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CAPITAL CONTROLS AND BANK REGULATION

Gerard Gennotte* - David Pyle**

Abstract

Our objective in this paper has been to analyze the effects of more stringent capital controls on the behavior of a bank that maximizes shareholder value where there are deposit guarantees and imperfect regulatory control of the risk of the bank's assets. In contrast to earlier work, we have taken the view that loan evaluation costs and loan monitoring costs make bank loans intrinsically different from zero npv (net present value) investments (e.g. market securities). Using a model incorporating a loan cost function that is increasing and convex in the level of investment and asset risk, we have shown that there are plausible circumstances in which an increase in capital requirements will result in a decrease in the level of investment, but an offsetting increase in asset risk. We have also shown that the conditions leading to this perverse response by banks are more likely to prevail the lower the current capital requirement and the higher the level of asset risk that a bank currently has. Furthermore, there are circumstances in which the resulting increase in asset risk will result in an increase in the probability of default.

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Introduction*

Bank accounts are an integral part of the economic life of citizens of developed countries. The key role played by commercial banks in developed economies and the memory of the bank runs of the Great Depression have led to extensive regulation of these financial institutions by the governments of most countries. The social costs of bank failure have induced governments to provide financial support and other forms of protection from failure. For example, in the U.S., the FDIC explicitly guarantees the principal of bank deposits (up to a limit that has varied over time) and, through their closure policies, U.S. regulators have implicitly guaranteed all deposits in large banks; in other cases such as post-war France, the government nationalized major banks. It is indeed commonly perceived that bank deposits should be riskless in nominal terms and that government guarantees, explicit or implicit, are directed toward this end.[1] If such deposits were risky, the aggregate costs of gathering information related to their risk by a large number of small investors would be large, creating the need for a more efficient monitoring procedure. By guaranteeing

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[1] See Diamond and Dybvig (1986) for a synthesis of banking theory that supports this perception.

deposits, governments have redistributed bankruptcy risks but have also been led to play the role of principal in order to prevent agents --commercial banks-- from generating excess profits at the social cost of increasing the risk of and losses due to failure. The recent financial distress experienced by financial institutions in the U.S. and elsewhere has intensified the debate over the role of regulatory agencies.

Corporate finance scholars and agency theorists have long recognized the inefficiency of simple debt contracts in cases where the likelihood of bankruptcy is large. Since bondholders ultimately bear the costs of bankruptcy, it is in the interest of shareholders --and hence of managers who represent shareholders-- to increase investment risk in the hope of receiving a high return if the economy evolves favorably while limiting their losses if it does not. These "financial distress" games by stockholders being anticipated, the required interest rate on corporate debt includes a risk premium and the debt contract includes a variety of covenants which restrict the actions of managers. By guaranteeing deposits, the government allows banks to offer a riskless or nearly riskless rate on their deposits. In the absence of covenants so strict that they essentially rule bankruptcy out, this constitutes a windfall profit, which is larger if the bank faces larger risks on its investments. The value maximization framework has been frequently used in previous research on the effects of deposit guarantees. Proponents of this analytic framework argue that the managers of a widely-held financial institution will choose investments so as to maximize the value of the deposit guarantee. Equivalently, the costs (net of monitoring costs) borne by regulatory institutions (and the taxpayer) are maximized in equilibrium. Deposit guarantees without effective restrictions on the recipient's investment policy constitute a transfer from the government to bank shareholders or bank customers or both. Furthermore, the deadweight costs incurred in bankruptcy make such a contract economically inefficient. Regulation of bank capital and bank portfolio restrictions have been introduced to reduce the incentive for banks to undertake highly risky positions.

Capital controls limit the banks' ability to lever their investment portfolios. But, banks may then have an incentive to shift their investments to riskier assets, thereby increasing the risk of bankruptcy and at least partially defeating the purpose of capital controls. The question of a risk offset to tighter capital regulation has been addressed in the academic and professional literature and conflicting answers have been provided.[e]

In the subsequent analysis, we focus on bank capital restrictions and consider their effect on the risky assets held by banks, on the probability of bankruptcy and on the economic efficiency of bank investment.

