Regulation of Bank Capital

and

Portfolio Risk

By

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ABSTRACT

This paper examines the impact of bank portfolio behavior when banks

are subject to capital regulation. It employs comparative static analysis

of bank portfolio risk when regulators increase the minimun level of capital

acceptable to them. The results show, under plausible assumptions, that an

increase in the required capital-asset ratio can lead, to a higher port-

folio risk and to a higher probability of failure. For the sys-

tem as a whole, the results of a higher required capital-asset ratio

in terms of the average probability of failure is ambiguous, while the

intra industry variance of probability of failure unambiguously increases.

This result leads us to question the viability of regulating commercial banks

in terms of a capital requirement. Thus, serious consideration should be

given to the discontinuance of regulation of bank capital via ratio constraints

and allowing the financial markets to control the risk behavior of bank

management. Alternatively such regulation should be imposed on a much more

selective basis.

INTRODUCTION

Recent large bank failures (e.g., Franklin National) coupled with an
unstable economic environment have rekindled the controversy over the question
of the adequacy of bank capital. Regulators such as the Federal Reserve,
have indicated their concern over the trend towards the reduction of capital
relative to assets by requesting banks to improve their capitalization and
be enforcing a "go slow" policy towards bank expansion. However, bank
management complains that such regulation restricts their investment oppor-
tunities, resulting in reduced bank profitability. They argue that the low
return on capital due to such restrictions is the ultimate cause of failure
and that the financial markets should be the sole mechanism for the control
of bank capital.

There is, of course, an abundance of literature on both sides of the
bank capital issue. On the side of the regulators, for example, such authors
as Wallich (18), Shay (16), and Watson (19) have pointed out that the cost
of bank failure is not simply the loss to equity holders. They assert that
bank failure disrupts the payments mechanism, and thus generates a far greater
cost than the capital markets would consider. Conversely, authors such as
Pringle (10), Vojta (17) and Robinson and Pettway (12) argue that the capital
markets should regulate banks via the price mechanism, and that bank management
should be free to maximize market value within an unconstrained environment.

Implicit in most of the literature on bank capital is the attempt to
define the amount of capital that would be "adequate" in light of the economic
environment and the cost of bank failure. Santomero and Watson (15) use a
macro general-equilibrium model to demonstrate that an optimal capital
structure can be found in terms of the capital-asset ratio. Their model

considers the social cost of bank failure as well as the cost of over-capitalization before determining the optimal capital-asset ratio. Using such a model as a basis, one can argue that bank capital may require some regulation and that capital structures should be held to the optimal amount.

It is interesting to note that much of the literature arguing for and against regulating bank capital has not considered the impact of such regulation on individual bank behavior nor whether the regulation actually achieves its desired result.[1] Regulation is assumed to function in an essentially *ceteris paribus* environment. The purpose of this paper is to explicitly examine the issue of portfolio reaction by investigating the effect of capital ratio regulation on the portfolio behavior of a commercial bank.[2] It develops a precise specification of the bank's portfolio decision that flows directly from a risk averse portfolio allocation decision by the firm. Next, using comparative static analysis, it examines the effects on bank portfolio risk of a regulatory increase in the minimum level of capital acceptable to the supervisory agency. It concludes that for the system as a whole, the results of a higher required capital-asset ratio in terms of the average probability of failure is ambiguous, while the intra industry variance of probability of failure unambiguously increases. This result leads us to question the viability of regulating commercial banks in terms of a capital requirement. Thus, serious consideration should be given to the discontinuance of regulation of bank capital via ratio constraints and allowing the financial markets to control the risk behavior of bank management. Alternatively, such regulation should be imposed on a much more selective basis.

The analysis will proceed in the following steps. Section I will lay out explicitly the assumptions concerning bank behavior and the bank environment. Section II will derive the analytic model. Section III will carry out comparative statics when the capital-asset ratio is increased. Section IV will examine these results and relate them to a measure of the probability of failure.[3] The final section will summarize the results.

I. ASSUMPTIONS OF THE MODEL

The approach taken here is to examine the portfolio response of the commercial bank, when faced with a regulatory change. The major assumptions used in order to derive the model and to explicitly carry out the analysis are listed below. In general, they require that the bank be viewed as an expected utility maximizer in the capital market. Its objective function is maximized subject to the capital market opportunity set and the regulated size of the bank's capital.

