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Bank Capital Requirements, Capital Structure and Regulation

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Abstract This paper studies the impact of capital requirements, deposit insurance and franchise value 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 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. The insights gained from the model are useful in guiding the discussion of financial regulatory reforms.

Keywords Banks · Capital Structure · Capital Regulation · Financial Intermediation · Leverage · GSE · Investment Banks

JEL G21 · G28 · G32 · G38 · M48

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 (Kane 2009; Caprio et al. 2008; Harding and Ross 2009). 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

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receivership which would likely wipe 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 1990; Marshall and Prescott 2000; Gueyie and Lai 2003)[1] because the insurance premium does not reflect or adapt to the underlying risk of the insured's activities.[2] 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 et al. (1981) point out that banks face significant additional costs attributable to regulations, investment restrictions and monitoring. Merton (1978) develops a contingent claims model of 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.[3] 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.

An exception to this pattern is Elizdale and Repullo (2007). They 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. 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

[1] Several models (Blum and Hellwig 1995; Bolton and Freixas 2006; Peura and Keppo 2006) generate bank capital holdings in excess of capital regulation requirements as a buffer to avoid violating the regulatory constraint or to avoid high transactions costs associated with continually updating capital holdings. However, in these models, the banks' optimal policy remains to minimize capital holdings subject to a regulatory constraint and so banks in these models are still effectively at a corner solution.

[2] Insured deposits represent one of the lowest cost capital sources for banks and until the recent crisis most solvent banks paid almost no premium for their insurance.

[3] Unlike the traditional moral hazard-regulatory cost models, models of banks that face principal agent problems can lead to banks that in equilibrium have an interior optimum for their capital holdings. For example, Allen et al. (2011) and Mehran and Thakor (2011) consider models where capital creates an incentive for banks to monitor loans lowering the equilibrium interest rate on those loans. Alternatively, Diamond and Rajan (2000) consider a model where the risk of bank runs force banks to use private skills to collect on loans, and holding capital protects banks against such runs but weakens the incentive for private effort.

to plan ahead for the risk associated with the possibility of multiple periods of negative shocks that slowly erode a bank's capital position. The recent financial crisis emphasizes the importance of considering models that do not allow the open market recapitalization of financial firms in response to negative shocks.[4]

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. We consider a model with bankruptcy costs and bank franchise value that is proportional to deposits which is very similar in form to Leland's tax advantage debt. In this model, we consider a world 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] 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 in response to losses - especially during economic downturns. Our model reasonably represents a world where banks must plan for adverse economic environments in which capital cannot be easily raised.

We find that there exists an interior optimal capital ratio for banks with deposit insurance, a minimum capital ratio and bank franchise value. That is, banks voluntarily choose to hold 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 including their franchise value 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.

In our opinion, a financial regulatory system that leads to financial institutions carrying a capital cushion has unique advantages that cannot be replaced by simply raising capital standards. Ideally, regulation should preserve incentives for owners to operate as deposit issuing banks, while selecting a prudent level of leverage tailored to the riskiness of their asset strategy – voluntarily holding capital in excess of the specified minimum. It is unreasonable and impractical to expect regulators to be able to establish capital standards tailored to an individual bank's operating strategy and asset risk. Similarly, regulators cannot monitor the portfolios of all financial institutions closely enough to accurately classify banks by the riskinesss of their assets. Consequently, it is important that the capital regulation framework provides owners and managers sufficient incentives to provide a capital cushion that reflects the operating strategy of the bank and appropriately reduces the risk of violating the standards in adverse times.

[4] Similarly, our model will hold the variance of the asset process fixed over time in essence assuming that banks cannot change their asset mix in response to changes in the economic environment. As with recapitalization, the illiquidity of fixed income securities markets during the recent crisis illustrates that banks may find it difficult to reduce portfolio risk during turbulent economic times.

[5] This case is similar in spirit to both the regulatory burden considered by Elizdale and Repullo (2007) and Leland's (1994) model of protected debt.

