

[12] Consider an investor who is forming a bank. We assume that the firm's initial book of assets, V, is fixed and the bank owner must choose how to best finance those assets—with either debt or equity. In our framework, the bank assets are fixed and the owner must first choose the optimal amount of deposits to issue to the public. The bank's owner must then contribute the remaining funds needed to purchase the initial assets. We assume that, as a practical matter, local market conditions and federal regulations impose upper bounds on firm size.

[13] A bank's assets comprise two major categories: loans and securities. While the assumption of active trading is valid for the securities component, we assume that the loan component is perfectly correlated with some actively traded benchmark security. We believe this assumption is reasonable given the close linkage between loan rates and capital market rates.

While, in general, this partial differential equation does not have a closed form solution for arbitrary boundary conditions, if $F_t=0$, then equation (2) becomes an ordinary differential equation with the general solution:

$$F(V) = A_0 + A_1 V + A_2 V^{-X} \tag{3}$$

where $X=2r/\sigma^2$ and A_0, A_1 and A_2 are determined by the boundary conditions. In the context of corporate debt (Leland, 1994), the assumption $F_t=0$ can be justified by considering only long maturity debt or debt that is continuously rolled over at a fixed rate or a fixed spread to a benchmark rate.[14] The latter justification is also applicable to banks. Ever though most bank deposits technically have short maturities, as long as the bank is solvent and maintains competitive pricing, it can rollover deposits at the riskless rate because depositors do not have an incentive to monitor a bank's financial condition. For example, although demand deposits can be withdrawn at any time by the customer, in bank acquisitions, these deposits are generally viewed as a long-term, stable source of funds and hence part of the charter value of the bank.

Using the general solution in equation (3), we can obtain an expression for the major claims that influence the market value of a firm including the current market value of potential bankruptcy costs (BC), of tax benefits associated with debt financing (TB), and of a new claim not considered by Leland the insurance provided by the federal government (IB). These costs can be viewed as a contingent claim on V, and we define the market value of the bank, v, as

$$v = V - BC(V) + TB(V) + IB(V) \tag{4}$$

2.1. Bankruptcy Costs

To apply equation (3) to value bankruptcy costs, we need to identify the appropriate boundary conditions that reflect the actual payments associated with the claim. When a bank

[14] See Leland (1994) for a detailed explanation, and Leland and Toft (1996) for a model with finite maturity debt.

becomes insolvent, its assets are liquidated. The liquidation is triggered when the value of the firm's assets, V(t), falls to a specified level, V_B. For our current purpose, it does not matter how V_B is set—only that it is an observable constant. We assume that when liquidation occurs, the firm will receive a fraction of the current market value of the assets, $(1-\alpha)V_B$, where $0<\alpha<1$. The inability to realize full market value can be attributed to the need for large bulk sales in a short time and problems of asymmetric information associated with the sale of loans. The second boundary condition is established by the fact that as V(t) gets very large, the possibility of liquidation becomes increasingly remote and the market value of the bankruptcy costs approaches zero. We thus have the following two boundary conditions:

$$BC(V) = \alpha V_B, \text{ when } V = V_B$$
$$BC(V) = 0, \quad \text{as} \quad V \to \infty$$

Using these conditions with equation (3) results in the following expression for BC(V):

$$BC(V) = \alpha V_B \left(\frac{V}{V_B}\right)^{-X}, \text{ where } X = {}^{2r}\!/\!_{\sigma^2} \tag{5}$$

The term $\left({}^{V}\!/\!_{V_B}\right)^{-X}$ can be interpreted as the present value of \$1 payable when the random variable V(t) first reaches V_B. With this interpretation, the market value of bankruptcy costs can be viewed as the expected present value of the deadweight costs associated with liquidation, αV_B.

2.2. Tax Benefits

According to the U.S. tax code, interest payments are deductible from corporate earnings when computing a firm's corporate income tax. Thus each dollar of interest paid results in a savings in taxes for a taxpaying firm equal to its marginal tax rate times the interest paid. Following Leland (1994), we assume that tax benefits for a solvent firm are proportional to the interest payment on its debt and are terminated at the insolvency threshold, V_B.[15] Thus, the market value of future tax benefits is zero when V hits V_B. For the second boundary condition, we again consider the case as V gets very large. As V increases relative to V_B, the likelihood of insolvency declines and the possibility of losing the tax benefits becomes remote. In this case, the tax benefits have a market value equal to the present value of a continuously paid perpetuity of τC, where τ represents the marginal tax rate and C denotes the continuously paid interest on the debt. Therefore the boundary conditions for valuing the tax benefits are:

$$TB(V) = 0, \qquad \text{when } V = V_B$$
$$TB(V) = \frac{\tau C}{r}, \qquad \text{as} \quad V \to \infty$$

Using these conditions with equation (3) results in the following expression for the market value of tax benefits:

$$TB(V) = \tau C \big/ r \left(1 - \left(\frac{V}{V_B} \right)^{-X} \right) \tag{6}$$

which is unambiguously positive for $V > V_B$.

2.3. Insurance Benefits

Deposit insurance covers the gap between the realizable value of assets and the face value of deposits if a bank must be liquidated. Thus, when $V=V_B$, the insurer must pay the Max[(D-(1-α)V_B),0], where D is the face value of deposits. Given the earlier assumptions and denoting the promised, continuous, interest payment as C, then the market value of the debt is simply D = C/r. However, when V becomes very large and the likelihood of insolvency declines, the market

[15] Because the tax deductibility of interest requires that the firm have taxable income, immediate tax benefits may decline or disappear in the face of negative shocks to a bank's portfolio. However, banks likely still have expectations of future tax benefits based on future positive shocks, plus the tax code provides firms that are currently not utilizing their tax benefits limited flexibility to carry taxable losses forward until they return to profitability.

value of the insurance payment claim falls to zero. Therefore, we have the following boundary conditions for the insurance benefit:

$$IB(V) = Max[\left(C/_r - (1-\alpha)V_B\right),0] \qquad \text{when } V = V_B$$
$$IB(V) = 0, \qquad \text{as} \quad V \to \infty$$

The market value of the insurance benefit claim is:

$$IB(V) = Max[\left(\left(C/_r\right) - (1-\alpha)V_B\right)\left(\frac{V}{V_B}\right)^{-X},0] \tag{7}$$

As long as the insolvency threshold satisfies, $V_B < \frac{C/_r}{(1-\alpha)}$, the insurance payment will be greater than zero and the max operator can be ignored in equation (7). If $V_B > \frac{C/_r}{(1-\alpha)}$, the market value of insurance benefits is uniformly zero because the bank is always closed before the recoverable value of the bank assets falls below the face value of the debt. When the insolvency threshold is determined by the regulator, it is reasonable to assume that the regulator will also set $V_B \leq \frac{C/_r}{(1-\alpha)}$ since a higher threshold totally eliminates all insurance benefits and thus makes the provision of insurance irrelevant.[16]

Conditional on $V_B \leq \frac{C/_r}{(1-\alpha)}$,

$$IB(V) - BC(V) = (C/_r - V_B)\left(\frac{V}{V_B}\right)^{-X} \tag{8}$$

[16] Harding, Liang, and Ross (2007) show that when the bank is free to select V_B, it will choose a level strictly less than C/r and so the value of insurance benefits is strictly positive in that case.

The canceling out of the term αV_B in equation (8) confirms that deposit insurance has the effect of transferring the burden of bankruptcy costs from the firm to the insurer. In this case, the deadweight cost factor, α, does not affect the overall firm value in the presence of deposit insurance.