The assumptions may be enumerated as:

a. Total deposit size is assumed to be under the control of bank management. That is, the amount of deposits raised by management to support the purchase of risky assets is a choice variable.[4]

b. For simplicity, there does not exist a risk-free asset for purchase by the bank, but the return paid to depositors is riskless.

c. The bank acts as if it is a risk averse expected utility maximizer.[5] This assumption is well known in the literature (see D. Pyle (11), for example). Furthermore, Ross (13) has shown that an optimal fee schedule can be derived such that the agent, i.e., bank management, acting so as to maximize its

expected utility will maximize the principles, i.e., owners, expected utility. It is further assumed that the objective function can be approximated by a Taylor series expansion in a quadratic function. Thus, the bank bases its portfolio decisions on mean-variance of total portfolio return.

d. The bank makes its portfolio decisions for a single period only. Thus, the portfolio decision is made at the beginning of a period and the portfolio is held until the end of the period.

e. All risky assets are traded in competitive markets so the individual bank treats the rates of return on each asset as given. That is, the bank is a price taker. This assumption could be criticized for certain asset markets (e.g., small commercial loans), but generally would seem to hold to a first approximation in every asset market. It should be pointed out that introducing market imperfections in the analysis (e.g., a monopoly position of the bank in an asset market) does not change the results.[6] Market imperfections do, however, complicate the derivation so they will subsequently be ignored in this analysis.

II. THE EFFICIENT OPPORTUNITY SET UNDER CAPITAL REGULATION

Given that the regulator fixes the capital to asset ratio, denoted $c \equiv K/A$, the choice problem facing the bank is to determine its optimal scale, i.e., the amount of deposits and capital to issue, as well as to optimally allocate its funds (deposits plus capital) over the available risky assets.

Since the bank is assumed to maximize expected utility based upon the first two moments of the portfolio return distribution, the particular portfolio chosen -- described by the relative quantities held of each asset and liability -- will be from the mean-variance efficient set.[7]

To find the entire efficient investment set the bank has the following quadratic programming problem:[8]

(1) minimize

$$\{x_i\} \quad \tfrac{1}{2} \sum_{i=1}^{n} \sum_{j=1}^{n} x_i x_j \sigma_{ij} - \lambda_o E_p \qquad \text{for all } \lambda_o,$$

$$0 \leq \lambda_o \leq \infty$$

subject to

$$(2) \qquad 1 = \sum_{i=0}^{n} x_i$$

$$(3) \qquad x_0 \geq 1 - \frac{1}{c}$$

with

$$(4) \qquad E_p = x_0 R + \sum_{i=1}^{n} x_i E_i$$

where

(a) E_i is the expected return on the ith asset

(b) x_i is the percentage of equity value invested in the ith asset, $i = 1, 2,\ldots, n$.

(c) σ_{ij} is the covariance of returns between the ith and j^{th} assets, and the variance of return on the ith asset is $\sigma_{ii} = \sigma_i^2$. We assume that the variance-covariance matrix is positive-definite.

(d) N is the total number of risky assets available for purchase by the bank.[9]

(e) E_p and σ_p^2 are the expected return and variance of return, respectively on the bank portfolio.

(f) c is the capital-asset ratio $(\frac{K}{A})$ which is regulated by bank supervisors.

(g) x_0 is the percentage of equity value held in the negative asset (deposits) paying the risk-free rate R.

(h) λ_0 is the real tradeoff between variance and expected return at any point on the efficient investment frontier, i.e., $\lambda_0 = \frac{d\sigma_p^2}{dE_p}$. Its value can range from 0 to ∞.

Given that the bank is interested in generating the entire opportunity set, it will set λ_0 equal to particular values within the relevant range and solve for the corresponding efficient portfolios. Obviously, for $\lambda_0 = 0$ the resulting portfolio will be the minimum variance efficient portfolio. Conversely, for $\lambda_0 = +\infty$, the corresponding portfolio will be the efficient portfolio with highest expected return. For values of λ_0 lying between these extremes the solution to equation (1) will yield efficient portfolios with intermediate values of E_p and σ_p. We should note here that the resulting value of λ_0 corresponding to the portfolio that maximizes the banks' expected utility is related to the risk aversion of the bank. Thus, a high value of λ_0 corresponds to a less averse attitude towards risk taking.