The 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 of banks, as well as the implications for financial regulatory policy more generally, 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 and equity. Uncertainty enters the model because the value of the firm's assets is 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.[6] 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. prior to the financial crisis, we further assume that banks do not pay an insurance premium for deposit insurance.[7] Under these assumptions, banks pay the riskless rate on all deposits. As in Leland, we assume that the firm's capital structure decision is summarized by a one time choice of a promised continuous coupon payment C, the firm's portfolio of assets V is fixed in initial size[8] and V is comprised of continuously traded financial securities, [9] the market value of which follows a standard geometric Brownian motion process:

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

Following Cox et al. (1985) and assuming a fixed riskless rate r, a claim F(V,t) with a continuous payment C must satisfy a standard partial differential equation, and under the assumption that $F_t=0$[10] the general solution for this equation is

$$F(V) = A_0 + A_1 V + A_2 V^{-X} \tag{2}$$

where $X=2r/\sigma^2$ and A_0, A_1 and A_2 are determined by the boundary conditions.

[6] Although this assumption allows firms to raise some capital during an economic downturn, the firms are not able to recapitalize after severe negative shocks and so face increased likelihood of involuntary closure by regulators. Further, firms never operate with negative equity, and therefore our assumption of the ability to raise equity is only for firms with positive equity.

[7] 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.

[8] We assume that in practice local market conditions and federal regulations impose upper bounds on firm size.

[9] A bank's assets are primarily composed of loans and securities. While the assumption of active trading is valid for securities, 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.

[10] In the context of corporate debt (Leland 1994; Leland and Toft 1996), 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. The latter justification is also applicable to banks. Even 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 franchise value of the bank.

Using the general solution in Eq. 2, we can obtain expressions for the major claims that influence the market value of a firm including the current market value of potential bankruptcy costs (BC), franchise value (FV), and the insurance provided by the federal government (IB). We then define the market value of the bank v as

$$v = V - BC(V) + FV(V) + IB(V) \tag{3}$$

2.1 Bankruptcy costs

To apply Eq. 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 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 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:

$$BC(V) = \alpha V_B, \ \text{when } V = V_B$$

$$BC(V) = 0, \qquad \text{as } V \to \infty$$

Using these conditions with Eq. 2 results in the following expression for BC(V):

$$BC(V) = \alpha V_B \left(\frac{V}{V_B}\right)^{-X}, \text{where } X = \frac{2r}{\sigma^2} \tag{4}$$

The term $(V/V_B)^{-X}$ can be interpreted as the expected present value of \$1 payable when the random variable V(t) first reaches V_B, and 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 Deposit based franchise benefits

Merton (1978) notes that bank deposits may be an important source of franchise value, and Bennett and Unal (2009) find that FDIC resolution costs are lower for banks with large branch networks and retail deposits. Further, tax advantage debt is a major source of franchise value for all levered corporations. Accordingly, we assume that bank franchise value is proportional to bank deposits (D) based on a proportionality factor (τ). The franchise value is zero when the bank reaches the insolvency threshold, V_B, while as V gets very large the likelihood of insolvency approaches zero and firm value includes the full franchise value. Therefore the boundary conditions for valuing franchise value are:

$$FV(V) = 0, \qquad \text{when } V = V_B$$

$$FV(V) = \tau D = \frac{\tau C}{r}, \qquad \text{as } V \to \infty$$

where D is simply the C divided by the risk free rate r due to deposit insurance.

Using these conditions with Eq. 2 results in a market value of tax benefits of

$$FV(V) = \frac{\tau C}{r}\left(1 - \left(\frac{V}{V_B}\right)^{-X}\right) \tag{5}$$

The tax deductibility of interest payments on debt provides an important source of franchise value to all firms (Miller 1977) including banks that pay interest on deposits, and bank franchise value takes the same form as the benefits of tax advantaged debt in Leland (1994).

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. However, when V becomes very large and the likelihood of insolvency declines, the market value of the insurance payment claim falls to zero. Therefore, we have the following boundary conditions for the insurance benefit:

$$
\begin{aligned}
IB(V) &= Max[\left(\frac{C}{r}-(1-\alpha)V_B\right),0] \qquad &\text{when } V = V_B\\
IB(V) &= 0, \qquad &\text{as } V \to \infty
\end{aligned}
$$

The market value of the insurance benefit claim is:

$$
IB(V) = Max\left[\left(\left(\frac{C}{r}\right)-(1-\alpha)V_B\right)\left(\frac{V}{V_B}\right)^{-X},0\right] \tag{6}
$$

