Capital Adequacy Rules and the Risk-Seeking Behavior of Banks: A Firm-Level Analysis

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1. INTRODUCTION

In 1988 the Basle Committee on Banking Supervision issued a package of guidelines setting minimum capital standards for banks in the Committee member countries. Implementation of the guidelines began in 1989 and was completed in 1993. The capital standards of the Committee’s guidelines exhibit two distinguishing features: they are risk-based in the sense that capital requirements vary across different categories of assets in accordance to the perceived risk of the assets and, secondly, they also apply to off-balance-sheet items.

Capital regulations are intended to raise the capital standards of the institutions which they cover. Since they increase the percentage of capital that banks must hold and hence enlarge the buffer available to absorb losses to the value of a bank’s assets, one would intuitively expect stricter capital requirements to lessen the chance of a bank failure, thereby increasing the protection of debt holders against loss and strengthening the soundness and stability of the banking system as a whole. And indeed, this is the stated aim of the Basle Accord (COOKE, 1991, 91). Nonetheless, a number of economic models take issue with this viewpoint. They suggest that raising capital requirements will cause banks to invest in more risk thereby offsetting the stabilizing effects of increased capital. Other theoretical models, on the other hand, disagree with this assessment and maintain that banks will not take on more risk. In short, though economic theory succeeds in calling the stabilizing effects regulators commonly expect from higher capital standards into question, it fails to dispel the uncertainty it engenders. Given the intended purpose of capital restrictions, the uncertainty as to their effects is quite disconcerting and in need of resolution.

* FAI, WWZ, Postfach, CH-4003 Basle. Without wishing to implicate them, I should like to thank NIKLAUS BLATTNER, ROLF ENDERLI, THOMAS GEHRIG, HANS GERSBACH, MARTIN HELLWIG, JOSEF WILLIMANN and WALTER WIRSIG for useful discussions. Thanks are also due to my discussant KLAUS SPREMANN as well as participants of the conference for helpful comments. I thank BENEDIKT GRATZL for assistance in collecting the data. Financial support of the Swiss Bankers Association is gratefully acknowledged.

1. The Basle Committee consists of representatives of the bank supervisory authorities and the central banks of the G10 countries, plus Switzerland and Luxembourg, meeting under the auspices of the Bank for International Settlements in Basle.
The following paper attempts to shed light on the risk effects of capital adequacy rules by studying the impact of the 1988 Basle Accord on a sample of 219 banks drawn from the Basle Committee member countries. The study covers the period from 1987 to 1994.

The paper unfolds as follows. Section 2 explains the theoretical rationale for questioning the risk-reducing effects of capital adequacy regulation. Section 3 characterizes the features of the 1988 Basle Accord and contrasts them with the regulations in place in the countries concerned prior to the implementation of the Basle guidelines. Section 4 lays out the empirical approach taken in this study to measure the effects of the guidelines, and Section 5 presents our findings. The final section provides a summary and concluding remarks.

2. THEORETICAL BACKGROUND

Although theoretical models can show that an increase in capital requirements may not lessen the probability that a bank will fail, the establishment of this point does not require economic reasoning. Rather it suffices to observe that the level of bank returns are inherently uncertain and to invoke basic laws of probability. To understand why, begin by noting that bankruptcy occurs by definition when a decline (−Δ) in the value of a bank's assets A exceeds its level of capital C, i.e., when

$$-\Delta A > C.$$  

Equation (1) can be written in relative terms by dividing both sides of the equation by A and multiplying through by minus one, yielding

$$\text{ROA} \equiv \frac{\Delta A}{A} < -\frac{C}{A} \equiv -\text{CAR}$$  

According to (2), bankruptcy occurs when the realized rate of return on assets (ROA) lies below the negative value of the bank's capital-to-assets ratio (CAR), a commonly used measure of capital adequacy.

The negative value of CAR defines the bankruptcy threshold of a bank. The probability that ROA will dip below this threshold is uncertain due to the inherent variability of ROA. In general, the probability of default depends on the ROA a bank achieves «on average», i.e., on the mean or expected rate of return E(ROA), and on the degree to which realized ROA fluctuates about its mean value, i.e., on the volatility or standard deviation σ(ROA) of ROA. In precise terms, the probability that a bank will default is a function of the distance z between the bank's default threshold −CAR and its mean rate of return E(ROA), measured in standard deviations σ(ROA), i.e.,

$$z = \frac{[-\text{CAR} - E(\text{ROA})]}{\sigma(\text{ROA})}.$$  

(3)
z merely represents \(-\text{CAR}\) in standardized form.

The probability of ROA falling below this standardized default threshold is given by

\[
\text{Prob}(\text{default}) = F(z),
\]

where \(F\) represents the probability distribution describing the variability of ROA, measured in standard deviations about its mean. The higher (lower) the value of \(z\), i.e., the closer (farther) the standardized default threshold looms, the more (less) likely the bank will fail, all else equal.