Equation (4) represents the leverage or capital constraint imposed by regulation. As such it needs more explanation. As the value of c varies from zero to one the amount of funds available for investment in risky assets varies from the maximum quantity of deposits the bank desires to issue unconstrained by its equity capital, to only an amount equal to its equity capital. Thus, when c=1, the bank acts like a mutual fund unable to issue deposits of any kind. Likewise, if c=.10, then the maximum proportion of equity which can take the form of deposit liabilities in the bank portfolio is:

$$x_0 = -9.$$

That is, the bank can issue liabilities up to 900% of its equity capital, and thus leverage its risky asset portfolio to an amount far greater than its equity.

Restating the above problem using Lagrangean multipliers yields:

$$(5) \quad \min \left[\tfrac{1}{2} \sum_{i=1}^{n} \sum_{j=1}^{n} x_i x_j \sigma_{ij} - \lambda_0 \left[x_0 R + \sum_{i=1}^{n} x_i E_i\right]\right]$$

$$+ \lambda_1 \left[1 - x_0 - \sum_{i=1}^{n} x_i\right] + \lambda_2 \left[1 + Z_0 - x_0 - \tfrac{1}{c}\right]$$

where

(a) Z_0 = dummy variable

(b) λ_1, λ_2 = Lagrangean multipliers.

Given that x_0 is a choice variable, the restriction on the capital-asset ratio c may never constrain the bank from reaching its desired size if $x_0^* > 1 - \tfrac{1}{c}$ and $Z^* > 0$. However, since interest centers upon the impact of a marginal change in c on bank portfolio behavior, it will be assumed that x_0 is constrained to $1 - \tfrac{1}{c}$ and $Z_0 = 0$, i.e., the scale or leverage of the bank is constrained by c. This assumption appears realistic, given bank management complaints that capital requirements are too restrictive and less capital should be allowed to support a given level of risky assets.

The first order conditions for a minimization of equation (5) are:

$$(6) \quad \sum_{j=1}^{n} x_i \sigma_{ij} - \lambda_0 E_i - \lambda_1 = 0 \qquad\qquad i = 1, 2, \ldots, n$$

$$(7) \quad -\lambda_0 R - \lambda_1 - \lambda_2 = 0$$

$$(8) \quad 1 - x_0 - \sum_{i=1}^{n} x_i = 0$$

$$(9) \quad 1 - x_0 - \tfrac{1}{c} = 0$$

The solution to the above system of equations are unique and will minimize equation (1) by the assumption that the variance-covariance matrix is positive-definite. The particular portfolio chosen by the bank, given that it is constrained by c, is obtained by the simultaneous solution of equations (6) to (9) and the equality of λ_0 to the marginal rate of substitution between risk and return dictated by the banks' objective function.

To obtain a unique portfolio of the firm, it will be assumed that the bank has a quadratic utility function of the general form:

$$U(R_p) = R_p - bR_p^2, \qquad\qquad (b > 0, \ \frac{1}{2b} \geq R_p \ \text{always})$$

and

$$E(U) = E(R_p) - b \ [E(R_p)^2 + \sigma_p^2].$$

For this objective function, the marginal rate of substitution between risk, defined as the variance of total portfolio return, and expected return is,

$$\left.\frac{d\sigma_p^2}{dE_p}\right|_{u=\bar{u}} = \frac{1}{b} - 2E_p = MRS_{\sigma_p^2, \ E_p} \ .$$

Since optimality requires equality of the MRS to the objective tradeoff of risk and return then the following condition must be satisfied for the optimal portfolio, viz.

$$\frac{1}{b} - 2E_p = \lambda_0.$$

Hence, the optimal solution for x_i, i=1, 2, ..., n in the institution's portfolio can be written as the following simplified system.