If the insolvency threshold satisfies,$(1-\alpha)V_B < C/r$, the insurance payment will be greater than zero and the max operator can be ignored in Eq. 6. If $(1-\alpha)V_B > C/r$, the market value of insurance benefits is uniformly zero because the bank will be closed before the recoverable value of bank's 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 set $(1-\alpha)V_B \leq C/r$ since a higher threshold eliminates all insurance benefits and any incentive to become a regulated bank. As a result,

$$
IB(V)-BC(V) = (\frac{C}{r}-V_B)\left(\frac{V}{V_B}\right)^{-X} \tag{7}
$$

The canceling out of the term αV_B in Eq. 7 confirms that deposit insurance has the effect of transferring the burden of bankruptcy costs from the firm to the insurer, and 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 Eqs. 4, 5 and 6 into the expression for the market value of the bank gives the following:

$$
v(V) = V+FV(V)-BC(V)+IB(V) = V+\left[\left(1-\tau\right)\frac{C}{r}\right)-V_B\right]\left(\frac{V}{V_B}\right)^{-X}+\frac{\tau C}{r} \tag{8}
$$

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,

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

2.5 Capital regulation of banks

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.[11] 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[12] 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 $\beta(C/r)$. 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 c. Using the accounting identity, this establishes a maximum leverage ratio, $D/V < 1 - c = \ell *$ and, in turn, that V>D/1-c. Thus, β=1/1-c.

Thus, if we set $V_B = \beta C/r$ and substitute into Eq. 8, we have:

$$v(V) = V + IB(V) - BC(V) + FV(V) = V + \left[\tau - k\left(\frac{C}{V}\right)^X\right]\left(\frac{C}{r}\right) \tag{10}$$

where $k = (\tau + \beta - 1)(\beta/r)^X$. Depending on the magnitudes of τ and β, k can be positive, negative or zero. In practice, we expect $(\tau+\beta)>1$[13] and thus we expect that k>0. In fact, as will be seen later in Eq. 12, an interior optimal value of C does not exist if $k\leq 0$. With k>0, the sign of the second term in Eq. 10 is indeterminate and the market value of the firm can be greater than or less than the value of its assets, V.

3 Optimal capital structure of banks

3.1 Determining the firm's optimal choice of leverage

As in Leland (1994), we consider a firm value maximizing bank. First, consider a world without franchise value. In our framework, this is accomplished by setting franchise value proportionality factor τ to zero in Eq. 10. Under this assumption, the sign of the derivative of Eq. 10,[14] 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 $\beta>1$ and the bank is liquidated while asset value exceeds deposits, the market value of the bank v(V) is a monotonic decreasing function of the coupon payment C.[15] Firm value achieves its

[11] 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.

[12] Earlier versions of this paper contained an extension that analyzed two capital thresholds: a high "warning" level and a lower insolvency level where the bank is liquidated. We found that the additional warning threshold has only a small impact on optimal leverage, even with substantial warning costs (Harding et al. 2007).

[13] τ should be positive and β should be close to one if not greater than one.

[14] In our model, firm value and equity value differ by the term -C/r. Thus for a fixed r, there is no difference between setting the partial derivative of the firm value equal to zero and the derivative of equity equal to -1/r.

[15] With zero franchise value, the model contains two contingent claims: bankruptcy costs that favor equity financing and insurance benefits that favor debt financing. Both claims pay off when the firm's assets, V, reach V_B, and one term always dominates the other over all V. This result can also be seen in Eq. 10 because when τ equals 0 the derivative depends upon the sign of k, which is in turn determined by the sign of (β-1).

maximum value equal to the unlevered value of the firm when the bank chooses all equity financing (C=0).[16] With no franchise value, such rigid regulatory regimes can be ruled out because under those circumstances doing business as a bank would be unprofitable.

On the other hand, when β<1 and the bank is only liquidated after it has become insolvent, the value of the bank increases monotonically with the coupon payment C. As a practical matter, we assume that regulators require a minimum investment of equity, which in turn places an upper limit on C. However, clearly under these circumstances owners will have a strong incentive to put as little capital in the company and choose as high a leverage as possible. Under traditional regulatory regimes, regulation consistent with c <0 or β<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 (Kane 1989).

The model without franchise value helps illustrate the importance of franchise value in the firm's capital structure choices. If increased competition in financial markets erodes bank franchise value, regulators are likely to face a difficult choice between establishing a regulatory regime that puts regulated financial institutions at a serious disadvantage relative to unregulated institutions (i.e., setting β>1) and adopting a light capital regulation (β<1) that would result in a strong appetite for leverage among such institutions.

