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Capital Regulation and Bank Risk-Taking: A Note

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This paper examines theoretically the effects of more stringent capital regulation on bank asset portfolio risk. The analysis shows that, for a value-maximizing bank, incentives to increase asset risk decline as its capital increases. Thus, as long as regulatory efforts to contain asset risk and size are not reduced, more stringent capital regulation unambiguously reduces the expected liability of the deposit insurance system.

Concern over the risk exposure of the federal deposit insurance system has been a major factor behind the increase in capital standards in banking in the 1980s. A central issue in bank capital regulation is whether the enforcement of higher capital ratio requirements gives banks greater incentive to increase asset risk, thereby partially or even fully offsetting the effect of a higher capital ratio on default risk. Indeed a major criticism of the regulatory attempts to raise bank capital ratios in the 1980s is that these efforts "drove" banks to seek out more risky activities. This view that more stringent capital regulation will exacerbate the problem of risk-taking appears to be held widely among commercial bankers and is evident in the financial press as well as in the academic literature.[1]

In this note, we address the question of how more stringent capital ratio requirements affect the incentives of a fully insured bank to increase the riskiness of its asset portfolio. The analysis builds on that of studies such as Sharpe (1978), Kareken and Wallace (1978), and Dothan and Williams (1980), which use state-preference models to examine the effects of deposit insurance, and those such as Merton (1977) and Pyle (1984), which model the deposit insurance guarantee as a put option. These studies show that, for a value-maximizing bank with subsidized deposit insurance, regulations are required to control both leverage and asset risk. What is not addressed fully is how a bank's incentives for increasing asset risk vary with changes in capital ratio requirements. It is important to fill this gap in order to assess the effect of bank capital regulation on bank default risk and the risk exposure of the deposit insurance system.

I. A State-Preference Model

In this section, a state-preference model is used to analyze the portfolio and leverage decisions of an insured bank that maximizes its current value (the market value of its equity). We use a two-period model with two possible future states. The current prices of a dollar payout in the future states are P_1 and P_2, for State 1 and State 2, respectively. These prices are taken as given and are unaffected by the portfolio decisions of banks.

To fund its current assets, A_0, a bank has an initial amount of capital, C_0, and issues insured deposits, D_0, so that $A_0 = D_0 + C_0$.[2] A unit of deposits pays off \$1 in each state and is summarized as $D(1,1)$. The current price of a unit of deposits is:

(1) $$P_D = P_1 + P_2.$$

Deposits then earn the risk-free real rate, $1/(P_1 + P_2) - 1$.

A bank can invest in two risky assets, Security X and Security Y. One unit of Security X represents a promise by the issuer to pay x_1 dollars if State 1 occurs and x_2 dollars if State 2 occurs, and is summarized as $X(x_1, x_2)$. Security Y is summarized as $Y(y_1, y_2)$. Security X is the riskier security such that $x_1 < y_1$ and $x_2 > y_2$. The current prices of Securities X and Y are:

(2) $$P_X = P_1 x_1 + P_2 x_2$$

and

(3) $$P_Y = P_1 y_1 + P_2 y_2,$$

respectively. Without loss of generality, the payouts in each state are defined to be such that the price of a unit of each security is the same, that is,

(4) $$P_X = P_Y = P_D = P.$$

The equalities in (4), along with the assumption that Security X is riskier than Security Y, imply that $x_1 < y_1 < 1 < y_2 < x_2$.

The share of a bank's assets allocated to the riskier asset, Security X, is S, and the share allocated to Security Y is $(1 - S)$.

II. Value of Deposit Insurance

For a bank that is capitalized such that it can meet its obligations to depositors in all future states, deposit insurance is redundant, and, thus, has no value. The current value, V_0, of a bank that can meet its obligations to depositors in both State 1 and State 2 equals the sum of the current value of the payoffs on assets in each of two states minus the current value of depositors' claims:

(5) $$V_0 = \frac{C_0 + D_0}{P}[Sx_1 + (1 - S)y_1]P_1 + \frac{C_0 + D_0}{P}[Sx_2 + (1 - S)y_2]P_2 - D_0.$$

(5) simplifies to $V_0 = C_0$. That is, the value of a bank that can meet its obligations to depositors in both states is equal to its initial capital; there is no deposit insurance subsidy.