$$(10) \quad \sum_{j=1}^{n} x_i \sigma_{ij} - \lambda_0 (E_i - R) + \lambda_2 = 0 \qquad\qquad i = 1, 2, \ldots, n$$

$$(11) \quad \sum_{i=1}^{n} x_i = \frac{1}{c}$$

$$(12) \quad \lambda_0 = \frac{1}{b} - 2[R + \sum_{i=1}^{n} (E_i - R)x_i]$$

Equations (10) to (12) are linear in the x_i's and thus from equation (10):

$$(13) \quad x_i = \lambda_0 \sum_{j=1}^{n} \nu_{ij} (E_j - R) - \lambda_2 \sum_{j=1}^{n} \nu_{ij} \qquad\qquad i = 1, 2, \ldots, n$$

where ν_{ij} is the ij^{th} element of the inverse of the variance-covariance matrix.

Following Merton (5) and eliminating λ_0 and λ_2, using equations (10) to (12), the optimal proportion x_i (i=1, 2, ...,n) held of each asset given the constraint $x_0 = 1 - \frac{1}{c}$ is:

$$(14) \quad x_i^* = \frac{AC(\frac{1}{b} - 2R) - C(1 + B)\frac{1}{c}}{C + D} \left[\frac{\sum_{j=1}^{n}(E_j - R)\nu_{ij}}{A} - \frac{\sum_{j=1}^{n}\nu_{ij}}{C} \right]$$

$$+ \frac{\sum_{j=1}^{n} \nu_{ij}(E_j - R)\frac{1}{c}}{A} \qquad\qquad i = 1, 2, \ldots, n$$

where[10]

$$A = \sum_{i}\sum_{j}\nu_{ij}(E_j - R)$$

$$B = \sum_{j}\sum_{i}\nu_{ij}(E_i - R)(E_j - R) > 0$$

$$C = \sum_{i}\sum_{j}\nu_{ij} > 0$$

$$D = BC - A^2 > 0$$

Equation (14) expresses the optimal proportions held of each risky asset in the portfolio chosen in terms of the parameters of the joint distribution of returns, the parameter b of the utility function and c, the capital asset constraint.

III. IMPACT ON THE COMPOSITION OF THE OPTIMAL BANK PORTFOLIO OF A CHANGING CAPITAL CONSTRAINT

Before the imposition of the increased capital constraint the balance sheet of the bank in equilibrium is made up of a fixed amount of deposit liabilities, $(1-\frac{1}{c})$ K, $\frac{K}{c}$ assets, and K amount of capital. The deposits are assumed to be homogeneous and pay a risk free rate R. The left hand side of the balance sheet is made up of n risky assets held in proportion described in equation (14). This particular portfolio is efficient.

Now consider an increase in c. From the budget constraint, equation (8), and the capital constraint, equation (9), we know that the bank will be unable to leverage its capital to the degree it had prior to the increase in c. That is, the imposition of an increased c restricts the leveraging capability of the bank, and its efficient investment frontier falls downward and to the left. Thus, over the entire frontier[11]:

$$\frac{\partial \sigma_P^2}{\partial c} < 0, \quad \frac{\partial E_P}{\partial c} < 0.$$

This implies unambiguously that over the entire permissable efficient frontier the total variance of the portfolios fall and the return on each set declines.

In addition, with the decrease in leverage, the bank reacts by reshuffling the composition of its efficient asset portfolio. The effect on the composition of the banks' portfolio, given a small change in the required capital-asset ratio, can be evaluated by differentiating equations (14) with respect to c.

$$(15) \quad \frac{\partial x_i^*}{\partial c} = \frac{1}{c^2} \frac{C(1+B)}{C+D} \left[\frac{\sum_{j=1}^{n} (E_j - R)\nu_{ij}}{A} - \frac{\sum_{j=1}^{n} \nu_{ij}}{C} \right]$$

$$- \frac{1}{c^2} \frac{\sum_{j=1}^{n} \nu_{ij}(E_j - R)}{A}, \quad\quad\quad i = 1, 2, \ldots, n$$

or, in elasticity form,

$$(16) \quad \varepsilon_{x_i,c} = \frac{1}{x_i} \frac{(\frac{1}{b} - 2R)(AC)}{C + D} \left[\frac{\sum_{j}^{n} v_{ij}(E_j - R)}{A} - \frac{\sum_{j}^{n} v_{ij}}{C} \right] - 1$$

$$i = 1, 2, \ldots, n$$

Equation (16) is the elasticity of proportional demand for the ith asset

with respect to the capital-asset constraint, evaluated at the optimum.