2.4. Firm and Equity Value

Substituting equations (5), (6) and (7) into the expression for the market value of the bank gives the following:

$$v(V) = V + TB(V) - BC(V) + IB(V) = V + \left[\left(1-\tau\right)\frac{C}{r}\right) - V_B\right]\left(\frac{V}{V_B}\right)^{-X} + \frac{\tau C}{r} \qquad (9)$$

Since v(V) must equal the sum of the market values of debt and equity and under our assumptions D(V)=C/r, the market value of equity is simply the market value of the firm less C/r. Thus,

$$E(V) = V + TB(V) - BC(V) + IB(V) - \frac{C}{r} = V + \left[\left((1-\tau)\frac{C}{r}\right) - V_B\right]\left(\frac{V}{V_B}\right)^{-X} - (1-\tau)\frac{C}{r} \qquad (10)$$

2.5. Capital Regulation of Banks

Bank capital requirements have grown increasingly complex in recent years and generally include a requirement to hold "capital" that reflects the risk of the exposures held by the bank, termed "risk-weighted" assets.[17] Two categories of capital are defined in the regulations, Tier I and Tier II. Tier I capital includes paid-in-capital, common stock, retained earnings, noncumulative preferred stock and certain other elements and is closest to the notion

[17] In the Basel I framework, banks were required to hold capital for each unit of risk-weighted assets. To calculate a bank's risk-weighted assets, one multiplied each category of assets by a factor that reflected the credit risk of that type of assets. The factors ranged from 0 to 1. In addition, certain off-balance sheet activities (e.g., letters of credit and derivatives) also contribute to the sum of risk-weighted assets. For most banks, the risk weighted assets total less than the book value of their assets. In recent years, bank regulators from major countries have been working on a new accord (Basel II) that is now largely in place. Basel II updates the risk weights for many institutions and requires the largest institutions to develop their own measures of risk.

used in this paper of capital as equity. Tier II capital includes Tier I capital plus subordinated debt, loss reserves, cumulative preferred stock and certain other debt instruments that are subordinate in priority to deposits. Under Basel II, a bank must maintain Tier I capital that exceeds four percent of risk-weighted assets and total Tier I and II capital that exceeds eight percent of its book assets.

We consider a simplified version of these regulations where a bank is required to maintain the market value of its assets, V, above some threshold that is related to the face value of its deposits.[18] That is, the bank is required to maintain $V>\beta D$, where the parameter β measures the stringency of the capital requirement. We assume a single capital threshold[19] and further assume that the bank is liquidated if it does not meet the specified requirement—i.e., when V first falls to βD or $\beta(C/r)$. Therefore, once the bank chooses D, βD can be viewed as the insolvency threshold.[20] This regulatory environment can be expressed in the more traditional language of minimum capital requirements and maximum leverage using the basic accounting identity that $V=D+Eq$, where Eq denotes the book value of equity not the market value of equity, E(V). A requirement to maintain a minimum capital ratio can be thought of as requiring (Eq/V) to remain above the specified threshold $\underline{c}$. Using the accounting identity, this establishes a maximum leverage ratio, $D/V<1-\underline{c}=\ell^*$ and, in turn, that $V>D/1-\underline{c}$. Thus, $\beta=1/1-\underline{c}$.

Thus, if we set $V_B=\frac{\beta C}{r}$ and substitute into equation (9), we have:

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[18] This simplified regulation structure is equivalent to considering a bank that only has Tier I capital and a low risk portfolio for which the book assets capital ratio is the binding constraint.

[19] As mentioned earlier, we also extend this model to analyze the case with two regulator thresholds. The higher warning threshold results in increased monitoring and scrutiny that imposes additional costs on the bank, but the bank continues to hold a claim on the value of bank equity. See Harding, Liang, and Ross (2007).

[20] Note that $\beta=1$ is equivalent to Leland's (1994) case of protected debt. For the regulatory constraint on capital to have any effect, $\beta>\frac{X}{1+X}$, where $X=\frac{2r}{\sigma^2}$. If β were set below this level, it would have no effect on the bank because it would be below the insolvency threshold the bank would select in the absence of capital regulation. See Harding, Liang, and Ross (2007) for a derivation of the optimal bankruptcy threshold for banks.

$$v(V) = V + IB(V) - BC(V) + TB(V) = V + \left[\tau - k\left(\frac{C}{V}\right)^X \right]\left(\frac{C}{r}\right), \text{ where}$$

$$\mathrm{k} = (\tau + \beta - 1)\left(\frac{\beta}{\mathrm{r}}\right)^X \qquad (11)$$

Depending on the magnitudes of τ and β, k can be positive, negative or zero. In practice, however, we expect (τ + β)>1[21] and thus we expect that k>0. In fact, as will be seen later in equation (13), an interior optimal value of C does not exist if k≤0. With k>0, the sign of the second term in equation (11) is indeterminate and the market value of the firm can be greater than or less than the value of its assets, V, depending on the magnitudes of C and β.

3. Optimal Capital Structure of Banks

3.1. Determining the Firm's optimal Choice of Leverage

As in Leland (1994), we consider a value maximizing bank.[22] First, consider a world without tax advantaged debt where τ is set to zero in equation (11). The bank's optimal choice of C and hence leverage depends in a "knife-edge" way on k and therefore on the capital regulation standard β because with τ=0, k=β-1. When β>1, the market value of the bank, v(V) is a monotonic decreasing function of the coupon payment, C,[23] and the bank is liquidated before V falls below the market value of deposits and thus while the shareholders still have positive

[21] For example, τ should be on the order of 0.2 to 0.4 and β should be close to one if not greater than one to avoid an insurance payout in excess of bankruptcy costs in the event of insolvency.

[22] In our model, firm value and equity value differ by the term -C/r. Thus for a fixed r, there is no difference between choosing the coupon payment that sets the partial derivative of the firm value equal to zero, and choosing the coupon that sets the derivative of equity equal to -1/r. Since firm value is fixed and the coupon determines the value of debt, this condition maximizes the current value of equity. Specifically, adding a dollar to the coupon increases initial debt and decreases initial equity investment by -1/r, and so a change in the value of equity of -1/r is consistent with no change in the value of existing equity.

[23] Note that $\frac{\partial v}{\partial C} = -\frac{p}{r} V^{-X} (1 + X) C^{X} < 0, \text{for c} > 0.$ This effect can also be seen in equation (11) with V_B>C/r. The second term on the right hand side of the equation is negative, implying an expected loss from liquidation, net of the insurance benefits

equity. This equity is wiped out by the liquidation. The "cost" to the equity holders from this expected loss exceeds the market value of the small insurance payout when $\beta>1$.[24] When $\beta<1$, the value of the bank decreases with the coupon payment C because the value of the insurance benefits contingent claim always exceeds the market value of the bankruptcy cost contingent claim, and the bank prefers the highest leverage possible.[25]

The model without tax advantaged debt is both of intrinsic interest and helps illustrate the importance of tax advantaged debt in the firm's capital structure choices. First, historically, many depository institutions in the U.S. have been granted tax provisions that lower effective tax rates or been exempt from the income tax. For example, federally chartered savings and loan associations were originally exempt from taxation and subsequently were granted special tax provisions (e.g., bad debt provisions) that lowered their effective tax rate. Currently, credit unions are the only major group of depositories that are exempt from the corporate income tax. Second, as will be seen below, the introduction of tax advantaged debt yields an interior optimum for the capital structure problem even when firms would have rationally chosen all debt without tax advantaged debt.

To find the optimal value of C (and hence the optimal leverage) in general,[26] we calculate the first two derivatives of v with respect to C.

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[24] With a tax rate of zero, the model contains two contingent claims: bankruptcy costs that favor equity financing and insurance benefits that favor debt financing, and both claims pay off when the firm's assets, V, reach V_B.

[25] A value of $\underline{c}<0$ or $\beta<1$ can arise if the definition of capital is based on an inappropriate accounting method. For example, if the available capital is based on the historical cost (e.g., book value) of assets and not the market value, then even though the technical capital regulation calls for positive capital, the effective capital requirement can be negative. This type of situation arose in the early 1980s when savings and loan associations were allowed to operate with negative market value of equity. Their rapid growth funded with new deposits in that era is consistent with the prediction of our model.