We turn next to a more general case with franchise value, τ>0. To find the optimal value of C and hence optimal leverage, we calculate the first two derivatives of v with respect to C.

$$\frac{\partial v}{\partial C} = \frac{\tau}{r} - (1+X)\left(\frac{k}{r}\right)\left(\frac{C}{V}\right)^{X} \tag{11}$$
$$\frac{\partial^2 v}{\partial C^2} = -X(1+X)\left(\frac{k}{r}\right)V^{-X}C^{X-1}$$

The second derivative is negative for k>0 and so, in that case, the market value of the bank is a strictly concave function of C.[17] Setting the first derivative equal to zero and solving for the optimal C* yields:

$$C^* = gV(0), \text{where g} = \left[\frac{\tau}{k(1+X)}\right]^{\frac{1}{X}} \tag{12}$$

where g can be interpreted as the optimal asset payout rate. An interior optimum exists even with a fairly weak capital standard, 1/(1-α)>β>1-τ.[18]

[16] 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.

[17] The k>0 condition also affects banks' preference for portfolio risk. When this condition is met, bank value monotonically decreases with risk/variance σ, but if the condition fails, banks choose both the maximum leverage and the maximum portfolio risk allowed. A similar corner solution for variance arises in Leland (1994).

[18] We have also examined a situation where deposit based franchise value is replaced by a more general form that depends linearly upon both total debt and total assets. Such a model continues to yield an interior optimal capital structure, but an optimal capital structure does not exist if franchise value only depends linearly on total firm assets.

Finally, substituting C* into Eq. 9 yields the initial market value of the firm.

$$v^*(V) = V\left(1 + \frac{X}{1+X}(\tau\ell^*)\right) \tag{13}$$

The resulting optimal initial leverage ℓ^* is equal to $C^*/(rV(0))$ and thus g, the optimal payout rate, is equal to r ℓ^*. The interior optimum ℓ^* exists because at low levels of leverage or low coupon payment, adding additional debt increases the value of the firm by increasing the franchise value while adding little to the net of expected bankruptcy costs and insurance benefits since insolvency is remote. However, as leverage increases, the incremental franchise value benefits are eventually outweighed by the higher risk to future benefits resulting from possible future insolvency.

It is notable that a franchise value that depends upon debt causes banks to hold substantial equity even under regulatory regimes that would have led banks to select all debt in the absence of franchise value. The combination of a capital requirement and the threat of liquidation with the potential for loss of franchise value creates an incentive for banks to limit their use of deposits. In this way franchise value allows regulators to be sufficiently lenient so that regulated financial institutions are competitive without creating strong incentives for those institutions to take on very high levels of leverage. This finding is comparable to results of Marcus (1984), Hellmann et al. (2000), and Repullo (2004) who document an important role for charter or franchise value in understanding the impact of regulation on bank risk taking behavior.

Figure 1 demonstrates the balancing of insurance benefits, franchise value and bankruptcy costs as a function of the bank's choice of C at time zero under the assumptions indicated at the top of the figure. The high concave (solid) line represents the market value of the franchise, 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 franchise value increases sharply with C when the resulting leverage is low. However, at higher levels of leverage, the franchise value begins to decline as the result of the increased likelihood of insolvency. Franchise value is zero when V_B=V (or C=rV/β). The

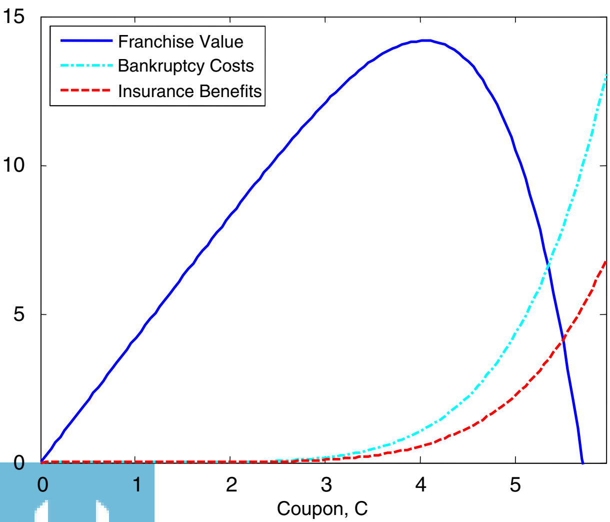

Fig. 1 Franchise Value, Bankruptcy Costs and Insurance Benefits as a Function of the Firm's Choice of Debt Payment, C. Figure 1 shows the response of the value of the three contingent claims to changes in the firm's choice of continuous debt service payment, C. All three lines assume V is fixed at 100 and the firm chooses how to finance those assets by selecting C, which determines the deposit level, D. The solid line represents the franchise value; 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 Eqs. 5, 4 and 6, respectively