It is easy to show that the relative size of the elasticity expression,

for every asset is determined by the assets' risk contribution to the optimal

portfolio. Risk contribution is defined as σ_{ip} so that $\varepsilon_{x_i,c} > \varepsilon_{x_j,c}$ if

$\sigma_{ip} > \sigma_{jp}$. This may be demonstrated as follows.

As is well known, any portfolio on the efficient frontier of risky

assets can be generated by two frontier portfolios or mutual funds made

up of the n risky assets. This is the Mutual Fund Theorem of Merton (6)

or Black (1). The proportions held of each risky asset in each fund is

independent of investor preferences and the proportions of each fund chosen

by the investor is independent of the parameters of the joint distribution

of returns. In the case of the bank, the mix chosen of the two funds will

be a function of the parameter of its quadratic utility function. The mix

will generate the optimal portfolio with proportions described in equation (14).

Since any two efficient portfolios can generate all other efficient

portfolios, assume the two funds are the minimum variance portfolio and

the fund on the efficient frontier that is tangent to the slope $\frac{E_p - R}{\sigma_p}$.

The proportions of the ith asset (i-1, 2, $\ldots$, n) held in the two

portfolios can be shown to be respectively:[12]

$$(17) \quad \beta_i = \frac{\sum_{j}^{n} v_{ij}}{C}$$

$$(18) \quad \alpha_i = \frac{\sum\limits_{j=1}^{n} v_{ij} (E_i - R)}{A}$$

The characteristics of these two portfolios are such that

$$(19A) \quad \sum_{i=1}^{n} \alpha_i E_i > \sum_{i=1}^{n} \beta_i E_i$$

or equivalently

$$(19B) \quad \sum_{i=1}^{n} (\alpha_i - \beta_i) E_i > 0$$

and

$$(20A) \quad \sum_{i}^{n} \sum_{j}^{n} \alpha_i \alpha_j \sigma_{ij} > \sum_{i}^{n} \sum_{j}^{n} \beta_i \beta_j \sigma_{ij}$$

or equivalently

$$(20B) \quad \sum_{i=1}^{n} (\alpha_i - \beta_i) \sigma_{ip} > 0$$

Using equations (17) and (18) the elasticity expression, equation (16), can be rewritten as

$$(21) \quad \varepsilon_{x_i, c} = \frac{1}{x_i} \frac{(\frac{1}{b} - 2R)AC}{C + D} (\alpha_i - \beta_i) - 1. \qquad i = 1, 2, \ldots, n$$

Equations (19) and (20) imply that $(\alpha_i - \beta_i)$ will be positive in equation (21) for those assets that have a relatively large risk contribution, σ_{ip}, to the optimal portfolio. For example, for any two assets i and j, $(\alpha_i - \beta_i) > 0$ and $(\alpha_j - \beta_j) < 0$ imply that $\sigma_{ip} > \sigma_{jp}$. Therefore, for any asset i that contributes relatively more risk than asset j, its elasticity will be greater than the elasticity of asset j. Thus in general,

$$\varepsilon_{x_i, c} > \varepsilon_{x_j, c} \quad \text{if } \sigma_{ip} > \sigma_{jp}, \quad i, j = 1, 2, \ldots, n.$$

It should be noted that if all assets are uncorrelated, then

$$\varepsilon_{x_i, c} > \varepsilon_{x_j, c} \quad \text{if } \sigma_i^2 > \sigma_j^2, \quad i, j = 1, 2, \ldots, n.$$

This result gives the following interpretation to equation (16) or (21).
Subsequent to the imposition of a decreasing leveraging capability, i.e., an
increasing c, reaction of the bank is to reshuffle its portfolio. The composition of
the resulting equilibrium portfolio after the increase in c is described
then by relatively more risky assets than before the increase. The effect
of an increased c on the bank portfolio is, thus, somewhat contrary to the
desired result.