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[e] See Furlong and Keeley (1987) for a review of this literature and an analysis that rejects the existence of a risk offset.

II Value maximization in a static model

In this section, we develop a model of the bank under the assumption that the bank managers act in shareholders' interests and that shareholders seek to maximize the net present value of their claim on the bank. First, let us describe the investment opportunities faced by the banking institution and then include the effect of deposit guarantees.

The investment opportunity set consists of a series of mutually exclusive projects with different risk characteristics parameterized by the risk index σ. By investing an amount I, the bank acquires an asset with cash flows having a present value v. The investment level is a function of the present value v and of the risk index σ chosen, denoted $I(\sigma,v)$. In the absence of deposits, the amount invested by the bank's shareholders is equal to $I(\sigma,v)$ and the net present value of the bank's assets is given by

$$V(\sigma,v,0) = v - I(\sigma,v). \qquad \text{(II-1)}$$

The investment strategy is chosen so as to maximize the net present value of the bank's assets. Denote σ_u and v_u the optimal risk index and investment level for the unlevered bank. σ_u and v_u are given by

$$I_v(\sigma,v) = 1$$

and

$$I_\sigma(\sigma,v) = 0$$

This optimal investment policy would be chosen by any firm facing the same investment opportunity set. In the absence of market imperfections, it is also the policy that would be chosen by a bank that financed with a combination of shares and unsubsidized deposits.

Governmental intervention in the form of deposit guarantees, however, modifies the bank's optimization problem. Assume now that the bank raises an amount D of deposits, D' being the amount due to depositors at a future date T. The amount available for investment I is now equal to the sum of the bank's shareholders capital and the amount borrowed D. At maturity, if assets exceed the amount owed, D', bank's shareholders receive the balance. In the other case, the government takes over, repays depositors and the shareholders receive nothing. The government's guarantee represents a subsidy because it allows the bank to borrow at the riskless rate: D' = D exp(rT).[3] Shareholders will thus seek to maximize the net present value of their claim on the bank, inclusive of the value of the subsidy:

$$V(\sigma,v,D) = C(\sigma,v,D') - (I(\sigma,v) - D) \qquad \text{(II-2)}$$

subject to: $D' = D\exp(rT)$.

Where $C(\sigma,v,D')$ denotes the value of an European call on an asset currently worth v with risk characteristics σ, a strike price of D', and maturity T.[4]

The total present value of the bank is equal to the present value of its assets plus the value of the subsidy. This total value is shared between the present value of the deposits and the present value of the shareholders' claim. Therefore, the government subsidy, $S(\sigma,v,D)$, is the following function of σ, v and D:

$$S(\sigma,v,D) = C(\sigma,v,D') + D - v. \qquad \text{(II-3)}$$

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[3] For simplicity, we assume that the payment promised to depositors at date T is guaranteed.

[4] See Merton (1977) for a statement of the isomorphic relation between deposit insurance and a call option on the bank's assets.

In addition to the risk level and the amount invested, the amount of deposits is also chosen so as to maximize the bank's net present value. It seems intuitively clear that the subsidy increases with the amount deposited and that the bank's shareholders will always seek to increase deposits. Thus, we have the following proposition.

Proposition 1:

The net present value V is an increasing function of the amount of insured deposits, ceteris paribus (i.e. for a fixed asset level v and risk parameter σ).

Proof:

The asset level v being fixed, the bank's shareholder's investment is equal to $I(\sigma,v)-D$ and the derivative of V with respect to D is given by:

$$\exp(rT)\ C_3(\sigma,v,D') + 1.$$

To prove that the sign of this expression is positive, we consider the following investment strategy: buy a European call on v with a strike price of D' and shortsell a European call with a strike price of D'+d'. The maximum cashflow generated by the strategy at date T is equal to the difference in the strike price d' when both call are exercised. Hence to prevent arbitrage the cost of the strategy must be strictly inferior to exp(-rT) d':

$$C(\sigma,v,D') - C(\sigma,v,D'+d') < \exp(-rT)\ d'$$

Rearranging terms and taking the limit of d' at zero, we have

$$\exp(rT)\ C_3(\sigma,v,D') + 1 > 0 \text{ for all } \sigma,\ v, \text{ and } D'.$$