However, a bank that can fail—that is, one that cannot meet its obligations to depositors in one state—benefits from deposit insurance. Given that the initial capital position and asset risk of a bank is such that bankruptcy occurs in State 1, and the deposit insurance premium rate is zero,[3] the current value of the deposit insurance subsidy, I_0, from (5) is

(6) $$I_0 = \frac{D_0}{P}P_1 - \frac{C_0 + D_0}{P}P_1[Sx_1 + (1 - S)y_1] > 0.$$

In (6), $(C_0 + D_0)/P$ is the number of units of asset securities held and $P_1[Sx_1 + (1 - S)y_1]$ is the current value of the asset payoff in State 1 per unit of security. $(D_0/P)P_1$ is the current value of depositors' claims in State 1. For deposit insurance to have a value to the bank, the value of the bank's assets in State 1 has to fall short of the claims of depositors. The current value of that short-fall, which corresponds to the option value of deposit insurance, is equal to the current value of the payout to depositors by the insurance fund in the bankruptcy state. Given C_0, a bank seeking to maximize the current value of its equity, which is $V_0 = C_0 + I_0$, will try to maximize the value of the deposit insurance option, I_0.

III. Leverage and Risk

It is well known that a bank can maximize I_0 by maintaining the highest degree of leverage (the lowest ratio of initial capital to initial assets) allowed by regulation and by increasing asset portfolio risk as much as possible. Under the traditionally invoked assumption that C_0 is fixed (an assumption that will be dropped shortly) the effect of a change in leverage (a change in D_0/A_0) on the value of the insurance guarantee is obtained by differentiating (6) with respect to D_0. Doing so yields

$$(7) \quad \frac{\partial I_0}{\partial D_0} \Big|_{C_0} = \frac{P_1}{P} \{1 - [Sx_1 + (1 - S)y_1]\} > 0.$$

The partial derivative is positive since, as stated above, $x_1 < y_1 < 1$, which means that $[Sx_1 + (1 - S)y_1] < 1$. Thus, the current value of the deposit insurance subsidy increases with leverage. With subsidized deposit insurance, a value-maximizing bank would limit its leverage only if forced to do so by regulation.

Constraints on bank asset risk also are required. In this model, increased asset risk is associated with a higher value of S. The effect of a change in risk-taking on I_0, as determined from (6), is

$$(8) \quad \frac{\partial I_0}{\partial S} = -A_0 \frac{P_1}{P} (x_1 - y_1) > 0.$$

The partial derivative is positive since $x_1 < y_1$. The positive relation between asset risk and the value of the deposit insurance guarantee indicates that a value-maximizing bank with underpriced deposit insurance would want to have $S = 1$. To prevent this, regulators would have to control asset risk, which in this model could mean limiting S to some maximum $\bar{S}$ or imposing regulatory costs that are a positive function of S. For a bank to be at $S < 1$, regulatory cost would have to be such that the marginal cost of exceeding that particular value of S was at least equal to the marginal value (in terms of increased value of deposit insurance) from doing so.

This condition for asset risk regulation to be effective is precisely the reason that the question of how capital regulation affects the incentives for increasing asset risk is important. Those who maintain that capital regulation leads to more asset risk implicitly argue that the marginal value from increasing asset risk is negatively related to changes in leverage (i.e., positively related to changes in the capital-to-asset ratio). This position implies that for higher capital standards to be fully effective they likely would have to be accompanied by the imposition of higher regulatory costs for violating asset-risk constraints. On the other hand, if the marginal value is either not related to or is positively related to changes in leverage, the enforcement of higher capital standards would not lead to greater asset risk, unless the restrictions on asset risk themselves were relaxed.

(8) indicates that the gain from increasing asset risk depends on asset size but not on the bank's leverage per se. Under the assumption of fixed capital, however, a change in leverage directly affects the volume of assets. A reduction in leverage can only be accomplished by selling assets and using the proceeds to retire liabilities. From (8), the marginal gain from increasing asset risk is positively related to a change in leverage. That is,

$$(9) \quad \frac{\partial^2 I_0}{\partial S \partial D_0} \Big|_{C_0} = -\frac{P_1}{P} (x_1 - y_1) > 0.$$

This means that a reduction in leverage achieved via retiring debt and shrinking assets would reduce the marginal gain from increasing asset risk. In other words, a bank would not be expected to respond to higher capital requirements by increasing the riskiness of its asset portfolio.