figure also points out the critical role that the franchise value plays in determining the optimal leverage because given the low bankruptcy costs in financial institutions franchise value is 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 insurance benefits net of bankruptcy costs are small except for extreme values of C where the franchise value is near zero and so for reasonable values the franchise value term dominates the optimal capital structure decision.

3.2 Changes in franchise value and optimal capital structure

Effect of τ on Book Leverage. While the existence of franchise value limits firm incentives for leverage, the impact of changes in franchise value on the book value of leverage can be seen by examining the response of the coupon payment (and in turn total deposits) to changes in the franchise value proportionality factor τ while holding the unlevered value of the firm (V) fixed.[19] Taking the partial derivative of the optimal coupon in Eq. 12 with respect to franchise value as a share of debt, we obtain:

$$\frac{\partial C^*}{\partial \tau} = \frac{gV}{X\tau}\left(\frac{\beta - 1}{\tau + \beta - 1}\right) \tag{14}$$

We first observe that for values of β close to one, the sensitivity of C* to changes in franchise value is small. Nevertheless, it is instructive to consider how franchise value interacts with the nature of the capital requirement β to influence C*. The sign of the partial derivative in Eq. 14 depends on the sign of the term in parentheses. For stringent capital requirements when $\beta > 1$, this term is positive and the optimal debt service payment C* is increasing in franchise value leading to an increase in the book value of leverage. However, if $\beta < 1$ (and τ is sufficiently large to keep the denominator positive), the opposite is true—a higher franchise value would lead bank owners to choose a lower debt service payment and lower book leverage. To understand this behavior on the part of the bank's owners, one must recall that without franchise value the bank would prefer to not use any debt when $\beta > 1$ in order to avoid the risk of insolvency costs. The use of debt is motivated entirely by the desire to obtain the franchise value arising from debt. When $\beta < 1$, the bank would choose the highest possible leverage with no franchise value, and the introduction of franchise value means that the firm now has something to lose in the event of insolvency. Therefore, a higher franchise value leads to larger possible losses from violating capital standards and a more conservative choice of debt service payment.[20]

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

[19] In terms of other comparative statics, a decrease in r (or an 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 and lower leverage. The optimal coupon C* is monotonically increasing in g, and g is an increasing function of the riskless rate r (a decreasing function of σ and β), as long as $\beta > 1 - \tau$. This result also requires 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.

[20] 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 franchise value. The first bank would lower its very high leverage while the second would increase its lower leverage.

rather chooses C^*. The market value of the bank including its contingent claims is determined by that choice. Using the definitions above, we find:

$$L^* = \frac{D^*}{v^*(V)} = \left(\frac{r}{g} + \frac{X}{1+X}\tau\right)^{-1} \quad \text{where} \quad g = \frac{r}{\beta}\left[\frac{\tau}{(\tau+\beta-1)(1+X)}\right]^{\frac{1}{X}} \tag{15}$$

Notice that optimal leverage is independent of the value of a bank's financial assets 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 expression in parentheses in Eq. 15 must be greater than one. This condition is met as long as optimal payout rate g is less than the riskless rate r, which will hold for a wide range of parameter values in our simulations later in the paper.[21] The second term in the expression is unambiguously positive yielding an optimal capital structure less than one.