Additional deposits have two effects on the shareholder net present value: first they allow shareholders to reduce capital by the corresponding amount, second they reduce the option value by increasing the strike price. For an additional deposit dollar, the bank commits to repay an additional $\exp(rT)$ at date T if it is solvent. The likelihood of bankruptcy being positive, this commitment does not completely offset the one dollar reduction in capital. If the government did not guarantee deposits, depositors would require a risk adjusted return and additional deposits would not benefit shareholders. Note, however, that this property holds only when the asset level v is held constant; in other words a substitution of deposit funds for bank capital increases the value of the bank. Depending on the increase in the asset present value associated by additional investment, it may or may not be in the best interest of shareholders to increase the amount invested by the full amount of additional deposits. Instead, shareholders might well prefer to reduce their own investment.

The existence of a deposit guarantee affects the bank's investment decision. The bank invests until the subsidy on the marginal dollar offsets the (negative) present value of the marginal investment.[5] Deposit guarantees thus lead to suboptimal investment choices by the bank in the sense that they induce the bank to undertake negative net present value investments. Bank's shareholders choose the investment and leverage policies which maximize the market value $V(\sigma,v,D)$. It follows from proposition 1 that the optimum will always be obtained at $K=0$.

In order to reduce the subsidy size and to control the bank's exposure, the government may impose capital constraints.

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[5] We assume that bank depositors have no monopsony power so that deposit guarantee subsidies are not passed on to them.

Such constraints can take a variety of forms; to simplify we will assume that the bank is required not to exceed a fixed deposit-to-asset value ratio, δ. It follows from proposition 1 that this constraint will be binding under our assumptions. Hence, the amount of deposits corresponding to a given asset value is simply $D = \delta\ v$. Given this constraint, the bank's optimization program consists in choosing the asset value v and risk level σ which maximize the objective function

$$V(\sigma,v) \equiv C(\sigma,v,\delta v \exp(rT)) + D - I(\sigma,v) \}$$

Under fairly general conditions[6] on the stochastic process describing fluctuations in the asset value through time, the value of the European call is homogeneous of degree one in the underlying asset value and the strike price. We will rewrite the call value as follows

$$C(\sigma,v,\delta v \exp(rT)) = \delta\ v\ c(\sigma, \frac{1}{\delta}) \qquad \text{(II-4)}$$

The call value is thus a function of the risk level σ and of the ratio of the asset value to the promised payment to depositors, δ.

If the assets available to the bank are all zero net present value investments, independent of the level of investment and the risk characteristics of the assets, the required investment $I(\sigma,v)$ is equal to v and the first order conditions for the maximum are:

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[6] Namely that the return on the asset over the life of the option is independent of the current asset value v, see Merton (1973), for example.

$$V_v = \delta\ (\ c(\sigma,\ \frac{1}{\delta}) + 1) - 1 > 0 \qquad (II\text{-}5.1)$$

$$V_\sigma = \delta v\ c_1(\sigma\ ,\ \frac{1}{\delta}\ ) > 0 \qquad (II\text{-}5.2)$$

The inequality in (II-5.1) is verified because the option value strictly[7] exceeds the present value of the underlying asset $1/\delta$ minus the exercise price of 1. Inequality (II-5.2) follows from the positive monotonicity of the call function with respect to asset risk.

Clearly, if the bank faced an unlimited set of investments with non-negative net present value, and was not constrained in the level of available deposits, it would seek to invest without bounds. In particular, if the bank was allowed to invest in traded assets, it would purchase the riskiest available assets it was allowed to purchase in infinite quantities.[8]

We believe it is more reasonable to assume that bank loans are not zero net present value investments and that the return to loan investments is a function of the level of investment and of the riskiness of the assets chosen. The cost of loan evaluation and the present value of future monitoring and loan workout costs are assumed to be increasing and convex functions of the level of investment and the risk index. The idea that loan costs increase with increases in investment may be thought of as a reflection of loan information costs as a bank attempts to extend beyond its existing loan markets and to the increase in monitoring and

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[7] The inequality is strict unless the probability that the option expires without being exercised is zero, an uninteresting case since the subsidy value would then be zero as well.