It can be seen from equation (21) that the degree to which this re-
shuffling occurs is dependent upon the risk aversion coefficient, b. For
highly risk averse institutions the elasticity value of high risk assets is
less than the elasticity for other institutions possessing less risk aversion.
Likewise, the conservative institution will shift its portfolio out of low
risk assets to a lesser degree than its risk taking counterparts. Thus,

$$\frac{\partial \varepsilon_{x_i, c}}{\partial b} = \frac{1}{x_{i(C+D)}} \left(- \frac{1}{b^2} AC\right)(\alpha_i - \beta_i)$$

which is positive or negative dependent upon the sign of $(\alpha_i - \beta_i)$.
It follows, therefore, that institutions which initially held relatively
more risky assets shift to offset capital restriction to a greater extent
than the more conservative group of firms. Consequently the distribution
of risk taking across the banking industry expands. Relatively conservative
institutions somewhat offset the capital restrictions. Their more risky
counterparts, on the other hand, reshuffle their balance sheet to an even
greater extent and therefore increase the variance of total risk for the
entire industry. The effect of this adjustment on the industry's probability
of failure will be, therefore, the next area of concern.

IV. CAPITAL REGULATION AND BANKRUPTCY

It will be assumed here that the central purpose of bank regulation
is to reduce the probability of bankruptcy. Therefore, regulators are not
concerned with the riskiness of the bank portfolio per se, but only insofar
as it affects the probability of failure. While some arguments to the
contrary may be offered, the alleged purpose of regulatory control over
these institutions has been to increase stability, and viability. Accordingly
the work of Santomero and Watson (15) and Blair and Heggestad (2), among
others, have made this explicit assumption as well.

An explicit relationship between the risk of the bank portfolio, the
amount of bank capital held and the chance of bankruptcy must, therefore,
be obtained to evaluate the result of bank capital regulation. This may
be accomplished once the characteristics of the distribution of the returns
from bank operations has been defined. There are essentially two choices.
Either the distribution can be assumed to be known, e.g., using a normality
assumption, or left indeterminant, e.g., using some general probability
characteristics. In either case, the analytic results indicated below
will immediately follow. For simplicity, therefore, the major part of the
analysis will make reference only to the Chebyshevs' Inequality. The normal
distribution assumption will be left to the interested reader.

The capital-asset ratio, the expected return of the portfolio, and
the variance of the return can be utilized, via the Chebyshevs Inequality,
to estimate the upper bound of the probability of failure, as suggested by
Roy (14) and Blair and Heggestad (2).[13] Given the characteristics of the
bank portfolio described by E_p and σ_p, this upper bound may be written as:[14]

$$(22) \quad \Pr\,[\tilde{R}_p < -c] \leq \frac{\sigma_p^2}{(E_p+c)^2} = P,$$

with

$$\frac{\partial P}{\partial \sigma_p^2} > 0, \quad \frac{\partial P}{\partial E_p} < 0, \quad \frac{\partial P}{\partial c} < 0.$$

As expected, an increased variance increases the probability of failure, while increased returns or capital ratio will, ceteris paribus, decrease failure risk. This is indicated by the partial derivatives of equation (22).[15]

Graphically this upper bound on the probability of failure can be seen as the square of the reciprocal of the slope of a ray in mean variance space.[16] The ray has an intercept of [-c] in Figure 1 and is denoted as D_0D_0. It intercepts the efficient frontier at point Z_0, where the optimal allocation is indicated by the tangency of the objective function. The portfolio at point Z_0 is characterized by the proportions x_i (i = 1, ..., n) or equation (14), and E_p^* and σ_p^*. The firm, therefore, can be described as possessing a portfolio that has an upper limit on its probability of failure of P_D, which is constant along the D_0D_0 ray.

If bank regulators feel, given the current bank portfolio Z_0, that the chance of failure is too high, then a higher capital-asset ratio is imposed. As c increases, the frontier moves down and to the left and the intercept moves down to (-c') on the vertical axis in Figure I. If the bank settles for the same risk-return trade-off in its portfolio as initially the asset set will shift to Z_1 on the new constrained frontier. Since the slope of D_1 through Z_1 is greater than the slope of D_0, the upper bound of the probability of failure decreases and the regulators achieve their desired result.