The first order partial derivative of L* with respect to franchise value is:

$$\frac{\partial L^*}{\partial \tau} = -(L^*)^2\left[-\frac{r}{Xg\tau}\left(\frac{\beta-1}{\tau+\beta-1}\right) + \frac{X}{1+X}\right] \tag{16}$$

which 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.[22] While the finding that leverage decreases with franchise value is intuitive for the case ($\beta<1$) where C^* is decreasing in τ, it is less so for the case where $\beta>1$ and the bank optimally increases C^* as a result of an increase in the franchise value. The result arises because although an increase in C^* directly increases D^*, it also increases $v^*(V)$ because of the contingent claims included in v(V). In fact, $v^*(V)$ increases more rapidly than D^* as a function of τ, with the result that L* actually declines. Unlike the bank's choice of C*, L* is inversely related to franchise value, regardless of the stringency of the capital threshold.[23]

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 $\beta=1$ 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 $\sigma=0.15$, and the franchise value proportionality factor $\tau=0.25$. [24] Although, the bankruptcy cost parameter, α, does not enter the formulas for firm value directly, it does influence the maximum level of β that the regulator can choose since

[21] 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 was in excess of the asset drift, this would imply a 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. Leverages above 1 can arise for values of β near ($1-\tau$), but at such values g is near zero and close to the knife-edge case where an optimal coupon does not exist.

[22] As in footnote 21, in practice, this relationship only breaks down for values of β near ($1-\tau$).

[23] Leverage also decreases with franchise value for reasonable parameter values when franchise value is defined more generally as a linear function of both firm debt and total firm assets.

[24] One source of franchise value for all firms is tax-advantage debt, and we use effective tax rates as a guide for setting franchise value. Although the top marginal corporate tax rate is 40%, FDIC Call reports show that the average effective tax rate for U.S. commercial banks is 31.9%. Further, 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%.

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 1 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 franchise value factor τ across the three panels of the Table. The assumed franchise value factors range from fifteen percent in panel A to thirty-five percent in Panel C. 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 franchise value. We also report both the market leverage and book leverage for this optimal choice of C*. For all three panels in Table 1, 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% as β increases from 0.90 to 1.1 when τ is 15%. The effect of β declines, however, as τ increases. When τ is 35%, C* falls by only 26.7% as β increases from 0.90 to 1.1. The differential effect of capital regulation for different τ's is consistent with Eq. 14, 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 τ increases when $\beta=0.9$ but increases from 3.51 to 3.68 with τ when $\beta=1.1$. The market value of the firm v* decreases as β increases as do both measures of leverage for all values of τ.

The last two columns in Table 1 present the value and capital structure of a comparable, unregulated, firm as studied by Leland (1994) using bankruptcy costs based on $\alpha=0.10$ and allowing for the same franchise value, which parallels Leland's benefits from tax advantaged debt. 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 ($\beta=1$). 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 franchise value. It chooses a very low bankruptcy threshold which contributes to the very high franchise value reported for these firms. This enhanced franchise value 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.[25] 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 franchise value and the value of the firm. The firm that issues protected debt has a lower optimal firm value than all but the banks with high capital requirements ($\beta \geq 1.05$).

Table 2 presents a similar set of panels varying the level of asset price volatility, σ, from 10% to 25% while holding the franchise value factor fixed at 25%. In general, the optimal debt service payment, C*, declines as volatility increases. For $\beta=1$, C* falls by 29.3% as σ rises from 10 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 and reducing franchise value which falls to zero if V(t) hits V_B. The primary factor behind the decline in C* is the increased risk of forced liquidation by regulators and the associated loss of franchise value, which as discussed previously is the

[25] 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 franchise value due to forced liquidation that yields an interior optimal capital ratio. As franchise values decrease, this risk becomes less important and bank leverage increases, while for the unregulated firm franchise value create an unambiguous incentive for taking on more leverage.

Table 1 The impact of insolvency threshold and franchise value 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 Insurance 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
FV Franchise Value	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 Insurance 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
FV Franchise Value	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 Insurance 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
FV Franchise Value	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	–	–

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.

3. The minimum capital requiriements c are fully determined by β and are reported because most regulations are described in terms of capital requirements.

largest contingent claim. For all values of β considered, franchise value falls by approximately 50% as volatility rises from 10 to 25%. The effect of insurance benefits net of bankruptcy costs on leverage depends upon β. For lax regulatory environments, where β<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 β>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 (or 3.54% of assets) when $\beta=0.9$ and decreases by 0.67 with both values evaluated at C*.

Table 2 The impact of insolvency threshold and asset return volatility on bank capital structure decisions

Panel A: $\sigma=10\%$	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 Insurance 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
FV Franchise Value	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: $\sigma=15\%$	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 Insurance 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
FV Franchise Value	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 Insurance 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
FV Franchise Value	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	–	–

Table 2 (continued)

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 Insurance 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
FV Franchise Value	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	–	–

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 franchise value factor, 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.