IV. Allowing Capital to Vary

While the assumption of fixed capital may be suitable for certain banks, it is not appropriate for many larger banking organizations with access to capital markets. The ability of a bank to issue new capital is a potentially important consideration since, as we show below, a bank would prefer to do so when it reduces leverage in response to more stringent capital requirements. The reason for this preference is that, for a given degree of leverage, the total value of the insurance subsidy, I_0, is positively related to the volume of assets, holding leverage constant. This can be seen from the derivative of the value of the insurance guarantee, in (6), with respect to assets, holding leverage constant, which is

$$(10) \quad \frac{\partial I_0}{\partial A_0} \Big|_{(D_0/A_0)} =$$

$$\frac{1}{A_0} \{\frac{D_0}{P} P_1 - \frac{A_0}{P} P_1 [Sx_1 + (1 - S)y_1]\} > 0.$$

The term in the braces is the expression for the value of the deposit insurance, which is positive given the bankruptcy conditions for State 1.

(10) indicates that, when a bank reduces leverage, it would receive a larger insurance subsidy by increasing C_0 than by selling assets and reducing deposits. This is relevant to the analysis since the extent to which a bank alters its leverage by issuing new equity affects the volume of assets, which from (6) determines how the gains from increasing asset risk are affected. As we show next, however, allowing capital to vary does not change the earlier conclusion from (9) regarding the effects of leverage on the change in the value of the insurance subsidy with respect to changes in asset risk. The reason is that, even when a bank can increase C_0, requiring the bank to reduce leverage will result either in a net contraction in A_0 or no change in A_0.

To see why initial assets would not expand, first note that from (10) a bank, as well as the banking industry as a whole, will expand as A_0 much as possible, independent of any requirement to reduce leverage. Specifically, a bank would have expanded assets to the point where the marginal gain from increasing assets was balanced by the marginal cost of doing so. The main source of such a cost would be regulatory constraints.

Next, assuming no change in the marginal cost of increasing assets when leverage is reduced (that is, regulatory restrictions are not relaxed), a bank would expand assets only if the change in the value of the insurance subsidy with respect to assets declines as leverage increases. However, from (10) the opposite is the case—that is: $[\partial^2 I_0/\partial A\ \partial(D_0/A_0)] > 0$. Therefore, a bank would not hold more assets when required to reduce leverage, even if the bank can increase C_0.

Given this result, the effect of leverage on the gains from increasing asset risk for a bank that can issue new capital (increase C_0) are similar to those for a bank with fixed initial capital. That is, from (8),

$$(11)\quad \frac{\partial^2 I_0}{\partial S_A \partial(D_0/A_0)} = -\frac{\partial A_0}{\partial(D_0/A_0)}\frac{P_1}{P}(x_1-y_1) > 0,$$

given that $[\partial A_0/\partial(D_0/A_0)] > 0$, which holds if A_0 contracts when a bank is required to reduce leverage. In the limiting case in which A_0 is unchanged, the partial derivative in (11) is equal to zero. Therefore, the incentives for a bank to increase asset risk do not rise as leverage falls.

The conclusion we draw from the state-preference model is that, if the costs to a bank from expanding asset risk and size are not reduced due to a relaxation of regulatory constraints, a value-maximizing bank, whether or not it can issue new capital, will not respond to more stringent capital requirements by increasing the riskiness of its assets. Thus, more stringent capital regulation unambiguously reduces the risk exposure of the deposit insurance system.

V. Options Model

Options models also have been used to analyze the effects of leverage and asset risk on the equity value of a bank when deposit insurance is mispriced. One advantage of options models is that they are more general than the two-state model presented above. However, as with the studies using state-preference models, the studies modeling deposit insurance as a put option do not address fully the question of how capital regulation affects the gains from increasing asset risk nor do they discuss why this issue is important. In this section, we show that an options model yields conclusions similar to those derived from the state-preference model concerning the implications of capital regulation for asset risk among value-maximizing banks.

Following Merton (1977), the Black-Scholes formula for a European put option can be adapted to apply to the federal deposit insurance guarantee. Assuming all earnings are retained and a zero insurance premium, the current value of the insurance guarantee is

$$(12)\qquad I_0 = D_0 F(\sigma\sqrt{t} - X) - A_0 F(-X)$$

where:

I_0 = the value of the option.
D_0 = the current value of insured deposits, which are assumed to constitute all deposits.
A_0 = the current value of assets (excluding the value of the insurance option).
σ = the standard deviation of the rate of return on assets, which is the measure of risk.
t = the interval to the next examination.

$$X = \frac{\log\left(\frac{A_0}{D_0}\right) + \left(\frac{\sigma^2 t}{2}\right)}{\sigma\sqrt{t}}$$

$F(\ )$ is the standard normal cumulative density function.