[26] As in Leland, our model can be solved with an endogenous bankruptcy threshold for the no capital regulation case. Without capital regulation, the model always implies that the bank uses all debt financing consistent with moral hazard from deposit insurance. The solution is shown in Harding, Liang, and Ross (2007) and is analogous to the derivation of Leland's smooth pasting condition.

$$
\begin{aligned}
\frac{\partial v}{\partial C} &= \frac{\tau}{r} - (1+X)\left(\frac{k}{r}\right)\left(\frac{C}{V}\right)^{X} \\
\frac{\partial^2 v}{\partial C^2} &= -X(1+X)\left(\frac{k}{r}\right)V^{-X}C^{X-1}
\end{aligned} \tag{12}
$$

The second derivative is negative for k>0 and so the market value of the bank is a strictly concave function of C. Further, k is positive for fairly weak regulatory standards where β is well below one. Setting the first derivative equal to zero and solving for the optimal C*, yields:[27]

$$C^{*} = gV(0), \text{where g} = \left[\frac{\tau}{k(1+X)}\right]^{\frac{1}{X}} \tag{13}$$

Finally, substituting C* into equation (10) yields the initial market value of the firm.

$$v^{*}(V) = V\left(1 + \tfrac{X}{1+X}\left(\tau\ell^{*}\right)\right) \tag{14}$$

The interior optimum ℓ^* exists because at low levels of leverage, adding additional debt increases the value of the firm by increasing the tax benefits while adding little to the net of expected bankruptcy costs and insurance benefits since insolvency is remote. However, as leverage increases, the incremental immediate tax benefits are outweighed by the risk to future tax benefits resulting from the possibility future insolvency.[28] It is notable that tax advantaged debt, typically thought of as a debt favoring factor, creates a firm franchise value that causes banks to hold substantial equity even under regulatory regimes that would have led banks to select all debt in the absence of tax advantaged debt.

Figure 1 demonstrates the balancing of insurance benefits, tax benefits and bankruptcy costs as a function of the bank's choice of C at time zero under the assumptions indicated at the

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[27] The optimal coupon C* is set at time zero based on the initial value of the firm. The value of the firm evolves over time, but these time subscripts have been suppressed throughout the paper since the model investigates the one time capital structure decision of a forward looking firm. Note also that ℓ*, the optimal initial leverage is equal to $\frac{C^*}{rV(0)}$ and thus g, the optimal payout rate is equal to rℓ*.

[28] An interior optimal capital structure exists even with a fairly weak capital standard, as long as 1/(1-α)>β>1-τ.

top of the figure. The high concave (solid) line represents the market value of the tax benefits, the convex (dash-dotted) line represents the bankruptcy costs, and the dashed line represents the insurance benefits. All three values are plotted against the coupon payment C. The figure shows that tax benefits increase sharply with C when the resulting leverage are low. However, at higher levels of leverage, the tax benefits begin to decline as the result of the increased likelihood of insolvency. Tax benefits are zero when $V_B=V$ (or $C=rV/\beta$). The figure also points out the critical role that the tax benefits play in determining the optimal leverage because they are relatively much larger than either of the other claims over much of the relevant range for C. With β set conservatively at 1.05, the bankruptcy costs increase with C more rapidly than do the insurance benefits, but the net insurance benefit is small over the entire range of C.

Consistent with an interior optimum value of ℓ^*, banks voluntarily choose a level of deposits that is significantly less than the maximum permitted under the capital regulation. Without strict capital regulation and the resulting threat of early liquidation and the loss of franchise value, banks with insurance benefits would seek to take on as much leverage as possible. The combination of a capital requirement and the threat of liquidation with the potential for significant loss creates an incentive for banks to limit their use of deposits.

3.2. Factors that Influence Optimal Capital Structure

C as a function of r.* The optimal coupon C* is monotonically increasing in g, and g is an increasing function of the riskless rate r (a decreasing function σ and β), as long as $\beta>1-\tau$.[29] A decrease in r (increase in σ and β) leads to a higher likelihood of insolvency, *ceteris paribus*, and so lead the bank to select a lower coupon rate.

[29] The results for the riskless rate and volatility of assets also require the assumption that $\log(1+X)>1/X$ where $X=2r/\sigma^2$. This assumption is satisfied whenever $2r/\sigma^2>1$, which is a fairly standard assumption in financial models.

The parameter g can also be thought of as an optimal "asset payout rate" to debt holders from the bank's financial assets V, and as noted in footnote 27 the asset payout ratio g is also equal to r ℓ*. Figure 2 plots g/r or ℓ* as a function of the riskless rate r, using the same parameter assumptions as figure 1. The figure shows that the bank's optimal initial leverage increases monotonically with r, ranging from slightly below .5, when the riskless rate is very low, to approximately .75 for a riskless rate of ten percent. Increases in r, ceteris paribus, lead to a lower likelihood of insolvency and as a result, the firm chooses higher leverage.

C as a function of* τ. Next, we investigate the relationship between the bank's capital structure decision and the corporate tax rate. Taking the partial derivative of the optimal coupon (equation 13) with respect to the tax rate, we obtain:

$$\frac{\partial C^*}{\partial \tau} = \frac{gV}{X\tau}\left(\frac{\beta - 1}{\tau + \beta - 1}\right) \tag{15}$$

We first observe that for values of β close to one, the sensitivity of C* to changes in the tax rate is small. Nevertheless, it is instructive to consider how the tax rate interacts with the nature of the capital requirement, β to influence C*. The sign of the partial derivative in equation (15) depends on the sign of the term in brackets. For stringent capital requirements when β>1, this term is positive and the optimal debt service payment, C*, is increasing in the tax rate. However, if β<1 (and τ is sufficiently large to keep the denominator positive), the opposite is true—a higher tax rate would lead bank owners to choose a lower debt service payment. To understand this behavior on the part of the bank's owners, one must recall that without tax benefits, when β>1, the bank would prefer to not use any debt in order to avoid the risk of insolvency costs. The use of debt is motivated entirely by the desire to capture the tax benefits of debt. In that environment, larger tax benefits associated with a higher tax rate provide more incentive to use debt. When

$\beta<1$, the bank would choose the highest possible leverage with no tax benefits, and the introduction of tax benefits means that the firm now has something to lose in the event of insolvency. Therefore, a higher the tax rate leads to larger possible losses of future tax benefits and a more conservative choice of debt service payment.[30]

Leverage based on Market Values. We define the bank's optimal leverage in terms of market values as $L^* = D^*/v(V)^*$ or $(C^*/r)/v(V)^*$. The bank does not choose L^* directly, but rather chooses C^*. The market value of the bank including its contingent claims is determined by that choice. Using the definitions above, we find:

$$L^* = \frac{D^*}{v^*(V)} = \frac{1}{\frac{r}{g} + \frac{X}{1+X}\tau} \tag{16}$$

Notice that optimal leverage is independent of the value of a bank's financial assets, V or v*.

Under the standard condition that $\tau+\beta>1$, g exists and $L^*>0$. However, for the optimal capital structure to be consistent with leverage less than one, the denominator must be greater than one. This condition is met as long as $g<r$, which was satisfied for our simulations in figure 2. The first term, r/g, is the inverse of the payout factor ratio portrayed in figure 2. There we saw that banks optimally choose a debt service factor, g, that represents a smaller percentage of its assets than the riskless rate. As a result, under stringent regulatory conditions, (i.e., $\beta>1$), the first term of the denominator will be greater than one**.** The second term adds a fraction of the tax rate and thus the optimal leverage will be between zero and one.[31]

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[30] It should be noted, however, that, *ceteris paribus,* a bank with $\beta<1$ will choose a higher C* than the equivalent bank with $\beta>1$. The difference we are talking about here is in the response of the bank to a change in tax rate. The first bank would lower its very high leverage while the second would increase its lower leverage.

[31] Under the risk neutral probability measure, all assets have a drift equal to the riskless rate. If banks chose to commit to a debt service payment rate (as a percentage of its assets) that is in excess of the asset drift, this would imply market value of debt in excess of the market value of assets under the risk neutral measure and the bank would be unable to raise new equity to service the debt commitment. Not surprisingly, simulations indicate that the

Unlike the bank's choice of C*, L* is inversely related to the tax rate, regardless of the stringency of the capital threshold. The first order partial derivative of L* with respect to the tax rate is:

$$\frac{\partial L^*}{\partial \tau} = -\left(L^*\right)^2 \left[-\frac{r}{Xg\tau}\left(\frac{\beta - 1}{\tau + \beta - 1}\right) + \frac{X}{1+X} \right] \tag{17}$$

The partial of L^* with respect to the tax rate is negative because the second term in brackets is unambiguously positive and for reasonable parameter values larger than any negative values taken by the first term.[32] While the finding that leverage decreases with the tax rate is intuitive for the case (β<1) where C^* is decreasing in the tax rate, it is less so for the case where β>1 and the bank optimally increases C^* as a result of an increase in the tax rate. The result arises because although an increase in C^* directly increases D^*, it also increases $v^*(V)$ because of the inclusion of the contingent claim in v(V). In fact, $v^*(V)$ increases more rapidly than D^* as a function of the tax rate, with the result that L* actually declines. These results suggest that a change to lower corporate tax rates may have the unintended consequence of increasing the optimal leverage ratio for banks.