[8] Or at least until the bank's purchases lead to a modified price equilibrium. The bank being subsidized, it would finally own all available traded assets.

workout costs for such loans. Similarly undertaking riskier loans involves added information costs and, perhaps more importantly, the greater likelihood of incurring monitoring and workout costs.[9]

When the bank is assumed to invest in assets with these characteristics, the first order conditions for a maximum are:

$$V_v = \delta \left(c(\sigma, \frac{1}{\delta}) + 1 \right) - I_v(\sigma, v) = 0 \qquad \text{(II-6.1)}$$

$$V_\sigma = \delta v \, c_1(\sigma, \frac{1}{\delta}) - I_\sigma(\sigma, v) = 0 \qquad \text{(II-6.2)}$$

where the partial derivative of the call value with respect to the risk level σ, $c_1(\sigma,v)$, is positive.

From these conditions, it is clear that a subsidized deposit guarantee results in inefficient investment ($I_v>1$) and inefficient risk taking ($I_\sigma>0$). The resulting new net present value is necessarily inferior to the optimum in the no-subsidy case. These inefficiencies are sustained because the unfavorable consequences will be borne ultimately by the provider of deposit guarantees.[10] We now turn to a more detailed analysis of the equilibrium to determine whether the bank expands its scale or risk level or both until the marginal return from the government subsidy is offset by the negative marginal return on loans.

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[9] See Black, Miller and Posner (1978), p. 384 for a discussion of the "administrative costs" associated with high-risk loans.

[10] It is often presumed that this adverse incentive problem can be solved by imposing a risk constraint as well as a capital constraint. We assume that risk constraints of this sort do not fully eliminate the subsidy to levered risk-taking.

III Capital controls and economic efficiency

Recognition of the perverse incentives of deposit guarantees has led a number of governments to impose capital controls on banking and recently to increase capital requirements. In this section, we examine the effect of a decrease in the deposit to asset value ratio (δ) on the bank's decisions. The three factors of interest are the effect on risk-taking, the effect on the probability of bankruptcy, and the effect on the economic efficiency of bank investment.

For simplicity, we will make the mild assumption that the option payoffs at maturity can be perfectly replicated by a (possibly dynamic) portfolio of traded assets.[11] The option value is then determined by arbitrage and we can price the option in a risk neutral fashion, provided we adjust the asset return distribution so that it's expected return is equal to the riskless rate[12]. We will also assume, without loss in generality, that the interest rate is equal to zero. The asset value at maturity, v', is then given by

$$v' = v\ (1 + \sigma Y),$$

where Y is a random variable with zero expectation and a variance of 1, Y is assumed to be bounded from below so that the asset value at maturity is always positive. The risk index σ is also the standard deviation of the return on the asset.

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[11] A Black and Scholes (1973) framework where the return on the asset held by the bank is lognormally distributed and there exists a combination of traded assets with perfectly correlated instantaneous returns, for example, would satisfy this assumption.

[12] We refer the reader to Harrison and Kreps (1979) for a formal statement and proof of this proposition.

The call value is then given by

$$c(\sigma, \frac{1}{\delta}) = E \{ \text{Max} [\frac{1}{\delta} (1 + \sigma Y) -1 , 0] \} ,$$

where E denotes the mathematical expectation. Denoting p(Y) the probability density associated with a given realization Y, and Y_o the default point (the lowest value of Y for which the option is exercised), we have

$$c(\sigma,\frac{1}{\delta}) = \int_{Y_0}^{Y_{Max}} (\frac{1}{\delta} (1 + \sigma Y) - 1) p(Y) dY,$$

with $\qquad Y_o = (\delta-1)/\sigma < 0 .$ (III-1)