These factors have clear implications for the market value of the firm. As volatility increases, the risk of loss of franchise value 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 franchise value per dollar of debt results in a significant decline of the franchise value contingent claim as volatility increases. This decline in the franchise value 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 monotonic decline in firm value with volatility, *ceteris paribus.* This example demonstrates the importance of having a comprehensive model that explicitly incorporates insurance benefits, bankruptcy costs and franchise value. Ignoring franchise value, we might conclude that banks subjected to lax capital regulation ($\beta<1$) would have a tendency to invest in riskier assets.[26]

4 Implications for bank capital regulation and policy

4.1 The tradeoff between bankruptcy costs and the provision of banking services

A 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 research

[26] The book leverage levels reported in Tables I and II tend to be lower than the industry average of 90%. Focusing on β=1.05 (roughly corresponding to a "Well Capitalized" bank standard) and ten percent asset volatility, the model predicts book leverage of 76%. There are several possible explanations for this difference. First, the overall industry average is distorted by the inclusion of large international banks. The industry average leverage for small banks (assets less than $100 million) is somewhat lower at 87%. Further, our model does not consider multiple types of debt. Deposits represent only 67% of bank 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, short-term borrowing via Fed Funds or repurchase agreements may be less costly than deposits which entail providing customer service, and subordinated debt has the advantage of being included in Tier II capital. Finally, our model does not incorporate agency cost motives for issuing debt (Jensen 1986; Jensen and Meckling 1976).

on bank capital structure focuses on the link between regulatory policy and bank risk taking associated with its investment portfolio (Hellmann et al. 2000; Besanko and Kanatas 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. Based on applying a traditional social planner's perspective to our specific model, bankruptcy costs are the only relevant factors 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).[27] 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 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 capital standards reduce the expected return to bank equity and in response the supply of capital as equity to the banking sector would fall leading to an imbalance between the supply of risk free deposits from potential depositors and the capital necessary to maintain banks' desired capital structure. 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.[28] Allen et al. (2011), Gale (2004), Gale and Ozgur (2005) and Van den Heuvel (2008) examine related situations where agency problems lead banks to hold excess capital leading to a banking sector that is too small to provide the optimal level of financial intermediation services.

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:

$$\rho = \frac{v - D}{V - D} = \left(v - \frac{C}{r}\right)\left(V - \frac{C}{r}\right)^{-1}. \tag{17}$$

[27] 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.

[28] 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 are similar to the Pareto Improvement arising from imposition of interest rate limits in Hellmann et al. (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 1 and 2 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 1 indicates that both bankruptcy costs and returns to bank equity are much more non-linear for low levels of franchise value suggesting that the costs and benefits of the sector are less responsive and the regulatory trade-off less critical when franchise value is high. In Table 2, 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 new regulatory regime including a new statutory minimum capital requirement. These two institutions hold investment portfolios and guarantee mortgage-backed securities (MBS) owned by other investors. The institutions were required to hold capital equal to 2.5% of balance sheet assets and .45% of off balance sheet guarantees (i.e., MBS).[29] However, regulation of the GSEs 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.[30] 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 if 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 3 reports the required capital, actual capital and excess capital for both GSEs from 1993 through 2007. Because the GSEs had to restate their financial reports beginning in 2003,[31] 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

[29] 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 assets and MBS. Consequently the risk-based standard was never binding because the GSEs were required to meet the higher of the two standards.

[30] 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.

[31] 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.

Table 3 Capital requirements for GSEs 1993-2007

Year	Required Capital	Fannie Mae Actual Core Capital	Excess – % of Assets & MBS	Required Capital	Freddie Mac 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%

amount of excess capital.[32] For both institutions, 1993 was the first year of operation under the statutory minimum capital requirement and Fannie Mae and Freddie Mac held excess capital of roughly $1 billion and $.7 billion, respectively. These amounts 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 its assets and MBS's. Freddie Mac's excess capital, while slightly higher when measured as a percentage of assets and MBS's, 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.

Both institutions had become accustomed to being able to raise capital[33] 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 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.

[32] 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 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.

[33] In the late 1990's, the GSE's were able to readily sell preferred stock on advantageous terms and used preferred stock sales when they needed to build capital.