3.3. Numerical Example

In this section, we demonstrate certain policy implications of our model through numerical examples. In all cases, we assume the initial value of the bank's financial assets, V(0), is one hundred dollars. For our base case, we set β=1 because at that value bankruptcy costs and insurance benefits perfectly offset each other. We further assume that the risk free rate r=0.06, volatility of asset returns σ=0.15, and the effective corporate tax rate τ=0.25. Although, the bankruptcy cost parameter, α, does not enter the formulas for firm value directly, it does

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optimal coupon payment implies leverage between 0 and 1 for most values of β between (1-τ) and 1. Leverages above 1 can arise for values of β near (1-τ), but at such values g is near zero where an optimal coupon does not exist.

[32] As in the previous footnote, in practice, this relationship only breaks down for values of β near (1-τ).

influence the maximum level of β that the regulator can choose since we have assumed throughout that $\beta<1/(1-\alpha)$. We consider a base case of α equaling ten percent, which in turn leads to a maximum for β of 1.11.

Table I illustrates the nature of bank capital structure decisions by varying β between .9 and 1.1 across the columns 1 through 5 and varying the tax rate, τ, across the three panels of the Table. The assumed tax rates range from fifteen percent in panel A to thirty-five percent in Panel C.[33] Each panel of the Table presents the firm's optimal choice of C* along with the corresponding time zero value of the firm and the associated values of the three contingent claims: insurance benefits, bankruptcy costs and tax benefits. We also report both the market leverage and book leverage for this optimal choice of C*. For all three panels in Table I, we hold constant the risk free rate $r=0.06$ and asset volatility $\sigma=0.15$.

Looking across the row labeled C* in each panel, we see that C* falls as the capital requirement becomes more stringent. The magnitude of this effect can be substantial with C* falling by 39.5 percent as β increases from 0.90 to 1.1 when the tax rate is 15 percent. The effect of β falls, however, as the tax rate increases. When the tax rate is 35 percent, C* falls by only 26.7 percent as β increases from 0.90 to 1.1. The differential effect of capital regulation for different tax rates is consistent with equation (15), which showed that the derivative of C* with respect to τ changes sign at $\beta=1$. For example, comparing Panel A with Panel C, C* falls from 5.80 to 5.02 as the tax rate increases when $\beta=0.9$ but increases from 3.51 to 3.68 with the tax rate when $\beta=1.1$. The bank's market value of leverage monotonically increases as β decreases for any tax rate. As noted before, because GAAP does not include any of the three contingent claims in

[33] Although the top marginal corporate tax rate in the U.S. is forty percent, based on FDIC Call reports, the average effective tax rate for all commercial banks in the U.S. is 31.9%. However, the effective tax rate for small commercial banks (assets less than \$100 million) is 19.8% while the rate for large banks (assets > \$1 billion) is 32.7%.

its measure of firm size, the market value of leverage (L_1) understates the “book” value calculation of leverage (L_2).

The last two columns in Table I present the value and capital structure of a comparable, unregulated, firm as studied by Leland (1994) using bankruptcy costs based on α=0.10. The first column of the pair presents the results for an unregulated firm that is free to choose its own bankruptcy threshold endogenously. The last column presents the results for a firm with protected debt that results in a positive net worth requirement (β=1). The first firm type (with unprotected debt) chooses a higher coupon than all the banks with the exception of the least constrained bank with low tax rates. It chooses a very low bankruptcy threshold which contributes to the very high tax benefit reported for these firms. This enhanced tax benefit outweighs the fact that the unregulated firm has no insurance benefit and the overall firm value is higher than all but the least regulated bank.[34] However, if the firm must provide debtholders with a positive net worth covenant, the firm voluntarily chooses a lower level of debt service. In turn this lowers the tax benefit and the value of the firm. The firm that issues protected debt has a lower optimal firm value than all but the bank with the highest capital requirement. These results suggest a positive charter value for operating an insured bank—even in the face of significant capital regulation.

Table II presents a similar set of panels varying the level of asset price volatility, σ, from 10% to 25% while holding the tax rate fixed at 25%. In general, the optimal debt service payment, C*, declines as volatility increases. For β=1, C* falls by 29.3 percent as σ rises from 10

[34] The possibility that a regulated bank might choose a leverage level that is higher than an unregulated firm without protected debt deserves some discussion. For the regulated bank that operates under the weakest capital standards, the insurance benefits net of bankruptcy costs provide an incentive for taking on more debt. It is only the risk of losing tax benefits due to forced liquidation that yields an interior optimal capital ratio. As tax rates decrease, this risk becomes less important and bank leverage increases, while for the unregulated firm tax benefits create an unambiguous incentive for taking on more leverage.

to 25%. Holding other factors equal, as volatility increases, the expected first passage time for $V(t)$ to strike V_B decreases thereby increasing the value of contingent claims payable at insolvency. The primary factor behind the decline in C* is the increased risk of forced liquidation by regulators and the associated loss of tax benefits, which as discussed previously is the largest contingent claim. For all values of β considered, tax benefits fall by approximately 50 percent as volatility rises from 10 to 25%. The effect of insurance benefits net of bankruptcy costs on C* depends upon β. For lax regulatory environments, where $\beta<1$, insurance benefits exceed bankruptcy costs, and this positive net benefit increases in magnitude with volatility leading to higher levels of leverage being chosen. With $\beta>1$, the insurance benefits are smaller than bankruptcy costs, and the magnitude of this negative net benefit increases with volatility leading to lower leverage. In terms of magnitude changes as volatility rises from 10 to 25%, insurance benefits net of bankruptcy costs increases by 3.54 when $\beta=0.9$ and decreases by 0.67 when evaluated at C*.

These factors have clear implications for the market value of the firm. As volatility increases, the risk of loss of future tax benefits because of insolvency dominates any increases in the value of the firm due to insurance benefits even when capital regulation is lax, $\beta<1$. The combination of less debt as C* falls and smaller tax benefits per dollar of debt results in a significant decline of the tax contingent claim, TB, as volatility increases. This decline in the tax benefit contingent claim dominates the small net increase from the other two contingent claims in a lax regulatory environment and reinforces the net decrease in the stringent regulatory environment. The net result is an unambiguous decline in firm value with volatility. This example demonstrates the importance of having a comprehensive model that explicitly incorporates insurance benefits, bankruptcy costs and tax benefits. Ignoring tax benefits, we might conclude that banks subjected to lax capital regulation ($\beta<1$) would have a tendency to invest in riskier assets. This finding is also consistent with the previous literature on bank portfolio choice in that the franchise value created by tax policies contributes to a bank preference for more conservative assets (Hellman, Murdock, and Stiglitz 2000).

The book leverage levels reported in Tables I and II for banks tend to be lower than the industry average of approximately ninety percent.[35] Focusing on $\beta=1.05$ (which roughly corresponds to the highest "Well Capitalized" bank standard) and ten percent asset volatility, the model predicts a debt to book value of assets of approximately seventy-five percent. There are several possible explanations for this difference. First, the overall industry average is somewhat distorted by the inclusion of the large international banks. The industry average leverage for small banks (assets less than $100 million) is somewhat lower at 87%. However, more significantly, our model does not consider multiple types of debt which may lead to an underestimate of the total leverage. On average, banks make extensive use of non-depository debt. Deposits represent only 67% of their assets – a figure lower than our predicted ratio. The use of other forms of debt is motivated by a number of different factors not captured in our model. For example, after considering operating costs, short – term borrowing via Fed Funds or repurchase agreements may be less costly than deposits which entail providing customer service as well as interest. On average, these items represent approximately 15% of the typical bank's assets.[36] Finally, our model does not incorporate any of the agency cost related motives for issuing debt.[37]

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[35] The industry average is based on FDIC reports for all commercial banks. The ninety percent figure is based on the ratio of the book value of total bank liabilities (including non-deposit debt) to the book value of total assets. While not directly comparable to either leverage ratio in the model, it should be reasonably close to L_2.