However, as was demonstrated earlier, a bank satisfying the conditions set above, will not move to point Z_1. That is, the portfolio Z_1 (identical in risk-return trade-off to portfolio Z_0) will not become as the equilibrium portfolio for the bank. Recall that subsequent to the increase in c, the bank reshuffles its portfolio towards relatively more risky assets. That is, the new equilibrium portfolio is composed of larger

relative quantities of riskier assets than before. This may be seen as a shift of the tangency point from Z_1 in Figure I to a point of higher risk and return. The exact point will, as noted above, be dependent upon the risk aversion factor of the institution's preference function.

Two cases can be distinguished and are pictured in Figure II. In the first of these the new portfolio choice results in a reduction in the probability of failure, even though some asset reallocation has occurred. This is denoted as Z_2 and lies to the left of DD. This locus maps a probability of failure that is equal to that which obtained on D_0D_0, the original locus. Its intercept is below the initial locus, given that higher capital ratios are required in the new regime, but is everywhere parallel to D_0D_0. The fact that Z_2 lies to the left of DD implies that the overall probability of failure for the institution has declined. On the other hand, Z_3 lies to the right, indicating that, for this institution, the probability of failure has <u>increased</u> as a result of increasing required capital.

To explain the differing results, reference must be made to the portfolio decision model of the previous section. Examination of equation (21) reveals that, for an institution with a smaller value of b, the bank's reaction to an increase in c is a larger shift towards riskier assets which more than offsets the effect of increasing c. Therefore the chance of failure increases. Conversely, if the bank is sufficiently risk averse, i.e., b is sufficiently large, then the movement towards riskier securities will be small, relative to the increase in c. In this case the chance of failure decreases.

This point may be seen analytically by examining the effect of variance reduction for institutions with different risk aversion coefficients, viz.,

$$\frac{d\left(\frac{d\sigma_p^2}{dc}\right)}{db} > 0.$$

Thus, σ_p^2 declines for every bank's portfolio, but the absolute magnitude of the decline depends upon b. If b is sufficiently small, the fall in E_p along with the reshuffling of the portfolio implies that the chance of failure increases.

Notice that the rank ordering of the increase in the relative holdings of the risky assets associated with a higher capital requirement is identical to the risk ordering of the institutions' portfolios before regulation. Firms with low values of b, the risk aversion factor, will initially possess larger quantities of risk assets in their portfolio than institutions with a higher degree of conservatism. A frequency distribution of the probability of failure for the entire industry will accordingly be equivalent to a frequency distribution of risk aversion coefficients. If regulation is now imposed so as to uniformly increase the capital requirements of the industry, offsetting reshuffling of the risk-asset components of the portfolio will occur based upon this same value, b. Risky institutions will react more than relatively safer institutions to thwart the regulatory intent.

From the above argument, therefore, it is clear that there exists some value of b, denoted b*, below which any increase in c will <u>increase</u> the probability of bankruptcy, rather than decrease it as assumed. Thus as the capital constraint increases, the probability of failure will decrease, increase or remain unchanged as b is greater than, less than or equal to the critical value b*. The final distribution of risk of failure for the banking industry will therefore possess a higher variance than before the imposition of regulation. Essentially, the relatively safe banks become safer, while risky institutions increase their risk position. The mean of the industry is dependent upon the underlying distribution of risk aversion, b.

If capital constraints are only imposed on a certain subset of the industry, the prognosis is no better. The banks likely to be subjected to a higher required c are ones that is less risk averse, i.e., a low value of b. In other words, one would expect that a less risk averse bank would hold risky securities and therefore be closely watched by regulators. However, the imposition of a higher required capital-asset ratio on these banks may well have a perverse effect. For such banks, it would seem that the

regulators should find some other instrument to control the probability of failure, such as asset restriction, or abandon attempts that essentially prove counterproductive. In general, since regulators cannot know a priori the degree of the bank's risk aversion - the size of b - hence they can never know with certainty the affect of an increase in the required c. Regulating bank capital, therefore, appears to be an inadequate tool to control the riskiness of banks and the probability of failure.