Let us now define two parameters, q and q' by the following

$$q \equiv \int_{Y_0}^{Y_{Max}} p(Y) dY, \qquad \text{and} \qquad q' \equiv \int_{Y_0}^{Y_{Max}} Y p(Y) dY.$$

where 1-q is the probability of default and q' is the expectation of Y conditional on no default. The option value can then be rewritten as

$$c(\sigma,\frac{1}{\delta}) = (\frac{1}{\delta} - 1) q + \frac{\sigma}{\delta} q' = \frac{\sigma}{\delta}(q'- Y_o q) ,$$

and the value function becomes

$$V(\sigma,\frac{1}{\delta}) = \sigma v(q'+ Y_o(1-q)) + J(\sigma,v) \qquad \text{(III-2)}$$

where $J(\sigma,v)$ is defined as the net present value of an investment with standard deviation σ and present value v ($J(\sigma,v)=v-I(\sigma,v)$). The first order conditions are[13]

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[13] The first equation is easily obtained by noting that the partial derivative of the call value with respect to the optimal exercise point Y_o is equal to $p(Y_o)$ times the exercise value at that point which is zero by definition.

$v\,q' = -J_\sigma(\sigma,v)$ and $a(q' + Y_o(1-q)) = -J_v(\sigma,v)$ (III-3.1&2).

We are interested in the effect of a decrease in δ on the optimal risk level, σ^* and on the optimal scale, v^* and have the following result.

Proposition 2:

Given a stable equilibrium, if the bank increases asset risk in response to tighter capital controls, it will simultaneously decrease its scale.

Proof:

Let σ' and v' be the derivatives of σ^* and v^* with respect to δ. The equations determining σ' and v' are

$$V_{\sigma\sigma}\,\sigma' + V_{\sigma v}\,v' + V_{\sigma\delta} = 0 \qquad \text{III-4.1}$$

$$V_{\sigma v}\,\sigma' + V_{vv}\,v' + V_{v\delta} = 0 \qquad \text{III-4.2}$$

where

$$V_{\sigma\sigma} = \frac{v}{\sigma}\, p(Y_0)\, Y_0^2 + J_{\sigma\sigma}$$

$$V_{\sigma v} = q' + J_{\sigma v}$$

$$V_{vv} = J_{vv} < 0$$

$$V_{\sigma\delta} = -\frac{v}{\sigma}\, p(Y_0)\, Y_0 > 0$$

$$V_{v\delta} = 1 - q > 0$$

A necessary condition for equilibrium is $\Theta > 0$ where

$$\Theta = V_{\sigma\sigma}\, V_{vv} - V_{\sigma v}^2 .$$

The solution for σ' is

$$\Theta\,\sigma' = -V_{\sigma\delta}\, V_{vv} + V_{v\delta}\, V_{\sigma v}$$

so a necessary condition for $\sigma' < 0$ is $V_{\sigma v} < 0$. From equation III-4.1, if σ' and $V_{\sigma v}$ are both negative v' must be positive and a decrease in δ will increase asset risk and decrease the scale of investment.

The response of the bank to a tighter capital constraint is seen to depend critically on the sign of the cross partial, $V_{\sigma v}$ with a negative sign necessary for asset risk to increase. This cross partial will be negative in equilibrium if increases in scale increase the marginal cost due to risk. For example, if marginal monitoring costs resulting from an increase in asset risk increase as the bank expands it scale, this necessary condition will be satisfied.

Futhermore, if $V_{\sigma v}$ is negative, the following important proposition holds.

Proposition 3: The smaller the current capital requirement and the riskier the current asset portfolio (i.e. the smaller Y_o in absolute value), the more likely that asset risk will increase with tighter capital controls.

Proof:

Consider

$$\Theta \, \sigma' = - V_{\sigma\delta} V_{vv} + V_{v\delta} V_{\sigma v}$$

as Y_o approaches zero, $V_{\sigma\delta}$ approaches zero and $V_{v\delta}$ increases so σ' is more likely to be negative.[14]

From Proposition 3, we see that increases in risk that are an offset to the desired effects of tighter capital controls are more likely when the current capital requirement is low and more

[14] It can also be shown that Θ is positive at $Y_o = 0$.

likely for the banks that are currently taking the most risk.