[36] Subordinated debt provides another example because banks can include some subordinated debt in their Tier II capital.

[37] Jensen (1986) and Jensen and Meckling (1976) argue that issuing debt can mitigate the agency problems associated with free cash flow.

4. Implications for Bank Capital Regulation and Policy

4.1. The Tradeoff between Bankruptcy Costs and the Provision of Banking Services

The key policy parameter available to regulators is the stringency of capital regulation of banks or specifically the bankruptcy threshold β. A considerable fraction of the existing work focuses on the link between regulatory policy and bank risk taking associated with its investment portfolio (Hellmann, Murdock, and Stiglitz 2000, Besanko and Katanas 1996, Rochet 1992, Genotte and Pyle 1991). In our case, we examine a bank's leverage choice as the central risk taking behavior abstracting away from portfolio risk. From a traditional social planner's perspective, bankruptcy costs are the only real costs to society since deposit insurance and tax advantaged debt simply result in transfers between agents in the economy. Based strictly on the partial equilibrium model specified here, a rational social planner would choose all equity to eliminate bankruptcy costs, but such a choice would eliminate the financial intermediation role of banks. Unless we are willing to make value judgments concerning the transfer payments or significantly alter the model to include the benefits of financial intermediation, the existence of banks must be justified outside of the model.

One of the natural benefits to society provided by banks is the provision of a risk free or near risk free asset that is either short term or can be costlessly liquidated upon demand (demand deposits).[38] Aggressive capital regulation that increases capital standards and reduces bankruptcy costs also reduces the size of the banking sector. A smaller banking sector is likely associated with a lower the risk free rate in equilibrium, effectively raising the cost of holding the risk free asset and thereby lowering the welfare of risk averse consumers. Specifically, higher

[38] A second benefit that is often discussed is the attraction or intermediation of more capital for investment which in turn leads to greater economic growth. We do not explicitly consider this benefit because it requires value judgments concerning whether the current level of investment is too high. Further, in many macroeconomic models, the organization of financial capital does not create additional physical capital because in equilibrium investment is determined by the share of an economies production that is not consumed, i.e. savings equals investment.

capital standards reduce the expected return to bank equity and in response the supply of capital as equity to the banking sector would fall. At the same time, banks would have to decrease their leverage leading to an imbalance between the supply of risk free deposits from consumers who are the potential depositors in banks and the capital necessary to maintain banks' desired capital structure. In equilibrium, excess supply of risk free deposits will bid down the risk free interest rate that must be paid on those deposits lowering the quantity of demand deposits supplied in equilibrium and raising the return to bank equity, which in turn attracts additional capital into the banking sector (effectively raising the quantity of deposits demanded along this reduced demand curve for deposits). Therefore, in equilibrium, increases in capital standards will both decrease the return to bank equity and the risk free rate paid on deposits hurting all asset holders, but also reducing bankruptcy costs.[39]

While our model does not consider the equilibrium asset allocations of households, results from our model simulations are useful for characterizing the social welfare problem potentially faced by a bank regulator. Specifically, the return to a dollar of equity captures the incentive for individual agents in the economy to invest in bank equity and so should vary monotonically with the benefits that the banking sector offers to society, *ceteris paribus*. In our framework, return to equity is calculated as the ratio of market value of equity at time zero (after making the optimal choice of leverage) to the initial book value of equity or the dollars contributed by investors. Using the fact that both the book value and market value of debt equal C/r and applying the basic firm accounting identity, the return on equity is:

$$\rho = \frac{v - D}{V - D} = \left(v - \frac{C}{r}\right)\left(V - \frac{C}{r}\right)^{-1}. \tag{18}$$

[39] An increase in the return to bank equity and the associated increase in the equilibrium risk free interest rate in response to lower capital standards is similar to the Pareto Improvement arising from imposition of interest rate limits in Hellman, Murdock and Stiglitz (2000).

The regulator must trade off the bankruptcy costs associated with the banking sector against the equilibrium return to equity and debt investments in the banking sector, which should vary monotonically with the return on bank equity. The last row in every panel of Tables I and II shows the return to equity for different parameter values.

The results for return to equity show that a more stringent capital standard reduces bankruptcy costs, but also reduces the return to equity. Comparing across the panels of Table I indicates that both bankruptcy costs and returns to bank equity are much more non-linear for low corporate tax rates suggesting that the costs and benefits of the sector are less responsive and the regulatory trade-off less critical when corporate taxes or franchise value are high. In Table II, increases in asset return volatility naturally increase the effect of capital regulation on bankruptcy costs, but dampen the effect of capital regulation on return to equity due to changes in the firm's optimal coupon or leverage. This pattern suggests that capital regulation should be more stringent in high volatility environments because such regulation saves considerable costs by reducing bankruptcy while only having a moderate effect on returns in the banking sector**.**

4.2. Policy Lessons from the GSEs and Other Financial Institutions

The two mortgage-related government sponsored enterprises (GSEs) provide an interesting case study of the model's predicted relationship between the regulator's power to close an institution and the institution's behavior. Beginning in 1993, the two GSEs (Fannie Mae and Freddie Mac) were subjected to a statutory minimum capital requirement. These two institutions hold investment portfolios and guarantee mortgage-backed securities (MBS) owned by other investors. The institutions are required to hold capital equal to 2.5% of balance sheet assets and .45% of off balance sheet guarantees (i.e., MBS),[40] However, regulation of the GSEs

[40] Beginning in 2002, the GSEs were also subject to a risk-based capital standard. From its inception through 2007, the risk-based capital requirement was significantly lower than the statutory minimum capital requirement based on

was shared by several entities and the safety and soundness regulator (The Office of Federal Housing Enterprise Oversight—OFHEO) did not have the power to place the GSEs in receivership or to appoint a conservator until the Housing Recovery Act of 2008.[41] Consequently prior to 2009, although they were required to maintain positive book net worth and β was arguably >1, the penalty for violating the standard was primarily operational and political. Violation of the standard would likely have resulted in restrictions on future operations (e.g., growth restrictions) and increased operational costs associated with increased supervisory and political scrutiny. However, there was no credible threat that shareholders would suffer the loss of their significant franchise value as soon as the capital standard was violated. In such a setting, our model predicts that the GSEs would operate with little or no cushion over the minimum requirement.

Table III reports the required capital, actual capital and excess capital for both GSEs from 1993 through 2007. Both GSEs experienced accounting problems in the period from 2003 through 2005. As a result of these problems, both GSEs had to restate financial reports and were required to maintain an additional thirty percent capital over the statutory minimum.[42] Consequently, the period from 1993 through 2001 provides the cleanest picture of the GSEs' intentions with respect to managing capital. The table shows that although the GSEs met their capital requirement throughout this period, they did not maintain any significant amount of excess capital.[43] For both institutions, 1993 was the first year of operation under the statutory

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assets and MBS. Consequently the risk-based standard has never been binding because the GSEs must meet the higher of the two standards.

[41] OFHEO did have the authority to issue cease and desist orders. However, ordering the immediate cessation of operations would have had far-reaching economic ramifications and was consequently not a credible threat.

[42] The capital shortfalls reported by Fannie Mae for 2002 and 2003 are the result of a restatement of earnings in those years. Similarly, the sharp increase in capital reported for Freddie Mac in 2002 (and the resulting above-average excess capital) is attributable to an upward restatement of earnings.