V. SUMMARY

Regulatory constraints that impinge upon bank behavior are designed -- excluding from consideration questions of monetary policy -- to limit competition and/or maintain bank soundness. The ultimate objectives of these constraints are (a) to protect depositors, and (b) to protect the banking system as a whole and therefore, the health of the economy.

The rationale given for these restrictions including capital constraints usually point to the lower probability of failure that will result when these constraints are binding. However, as was demonstrated above, this is not what necessarily obtains. In fact, a case could be argued that the opposite result can be expected to that which is desired when higher capital requirements are imposed.

It is interesting to note that a number of researchers have not found an explicit relationship between bank failure and the amount of capital held.[17] The model presented above explains why this might be the case, for it includes consideration of the reaction of the institution to new regulatory stringency. This implies that the result of such regulation may be the opposite of regulatory intent.

FOOTNOTES

1. The only exception to this is a paper by Mingo and Wolkowitz (8). However, this work neglects several essential features by assuming a linear utility function and a non-stochastic profit function. Their work using a loan quality index and an essentially certainty model may, therefore, be viewed merely as a first step in our understanding of this problem.

2. We will assume that regulators can enforce capital requirements and that the measure of adequacy used is the capital-risk asset ratio. See Santomero and Watson (15) and Wolkowitz (20) for a discussion of capital enforcement and the use of the capital-asset ratio as a useful measure of capital adequacy. We should point out here that we do not defend the capital-risk asset ratio as the appropriate measure of bank risk but only attempt to understand bank behavior if regulators enforce such a measure. Throughout the paper, then, the capital-risk asset ratio will refer to the ratio of equity and debt capital to assets subject to either interest rate risk or default risk.

3. The measure of the probability of failure comes from Roy (14). Using Roy's model, Blair and Heggestad (2) have examined bank portfolio restrictions and their impact on solvency. The present paper exploits this relationship for the purposes of capital regulation.

4. It will be assumed the bank holds enough cash to satisfy reserve requirements as well as working cash needs. Cash holdings will subsequently be ignored.

5. See Michaelsen and Goshay (7). There may be a question as to whether a bank should act in accordance to the market value rule or act as if it maximized a concave utility function. If we assume that banks are closely held then assuming risk aversion is not unreasonable. Furthermore, without a well-defined general equilibrium model of the capital markets, it is not clear what determines market value. See D. Pyle (11) and O. Hart and D. Jaffee (4) for examples of the use of utility functions to describe intermediary behavior. See also J. Cozzolino and T. Taga (3).

6. See James (5) for a discussion of the impact of market imperfections on the mean-variance efficient frontier.

7. The efficient frontier is made up of portfolios with maximum expected return for all possible levels of variance. See Merton (6).

8. See Merton (6) for the derivation under no constraints.

9. We will neglect the effects on solvency and bank behavior if certain assets are restricted from purchase by regulation.

10. See Merton (6) for proof of the following inequalities. The inequalities result from the fact that the inverse of the variance-covariance matrix is positive-definite.

11. To show the sign of these derivatives, differentiate σ_p^2, and E_p with respect to c, using the definitions of σ_p^2 and E_p and equation (15).

12. Merton (6).

13. Blair and Heggestad's model is an application of Roy's (14) Safety First Model.

14. Following Blair and Heggestad the Chebyshev Inequality states

$$P_r \; [\,|\tilde{R}_p - E_p| \, > k\sigma_p] \leq \frac{1}{k^2}$$

$$P_r \; [\tilde{R}_p < (E_p - k\sigma)] \leq \frac{1}{k^2}$$

$$\text{Set} \; -c = E_p - k\sigma_p, \; \text{so} \; k = \frac{E_p + c}{\sigma_p}$$

Substitution of k yields equation (22).

15. The necessary results to carry out the analysis conducted below are the partial derivative signs of equation (22). This will allow for a monotonic failure locus and all other results obtained. A normal distribution, as well as most others used in portfolio thoeory, would satisfy these conditions.

16. See Roy (14) for a proof of this, or Blair and Heggestad (2) for a thorough discussion.

17. See S. Peltzman (9) for example.

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