Returning to the first order conditions, let us consider some specific cases. Observe that the ratio of the second first order condition to the first yields the important equation[15]:

$$\frac{Y_0(1-q) + q'}{q'} = \frac{v\, J_v}{\sigma\, J_\sigma} \qquad \text{(III-5)}$$

Equation (III-5) shows that the optimum is obtained by equating a function of the optimal exercise point Y_o to the ratio of the elasticities of the net present value function with respect to the control variables σ and v. Let us denote this ratio of elasticities $\epsilon(\sigma,v)$.

Since the capital constraint requires the asset value to be strictly superior to the amount of deposits ($\delta<1$), Y_o is negative and it must be the case that in equilibrium the elasticity ratio, $\epsilon(\sigma,v)$ will be smaller than one.[16] Equivalently, the elasticity of the net present value function with respect to the standard deviation σ is larger than the elasticity with respect to the investment scale, v.

Let us assume at first that this ratio is a constant K ($=\Phi/\beta<1$).[17] Then Y_o is determined by equation (III-5):

$$Y_o\ (1-q) = (K-1)\ q'$$

That is, the optimal exercise point Y_o is independent of the

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[15] Note that the numerator is equal to the difference between the option value and its exercise value, so it is positive as long as default is possible.

[16] It is easily verified that the numerator on the r.h.s. of III-4 is positive as long as default is possible.

[17] The ratio of elasticities is a constant if the net present value function is given by $J(\sigma,v) = J_o + J_1\sigma^\beta v^\Phi$. Given our earlier assumption regarding the nature of loan evaluation and monitoring costs, it follows that $J_1<0$, $\beta>1$, and $\Phi>1$.

capital constraint, δ. Equivalently, the probability of bankruptcy is unaffected by a change in the capital constraint. This result seems counter-intuitive but it stems from the adjustment in the risk level σ made by the bank. To see this, let us rewrite equation (III-1) as:

$$\sigma = \frac{\delta - 1}{Y_0}$$

Hence, Y_o being a negative constant, the bank responds to a tightening in the capital constraint (decease in δ) by increasing the risk level σ. As we know from our earlier analysis, this increase in the risk level is accompanied by a decrease in the present value chosen by the bank. Specifically, for $\epsilon(\sigma,v) = \Phi/\beta$, we have

$$\sigma' = \frac{1}{Y_0} < 0 \quad \text{and} \quad v' = \frac{(\beta - 1)v}{(1-\Phi)\sigma} Y_0 > 0$$

Using these results, we can evaluate the effect of a decrease in δ on the net present value of the bank's loan investment and show that

$$\text{sign} \frac{dJ}{d\delta} = \text{sign} (\Phi - \beta) < 0.$$

Of course, these results are only relevant if the second order conditions for an optimum are satisfied at the equilibrium point. Since V_{vv} is negative by assumption, the second order conditions will be satisfied if Θ is positive. When the net present value J is a power function in σ and v, Θ will be positive if and only if

$$Z(Y_o) = p(Y_o)Y_o[q' + (1-q)Y_o] + q'(1-q) > 0$$

It can be shown that this inequality is satisfied for any distribution that is linear and non-decreasing with increases in Y for $0 \geq Y \geq Y_d$, where Y_d is the lower bound on Y. This includes the zero mean, unit variance uniform distribution ($p(Y)=k$). It also holds for any zero mean, unit variance density function that is an upward sloping linear function of Y in the range $0 \geq Y \geq Y_d$ ($p(Y)=K(1+Y/Y_d)$ for $Y \leq 0$). This allows more realistic distributions for bank loans, for example a distribution that includes a probability spike at the promised value of the loans and a probability density that decreases linearly as the realized payoff decreases. More generally, a sufficient condition for $Z(Y_o)>0$ is that the value of the distribution function at Y_o (i.e. the probability of default) be greater than or equal to the density at Y_o times Y_o. Clearly the smaller Y_o, the more likely this condition will hold.