[43] The GSE capital standard is contemporaneous and requires that capital at the end of the quarter meet the standard—even though the actual values for assets and MBS are not known with certainty until after the books are

minimum capital requirement and Fannie Mae and Freddie Mac held excess capital of roughly $1 billion and $.7 billion, respectively. These amount expressed as a percentage of assets plus MBS outstanding were .14% and .13%, respectively. In most of the eight subsequent years, Fannie Mae held excess capital well under $1 billion and in 1998 and 1999 its excess capital was 1/100th of a percent of the assets and MBS. Freddie Mac's excess capital, while slightly higher when measured as a percentage of assets and MBS, was smaller when measured in dollars and is also consistent with the claim that the firm intended to meet but not exceed its capital standard. On average over the period from 1993 through 2001, Fannie Mae and Freddie Mac held less than 1/10th of a percent of excess capital.[44] This behavior differs markedly from that predicted by our model for firms that are subject to a credible threat of losing their franchise value, such as smaller commercial banks which tend to hold a significant capital cushion on average.[45]

Both institutions had become accustomed to being able to raise capital[46] when circumstances required with little threat of significant shareholder loss in the event that the capital standard was breached. Consequently, neither institution attempted to maintain a capital cushion to prevent violation if asset values declined. Both institutions had active share repurchase programs which enabled them to manage their capital account by distributing extra retained earnings to the shareholders. This behavior is consistent with the predictions of our model which shows that when shareholders believe there is little risk of losing franchise value, it

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closed after the end of the quarter. This process led the institutions to target a small precautionary excess capital amount to cover unexpected fluctuations in assets and MBS.

[44] The period from 2002 through 2007 is distorted by the effects of financial restatements as noted above. However, the numbers for 2007 most likely reflect the firms' contemporaneous intentions and they still suggest that the firms were not holding precautionary excess capital.

[45] As a point of reference, as of 12/31/2001, commercial banks held Tier 1 plus Tier 2 capital equal to 9.85% of their assets—almost two percent more than required.

[46] Core capital for the GSEs is defined as the sum of outstanding common stock, the par or stated value of preferred stock, paid-in capital and retained earnings. It differs from GAAP shareholder's equity by excluding Accumulated Other Comprehensive Income. In the late 1990s , the GSEs found they were able to readily sell preferred stock on advantageous terms and used preferred stock sales when they needed to build capital.

is optimal to maximize leverage and there is little reason to maintain capital in excess of the absolute minimum required. The Housing Recovery Act of 2008, which provided regulators the authority to place the GSEs in conservatorship came too late in the financial crisis for either entity to raise sufficient capital to provide the needed cushion and both GSEs were placed in conservatorship on September 7, 2008.

Our model also sheds light on another important policy issue. In 1999, the Gramm-Leach-Bliley Act removed the barriers separating commercial banks and investment banks in the U.S. One motivation for this action was to increase the global competitiveness of U.S. financial institutions by allowing a single institution to provide both commercial lending services and investment banking services. However, a consequence of removing these barriers was a reduction in the franchise value -- especially that of investment banks. Large investment banks, which might have been viewed by creditors as "Too Big to Fail," now faced significant competition from large commercial banks in areas such as IPOs, security sales and trading and merger and acquisition advising. With diminished franchise value, investment banks had less incentive to maintain a conservative capital cushion and more incentive to enhance returns through increased leverage.[47] In addition, there was no regulator with the authority to step in while net worth or equity capital was still positive. Although time series data on capital and assets is less available for investment banks than for the GSEs, the dramatic failures of Bear Stearns, Lehman Brothers and Merrill Lynch and the conversion of Goldman Sachs into a bank holding company suggest that there was insufficient capital cushion maintained at these institutions as well.

[47] A similar argument can be made that in 2005-2007 the rapid growth and market acceptance of "private label" mortgage-backed securities (i.e, those not guaranteed by a GSE) reduced the franchise value of the GSEs and led to increased risk-taking behavior. However, since they were already operating at their minimum capital threshold, the incentive to take more risk was reflected in their asset mix—an aspect not incorporated in our model.

Our model emphasizes that it is critical to have both strong franchise value and the credible risk of losing that franchise value to motivate institutions to voluntarily maintain a significant capital cushion. Policies that reduce franchise value or limit a regulatory authority's ability to establish and enforce stringent capital standards are likely to encourage riskier capital structures.

5. Summary and Conclusions

This paper examines the capital structure of insured banks. In a world with binding capital regulation where regulators liquidate banks that fall below a predetermined capital standard, we find that a bank's capital structure choice depends critically on the presence of tax benefits or other sources of firm franchise value. Without such franchise value, the bank's capital structure's problem is knife edged with banks choosing all debt if regulation is loose and choosing all equity if capital regulation is strict. The inclusion of tax benefits or other sources of franchise value significantly alters these results. Specifically, we find that there is an interior optimal level of leverage for all banks, even those that face relatively weak capital regulation. In operational terms, an interior solution means that banks voluntarily hold excess capital to protect their franchise value in bad times. With capital regulation comes the threat of liquidation and, consequently, the market value of a claim to future tax benefits does not monotonically increase with leverage.[48]

Our results are also relevant to the current financial crisis and debate over future regulation of financial institutions. The failure of major investment banks early in the crisis was

[48] The specific finding concerning tax benefits is significant because there are still a large number of insured depositories (credit unions) that are exempt from the corporate income tax. For these institutions, the nature of the capital requirement is crucial. In the absence of other significant franchise value elements, our model implies a knife-edge type of response with firms choosing extremely high leverage when the capital standard allows for negative net worth on a market value basis and preferring no leverage at all when the standard requires positive market value net worth.

in large part due, not just to risky investments, but rather to the very high levels of leverage held by those institutions. The government rescues of Bear Sterns, AIG, the large mortgage GSE's, and other financial institutions under the broader federal bail-out program raises important concerns about moral hazard in the future capital structure decisions of financial sector institutions. Our model provides useful insights concerning this problem. First, while much of the debate concerning the federal bail-out has focused on stock holders and executives, the model illustrates that the central moral hazard problem arises from the protection of debt or bond holders whose lending decisions would be distorted towards firms with higher leverage due to the potential for a government bail-out in bad economic times.

Second, in our model, the discipline imposed by capital regulation replaces the risk faced by creditors without government guarantees. Prior to this economic crisis, the federal government did not have the clear power to liquidate the mortgage GSEs, investment banks, or other large, unregulated financial institutions, which might be considered too big to fail, for violating explicit or implicit capital standards. Our model suggests that the regulator's ability strip equity holders of the remaining market value of their ownership when capital standards are violated is crucial to establishing a system that limits a firm's incentives for very high levels of leverage.

Further, it is the presence of tax-advantaged debt or other forms of franchise value that give capital standards teeth and lead to an interior optimal leverage. This aspect of our model helps illustrate how the increases in competition in financial markets may have contributed to the risky behavior of financial firms. Large, well known financial institutions like Bear Sterns and Lehman Brothers likely derived substantial franchise value from name recognition and established networks of brokers and financial managers. The dramatic increase in competition from new, less known financial players, including large hedge funds may have eroded the franchise value associated with the large investment banks leading them to take riskier levels of leverage. The implications of our model for firm leverage in response to changes in franchise value are quite similar to those of Marcus (1984) and Hellman, Murdock, and Stiglitz (2000) who find that increases in bank charter or franchise value can reduce bank incentives for risk in leverage and portfolio decisions, respectively.