Assuming that capital is fixed, the familiar results regarding the effects of leverage and asset risk on the value of deposit insurance, the put option, can be derived from (12) as follows:

$$\text{(13)} \quad \frac{\partial I_0}{\partial D_0} \mid_{C_0} = F(\sigma\sqrt{t} - X) - F(-X) > 0$$

and

$$\text{(14)} \quad \frac{\partial I_0}{\partial \sigma} = A_0\sqrt{t}\, F'(X) > 0$$

where $F'(\ )$ is the standard normal density function.[4] From (13), it follows that a value-maximizing bank will increase leverage indefinitely unless constrained by regulation. (14) indicates that a bank has an incentive to increase asset risk.

How the incentives for increasing asset risk, holding C_0 constant, would be affected by changes in leverage induced by regulation can be determined by taking the partial derivation of (14) with respect to the current value of deposits. This yields the result:

$$\text{(15)} \quad \frac{\partial^2 I_0}{\partial \sigma \partial D_0} \mid_{C_0} = A_0\sqrt{t}\, F''(X)\frac{\partial X}{\partial D_0} + F'(X)\sqrt{t} > 0.$$

As long as a bank has positive initial capital, this last partial derivative will be positive because $F''(X) < 0$ and $\partial X/\partial D_0 < 0$ *and* $F'(X) > 0$. This result is qualitatively the same as that obtained from the state-preference model. The marginal gain from risk-taking increases with leverage, holding capital constant. Therefore, higher capital standards by themselves would not increase the incentives for insured banks to increase asset risk.

As in the state-preference model, this conclusion also holds for a bank that can increase C_0 in order to reduce leverage. Again, under the options model, a bank would expand assets, holding leverage constant, as much as possible, independent of any required change in leverage, since from (12)

$$\frac{\partial I_0}{\partial A_0} \mid_{(D_0/A_0)} > 0.$$

However, regulatory costs that are sufficient to limit A_0 at a given level of leverage will be sufficient at any lower level of leverage since

$$\frac{\partial^2 I_0}{\partial A_0\, \partial(D_0/A_0)} > 0.$$

Therefore, a reduction in leverage will not lead to an increase in A_0, everything else equal.

With an increase in A_0 ruled out, it follows from (14) that the effect of leverage on the gains from increasing asset risk is

$$\text{(16)} \quad \frac{\partial^2 I_0}{\partial \sigma\, \partial(D_0/A_0)} = \frac{\partial A_0}{\partial(D_0/A_0)} \sqrt{t}\, F'(X) + A_0\sqrt{t}\, F''(X)\, \frac{\partial I}{\partial(D_0/A_0)} > 0.$$

since $[\partial A_0/\partial(D_0/A_0)] \geqslant 0$. Thus, whether or not is C_0 constant, higher capital requirements reduce the marginal gains from increasing asset risk. This in turn means that the risk exposure of the deposit insurance system is lower.

VI. Conclusion

This note analyzes the theoretical relationships between capital regulation and bank asset risk. The key finding is that regulatory increases in capital standards by themselves will not require greater efforts to restrain asset risk. Higher capital requirements reduce the incentives for a bank to increase asset risk. Our results also indicate that a value-maximizing bank prefers to meet higher required capital ratios by raising additional capital, rather than merely by selling assets and retiring deposits. In this way the bank maximizes its volume of assets and thereby the value of the deposit insurance subsidy.

The implication is that regulatory efforts to raise capital standards do not lead a value-maximizing bank to hold a more risky asset portfolio, as long as regulators do not also relax efforts to limit asset risk and size. Thus, a more stringent capital regulation will reduce the risk exposure of the deposit insurance system.

NOTES

1. In a *New York Times* article on March 5, 1987, concerning a Federal Reserve proposal to require banks to hold capital in connection with interest rate and currency contracts, William McDonough, vice chairman of First National Bank of Chicago, is quoted as saying that ". . . the proposal could lead banks to take on riskier business to compensate for the lower returns they would almost assuredly get by having to maintain more capital."

In the academic literature, studies such as Kahane (1977) and Koehn and Santomero (1980), applying a mean-variance model to utility maximizing banks, conclude that higher capital ratios can lead to greater asset risk. In a recent article in this journal, Keeley and Furlong show that the previous studies using such a framework are internally inconsistent and the models cannot be used to support the conclusion that a higher bank capital ratio can lead to greater risk-taking.

2. Thus, A_0 and C_0 exclude the value of any deposit insurance subsidy, which will be introduced shortly.

3. The conclusions from the analysis would be unchanged if the rate were a positive, fixed-rate premium.

4. See Jarrow and Rudd (1983).

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