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. For example, the average total capital ratio for all commercial banks was 12.3% from 2001 through 2008, 2.3% above the ten percent standard for well-capitalized banks. Furthermore, within the bank population, large commercial banks that might have viewed themselves as having some protection from regulatory takeover because they were "Too Big to Fail" maintained a lower average total capital ratio of 11.8% . The .5% difference in capital represents a 22% smaller cushion.[34]

Our model also sheds light on another important policy issue. The model implies that declines in franchise value will increase a bank's optimal leverage based on market values. 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" and so benefit from an implicit government guarantee and the resulting increased access to debt markets and lower borrowing costs, now faced significant competition from large commercial banks in areas such as IPOs, security sales and trading and merger and acquisition advising. This increased competition lowered the franchise value previously associated with investment banking charters. With diminished franchise value, investment banks had less incentive to maintain a conservative capital cushion and more incentive to enhance returns through increased leverage.[35] 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.

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 limit a regulatory authority's ability to establish and enforce stringent capital standards are likely to encourage riskier capital structures, and the negative impact of such policies likely increases as markets become more competitive and franchise values decline.

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 optimal capital structure choice depends critically on the presence of

[34] Data on commercial bank capital ratios is available at www2.fdic.gov/SDI.

[35] 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. Also see Jaffee (2003, 2007) for discussions of the GSE's exposure to interest rate risk and the implications of the implicit government guarantee of GSE debt.

deposit based bank franchise value. Without such franchise value, the bank's capital structure 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 franchise value significantly alters these results. Specifically, when franchise value is considered, 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 effective capital regulation comes the threat of liquidation and, consequently, the market value of a claim to franchise value does not monotonically increase with leverage. Without the threat of liquidation, financial institutions will not willingly carry a capital cushion. Such an incentive cannot be replaced by simply raising capital standards because regulators cannot perfectly monitor the risk faced by financial institutions and the soundness of the financial system is enhanced by regulations that create incentives for prudence among the managers of financial institutions.

Our results are relevant to the current financial crisis and debate over future regulation of financial institutions.[36] The failure of major investment banks early in the crisis was 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 and the stabilization of large commercial banks and bank holding companies like Citigroup under the broader federal bail-out program raises important concerns about the future capital structure decisions of financial sector institutions. Our model illustrates that any perceived weakening of regulator ability or willingness to dissolve financial institutions that clearly violate capital standards can lead to firms holding less of a financial cushion above those capital standards.

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 for violating explicit or implicit capital standards. Our model suggests that the regulator's ability to 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. This implication of our model is consistent with the empirical findings of Brewer et al. (2008) that capital ratios are higher in countries that practice regulatory prompt corrective action.

Further, it is the presence of franchise value that gives capital standards teeth and leads to an interior optimal leverage. Significantly, our model shows that optimal market leverage increases when franchise values decline. These aspects of our model 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) or Hellmann et al. (2000) and Repullo (2004) who find that increases in franchise value can reduce bank incentives for risk in leverage or portfolio decisions, respectively.

[36] See Kane (2009), Caprio et al. (2008), Chari et al. (2008), Cohen-Cole et al. (2008) for more general discussions of the causes of the current financial crisis. See Harding and Ross (2009) for a more specific discussion of the implications of financial models of firm capital structure for reform of financial regulation.

Finally, in contrast to models where excess capital is held as a buffer to mitigate the costs of continually updating capital holdings (Blum and Hellwig 1995; Bolton and Freixas 2006; Peura and Keppo 2006), our model generates predictions that match recent empirical studies of bank capital structure. Berger et al. (2008) find that bank holding companies set target capital levels substantially above regulatory thresholds and make rapid adjustments toward their targets, Gropp and Heider (2010) find that banks that are more profitable, pay significant dividend and have high market to book ratios hold more capital, while these factors should be expected to the lower cost of raising equity at short notice. Flannery and Rangan (2008) find that in the 1990's bank capital holdings were strongly positively related to portfolio risk. These findings have been used to argue that market discipline is likely more important than capital standards for determining bank capital ratios. However, consistent with empirical findings, our model also implies that firms will hold excess capital whether or not transactions costs are important, will hold more capital if they have higher franchise value (high profits or significant dividend), and will hold more capital when they face higher risk in their portfolio; consistent with the empirical findings just discussed. In our model, banks hold capital in excess of the regulatory capital requirement entirely due to the presence of that requirement, and so market discipline is not required to explain the current empirical findings in the bank capital literature.

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