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Value of Tax Benefits, Bankruptcy Costs and Insurance Benefits

(V=100, σ=.15, r=.06, β=1.05, α=.10 and τ=.25)

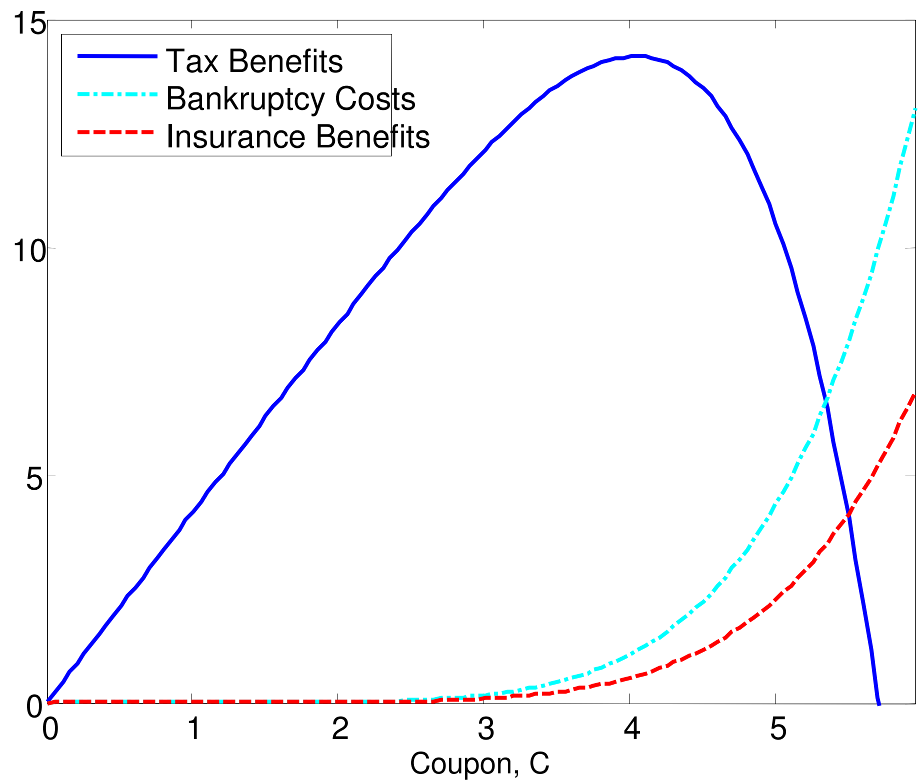

Figure 1. Market Value of Tax Benefits, Bankruptcy Costs and Insurance Benefits as a Function of the Firm's Choice of Debt Payment, C. Figure 1 shows the response of the value of the three contingent claims to changes in the firm's choice of continuous debt service payment, C. All three lines assume V is fixed at 100 and the firm chooses how to finance those assets by selecting C, which determines the deposit level, D. The solid line represents the market value of future tax benefits; the dash-dotted line represents the value of the bankruptcy costs and the dashed line represents the value of future insurance benefits. All three are calculated using the listed parameter values and equations 6, 5 and 7, respectively.

Optimal Initial Leverage

(V=100, σ=.15, r=.06, β=1.05, α=.10 and τ=.25)

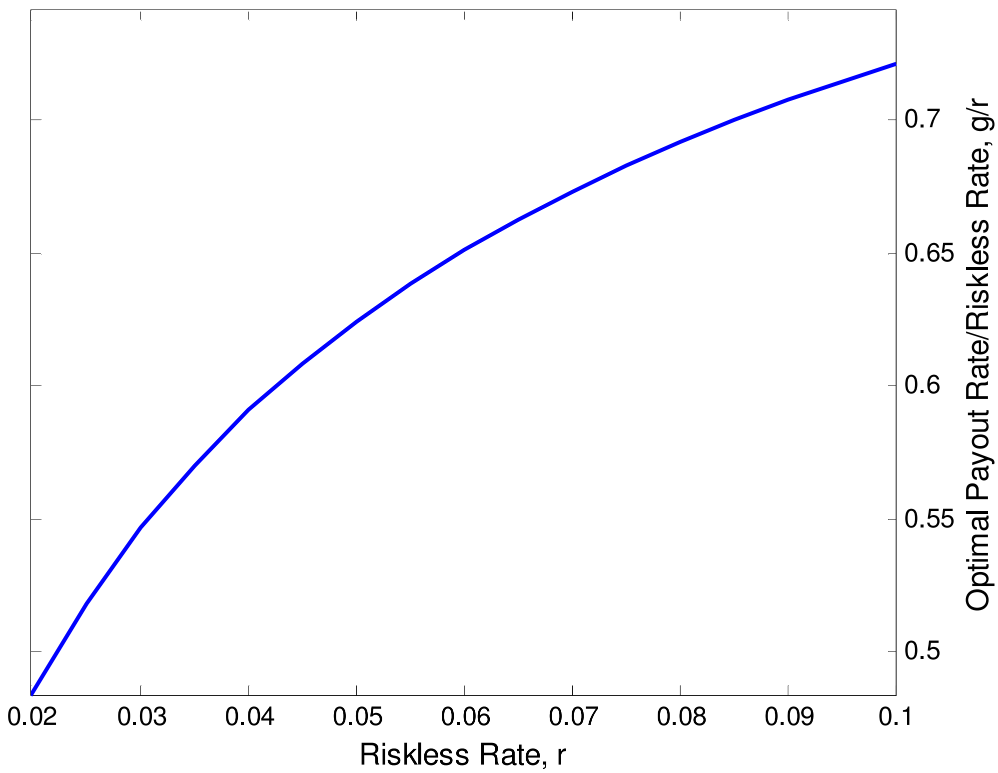

Figure 2. Sensitivity of Leverage and Bank Payout Rate to Changes in the Riskless Rate. The bank's optimal coupon rate, C*, is determined at time zero based on the relationship, C*=gV(0), where g is defined in equation (13). The variable, g, can be thought of as the optimal payout rate expressed as a percentage of the firm's initial assets. By dividing g by the riskless rate, we obtain the optimal initial leverage, L*. The figure shows that the bank's optimal initial leverage increases (at a decreasing rate) with the riskless rate and ranges from roughly .5 to .75, for the assumed parameters. The optimal payout rate (as a percent of bank assets, V) is less than the riskless rate for reasonable parameter values

Table I
The Impact of Insolvency Threshold and Tax Rate on Bank Capital Structure Decisions

	Panel A: τ = 15%							
		Banks with Deposit Insurance and Capital Requirements					**Non-regulated firms**	
β	Insolvency Threshold	0.90	0.95	1.00	1.05	1.10	Endog	1.00
c	c, Minimum Capital Requirement	-11%	-5%	0%	5%	9%	--	--
C*	Optimal Debt Service Payment	5.8	4.82	4.24	3.83	3.51	5.51	3.86
v*	Firm Value at C*	112.2	110.15	108.94	108.06	107.38	111.6	108.12
IB	Insurnace Benefit	8.69	2.76	1.12	0.42	0.06	--	--
BC	Bankruptcy Costs	4.12	1.81	1.12	0.79	0.61	0.7	0.61
TB	Tax Benefits	7.63	9.2	8.94	8.44	7.94	12.31	8.73
L1	Market Value Leverage = C*/rv*	86.08%	72.95%	64.94%	59.07%	54.42%	82.31%	58.46%
L2	Book Value Leverage = C*/rV	96.59%	80.35%	70.74%	63.84%	58.44%	91.86%	64.28%
ρ	Return to Bank Equity	4.573	1.517	1.305	1.223	1.178	--	--
	Panel B: τ = 25%							
		Banks with Deposit Insurance and Capital Requirements					**Non-regulated firms**	
β	Insolvency Threshold	0.90	0.95	1.00	1.05	1.10	Endog	1.00
c	c, Minimum Capital Requirement	-11%	-5%	0%	5%	9%	--	--
C*	Optimal Debt Service Payment	5.19	4.66	4.24	3.91	3.62	6.44	3.99
v*	Firm Value at C*	118.21	116.35	114.89	113.71	112.71	122.61	113.98
IB	Insurnace Benefit	4.33	2.22	1.12	0.47	0.07	--	--
BC	Bankruptcy Costs	2.05	1.46	1.12	0.9	0.75	0.85	0.75
TB	Tax Benefits	15.94	15.58	14.89	14.14	13.39	23.46	14.73
L1	Market Value Leverage = C*/rv*	73.18%	66.74%	61.57%	57.26%	53.57%	87.58%	58.27%
L2	Book Value Leverage = C*/rV	86.51%	77.65%	70.74%	65.11%	60.38%	107.38%	66.42%
ρ	Return to Bank Equity	2.350	1.731	1.509	1.393	1.321	--	--
	Panel C: τ = 35%							
		Banks with Deposit Insurance and Capital Requirements					**Non-regulated firms**	
β	Insolvency Threshold	0.90	0.95	1.00	1.05	1.10	Endog	1.00
c	c, Minimum Capital Requirement	-11%	-5%	0%	5%	9%	--	--
C*	Optimal Debt Service Payment	5.02	4.6	4.24	3.94	3.68	7.55	4.05
v*	Firm Value at C*	124.68	122.59	120.85	119.37	118.08	137.07	119.89
IB	Insurnace Benefit	3.52	2.05	1.12	0.5	0.08	--	--
BC	Bankruptcy Costs	1.67	1.34	1.12	0.95	0.83	0.94	0.83
TB	Tax Benefits	22.83	21.89	20.85	19.82	18.84	38.01	20.72
L1	Market Value Leverage = C*/rv*	67.15%	62.53%	58.54%	55.05%	51.96%	91.76%	56.29%
L2	Book Value Leverage = C*/rV	83.72%	76.65%	70.74%	65.71%	61.35%	125.77%	67.49%
ρ	Return to Bank Equity	2.516	1.968	1.713	1.565	1.468	--	--