In summary, if the net present value function for the bank is represented by a power function in σ and v, a tightening of the capital constraint will result in an increase in asset risk, an unchanged probability of insolvency, a decrease in lending, and an increase in the net present value (npv) of the bank's loan portfolio. From a policy viewpoint, the increase in the npv of the bank's loans is a movement toward more efficient asset allocation. This positive result of tighter capital controls will be offset to the extent that the social costs of bankruptcy increase with the increased riskiness of the asset portfolio.[18] To the extent that the major policy concern is general financial

[18] That is to say if the loan workout costs on higher risk loans are greater (loan resale value smaller) for the deposit guarantor in a bankruptcy than they are for a solvent bank.

instability triggered by bank failure, the tighter capital constraint is a totally ineffective tool in this particular case.

Of course, there is no compelling reason to believe that the elasticity ratio, $\epsilon(\sigma,v)$, is a constant. Taking the total differential of equation III-5, we obtain the following following general expression for σ'

$$\sigma' = \frac{Z(Y_0) \quad - \sigma\epsilon_v(q')^2 v'}{Z(Y_0)Y_0 + \sigma\epsilon_\sigma(q')^2} \qquad \text{III-6.}$$

where $Z(Y_0) = q'(1-q) + p(Y_0)Y_0(q'+(1-q)Y_0)$ and ϵ_σ and ϵ_v are partial derivatives of $\epsilon(\sigma,v)$.

For $\epsilon_v=\epsilon_\sigma=0$, we have the earlier result $\sigma'=1/Y_o$ and in this case the necessary condition for a stable equilibrium implies that $Z(Y_o)>0$. By appealing to continuity, we can evaluate the effects of non-zero partial derivatives of the elasticity ratio for ϵ_σ and ϵ_v small (i.e. $\sigma'\approx 1/Y_o$). In particular for $\epsilon_v=0$, it can be seen from equation III-6. that σ' will be less than (greater than) $1/Y_o$ for ϵ_σ positive (negative). The derivative of Y_o with respect to δ is

$$\frac{dY_0}{d\delta} = \frac{(1-Y_0\sigma')}{\sigma}$$

so it follows that a tighter capital constraint will result in an increase (decrease) in the probability of default if the elasticity ratio increases (decreases) with increases in asset risk. Similarly, for $\epsilon_\sigma=0$ and ϵ_v small, the probability of default will increase (decrease) with a decrease in δ if the elasticity ratio decreases (increases) with increases in the scale of investment.

Based on our analysis of equation III-6., we conclude that as long as the elasticity ratio $\epsilon(\sigma,v)$ is relatively insensitive to changes in the control variables, asset risk will increase with a tightening of capital controls. Furthermore, it is feasible that this increase in asset risk will result in an increase in the probability of default.

IV Conclusions

Our objective has been to analyze the effects of more stringent capital controls on the behavior of a bank that maximizes shareholder value where there are deposit guarantees and imperfect regulatory control of the risk of the bank's assets. In contrast to earlier work, we have taken the view that loan evaluation costs and loan monitoring costs make bank loans intrinsically different from zero npv investments (e.g. market securities). Using a model incorporating a loan cost function that is increasing and convex in the level of investment and asset risk, we have shown that there are plausible circumstances in which an increase in capital requirements will result in a decrease in the level of investment, but an offsetting increase in asset risk. We have also shown that the conditions leading to this perverse response by banks are more likely to prevail the lower the current capital requirement and the higher the level of asset risk that a bank currently has. Furthermore, there are circumstances in which the resulting increase in asset risk will result in an increase in the probability of default.

In many, but not necessarily all, cases, the increase in capital will reduce the deposit guarantor's liability and improve the economic efficiency of bank lending, but not by as much as if the risk offset did not occur. Increases in bank capital are not a substitute for the monitoring and control of asset risk by the bank regulator and may imply an increased need for such regulation, especially at banks where the existing capital position is weak and where asset risk is high.

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