Notes:
1. All results for bank capital structure were calculated based on the formulas derived in Section 2. For all three panels, the riskless rate, r =6%, the volatility of assets returns σ=15% and the deadweight loss in insolvency, α=10%.
2. The values in the columns labelled Non-regulated firms are calculated using the formulas derived by Leland (1994)
The first column corresponds to the case with unprotetced debt and an endogenous bankruptcythreshold
The second column represents the case with protected debt where the firm provides a positive net worth covenant
The values in these columns are based on the same assumptions for the riskless rate, asset volatility and bankruptcy costs.

Table II
The Impact of Insolvency Threshold and Asset Return Volatility on Bank Capital Structure Decisions

		Panel A: σ = 10%						
		Banks with Deposit Insurance and Capital Requirements					**Non-regulated firms**	
β	Insolvency Threshold	0.90	0.95	1.00	1.05	1.10	Endog	1.00
c	c, Minimum Capital Requirement	-11%	-5%	0%	5%	9%	--	--
C*	Optimal Debt Service Payment	5.62	5.2	4.85	4.55	4.28	6.86	4.71
v*	Firm Value at C*	121.61	119.98	118.64	117.48	116.47	126.38	118.12
IB	Insurnace Benefit	2.28	1.21	0.62	0.27	0.04	--	--
BC	Bankruptcy Costs	1.08	0.79	0.62	0.51	0.43	0.48	0.43
TB	Tax Benefits	20.41	19.57	18.64	17.72	16.87	26.85	18.55
L1	Market Value Leverage = C*/rv*	76.99%	72.18%	68.07%	64.48%	61.29%	90.44%	66.48%
L2	Book Value Leverage = C*/rV	93.63%	86.60%	80.76%	75.75%	71.38%	114.29%	78.52%
ρ	Return to Bank Equity	4.392	2.492	1.968	1.781	1.576	--	--
		Panel A: σ = 15%						
		Banks with Deposit Insurance and Capital Requirements					**Non-regulated firms**	
β	Insolvency Threshold	0.90	0.95	1.00	1.05	1.10	Endog	1.00
c	c, Minimum Capital Requirement	-11%	-5%	0%	5%	9%	--	--
C*	Optimal Debt Service Payment	5.19	4.66	4.24	3.91	3.62	6.44	3.99
v*	Firm Value at C*	118.21	116.35	114.89	113.71	112.71	122.61	113.98
IB	Insurnace Benefit	4.33	2.22	1.12	0.47	0.07	--	--
BC	Bankruptcy Costs	2.05	1.46	1.12	0.9	0.75	0.85	0.75
TB	Tax Benefits	15.94	15.58	14.89	14.14	13.39	23.46	14.73
L1	Market Value Leverage = C*/rv*	73.18%	66.74%	61.57%	57.26%	53.57%	87.58%	58.27%
L2	Book Value Leverage = C*/rV	86.51%	77.65%	70.74%	65.11%	60.38%	107.38%	66.42%
ρ	Return to Bank Equity	2.350	1.731	1.509	1.393	1.321	--	--
		Panel A: σ = 20%						
		Banks with Deposit Insurance and Capital Requirements					**Non-regulated firms**	
β	Insolvency Threshold	0.90	0.95	1.00	1.05	1.10	Endog	1.00
c	c, Minimum Capital Requirement	-11%	-5%	0%	5%	9%	--	--
C*	Optimal Debt Service Payment	4.98	4.29	3.78	3.39	3.07	6.28	3.38
v*	Firm Value at C*	115.56	113.39	111.81	110.59	109.6	119.63	110.56
IB	Insurnace Benefit	6.57	3.24	1.57	0.65	0.09	--	--
BC	Bankruptcy Costs	3.11	2.12	1.57	1.24	1.01	1.2	1.01
TB	Tax Benefits	12.1	12.28	11.81	11.17	10.51	20.83	11.56
L1	Market Value Leverage = C*/rv*	71.81%	62.99%	56.34%	51.05%	46.71%	87.50%	50.93%
L2	Book Value Leverage = C*/rV	82.99%	71.43%	63.00%	56.46%	51.19%	104.67%	56.31%
ρ	Return to Bank Equity	1.915	1.469	1.319	1.243	1.192	--	--
		Panel A: σ = 25%						
		Banks with Deposit Insurance and Capital Requirements					**Non-regulated firms**	
β	Insolvency Threshold	0.90	0.95	1.00	1.05	1.10	Endog	1.00
c	c, Minimum Capital Requirement	-11%	-5%	0%	5%	9%	--	--
C*	Optimal Debt Service Payment	4.98	4.06	3.43	2.97	2.62	6.34	2.88
v*	Firm Value at C*	113.64	111.12	109.41	108.15	107.18	117.37	107.9
IB	Insurnace Benefit	9	4.2	1.96	0.78	0.11	--	--
BC	Bankruptcy Costs	4.26	2.75	1.96	1.49	1.17	1.49	1.17
TB	Tax Benefits	8.9	9.67	9.41	8.86	8.25	18.86	9.07
L1	Market Value Leverage = C*/rv*	73.01%	60.89%	52.31%	45.83%	40.74%	90.02%	44.51%
L2	Book Value Leverage = C*/rV	82.97%	67.66%	57.23%	49.57%	43.66%	105.66%	48.03%
ρ	Return to Bank Equity	1.801	1.344	1.220	1.162	1.127	--	--

Notes:

1. All results for bank capital structure were calculated based on the formulas derived in Section 2. For all four panels, the riskless rate, r =6%, the tax rate τ=25% and the deadweight loss in insolvency, α=10%.
2. The values in the columns labelled Non-regulated firms are calculated using the formulas derived by Leland (1994)
 The first column corresponds to the case with unprotetced debt and an endogenous bankruptcythreshold
 The second column represents the case with protected debt where the firm provides a positive net worth covenant
The values in these columns are based on the same assumptions for the riskless rate, asset volatility and bankruptcy costs.

Table III
Capital Requirements for GSEs
1993-2007

	Fannie Mae			Freddie Mac		
Year	**Required Capital**	**Actual Core Capital**	**Excess -- % of Assets & MBS**	**Required Capital**	**Actual Core Capital**	**Excess -- % of Assets & MBS**
1993	7,064	8,052	0.14%	3,782	4,437	0.13%
1994	9,415	9,541	0.02%	4,884	5,169	0.05%
1995	10,451	10,959	0.06%	5,584	5,829	0.04%
1996	11,466	12,773	0.15%	6,517	6,743	0.03%
1997	12,703	13,793	0.11%	7,082	7,376	0.04%
1998	15,334	15,465	0.01%	10,502	11,266	0.10%
1999	17,770	17,876	0.01%	12,352	13,417	0.12%
2000	20,293	20,827	0.04%	14,396	16,273	0.18%
2001	24,182	25,182	0.06%	19,014	20,181	0.09%
average	14,298	14,941	0.07%	9,346	10,077	0.09%
2002	27,688	20,431	-0.37%	22,340	28,991	0.45%
2003	31,816	26,953	-0.21%	23,362	32,417	0.13%
2004	32,121	34,514	0.10%	23,714	34,106	0.20%
2005	28,233	39,433	0.11%	24,791	35,043	0.16%
2006	29,359	41,950	0.14%	25,607	35,366	0.11%
2007	31,927	45,373	0.13%	26,743	37,867	0.14%