From (3) it becomes apparent that the probability of bank failure, given by (4), depends not only on the size of a bank's capital buffer \(\text{CAR}\) but also on the mean and volatility of its returns. Higher values of \(\text{CAR}\) and \(E(\text{ROA})\) reduce the probability of bankruptcy, while higher values of \(\sigma(\text{ROA})\) increase it. Hence if capital standards increase \(\text{CAR}\), the probability of default will only then be reduced if the rise in \(\text{CAR}\) is not offset by a decrease in \(E(\text{ROA})\) or an increase in \(\sigma(\text{ROA})\). Here is where economic theory steps in by offering reasons for believing that \(E(\text{ROA})\) and \(\sigma(\text{ROA})\) may indeed not remain constant.

Economic models that analyze the effect of increased capital standards on the stability of banks focus on \(\sigma(\text{ROA})\). The majority of these approaches\(^2\) belong to one of two broad categories of models (cf. FURLONG/KEELEY, 1987):

- utility maximizing models or
- value maximizing models.

The utility maximizing approach\(^3\) views banks as management-owned and assumes that risk-adverse owner-managers attempt to maximize their expected wealth in the context of a mean-variance portfolio model. The set of efficient portfolio risk-return combinations available to the bank in this setting corresponds to the linear capital market line which intersects the vertical axis, measuring the expected return on capital \(E(\text{ROE})\), at the risk-free rate of interest \(i\) and which is tangent to the efficient risk-return frontier at \(M\) (Figure 1). Points along this line correspond to various portfolios yielding different risk-return combinations. Points on the capital market line to the right (left) of \(M\) represent leveraged (non-leveraged) portfolios.\(^5\)

Capital adequacy rules in this context place an upper limit on leverage, i.e., they truncate the capital market line at the maximum permitted degree of leverage. Since

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2. The analysis of GEHRIG (1996) differs from the above approaches in that GEHRIG examines the effect of restricting a bank's leverage on its investment in credit monitoring rather than in risk directly.
4. Note that the previously employed variables \(E(\text{ROA})\) and \(\sigma(\text{ROA})\) equal \(E(\text{ROE})\text{CAR}\) and \(\sigma(\text{ROE})\text{CAR}\), respectively.
5. Readers unfamiliar with the basics of Figure 1 are referred to any textbook in finance, say ELTON/GRUBER (1991), Chap. 3.
further leverage is ruled out, the capital market line at this point becomes convex in accordance to the curvature of the risk-return frontier.

Figure 1: Mean-Variance Analysis of Leverage Restrictions

An unconstrained bank will choose a degree of leverage and a mean-variance combination commensurate with its taste for risk. This corresponds in Figure 1 to the point of tangency between the indifference curve U1 and the capital market line. Were a bank now to be constrained by a new leverage restriction, its preferred return-risk combination would shift to a point where a lower indifference curve U0 of its utility function is tangent
to the curved (in Figure 1, dotted) section of the constrained capital market line. As can be seen from Figure 1, the marginal rate of substitution \( \frac{\partial E(\text{ROE})}{\partial \sigma(\text{ROE})} \) between mean return and volatility is flatter at this new point of tangency, implying that the bank now requires a smaller increase in expected return \( E(\text{ROE}) \) to induce it to take on more risk \( \sigma(\text{ROE}) \). It is this result that is used in utility maximizing models to conclude that increasing CAR, i.e., lowering leverage will increase bank risk.

This result holds for any bank not previously constrained by capital regulations since restricting leverage implies a movement from an unconstrained capital market line to the convex section of a constrained capital market line with a flatter slope. For the banks previously constrained the outcome is uncertain, however, as it involves a shift from the convex section of the original constrained capital market line to the convex section of the new constrained market line. The value of the marginal rate of substitution between return and risk at the new point of tangency depends on the specific shape of the bank’s utility function, i.e., on the degree of its risk aversion, which is not generally known, hence the uncertainty.

Note that a decrease in the marginal rate of substitution between return and risk does not necessarily imply that the return-risk structure \( \frac{E(\text{ROE})}{\sigma(\text{ROE})} \) of a bank’s portfolio will shift towards more risk, nor does it mean that the probability that the bank will fail will increase. This becomes clear by observing first that the risk composition of a bank’s portfolio corresponds in Figure 1 to the slope of a ray from the origin to the given point of tangency between an indifference curve and the capital market line. The flatter the slope of this ray, the riskier is the portfolio composition.

The probability of default, on the other hand, is depicted in Figure 1 by a ray from \(-1\) on the vertical axis to the same point of tangency. This can be seen by noting that bankruptcy occurs when the realized rate of return on equity ROE equals \(-100\%\), in which case a bank’s equity is completely wiped out. This level of return represents the bankruptcy threshold of the bank expressed in terms of ROE. Measured in standard deviations from \( E(\text{ROE}) \), the failure threshold is thus equal to

\[
z = \left[ -1 - E(\text{ROE}) \right] / \sigma(\text{ROE}).
\]  

Solving for \( E(\text{ROE}) \) yields

\[
E(\text{ROE}) = -1 - z \cdot \sigma(\text{ROE}),
\]

which is the equation for a line from \(-1\) on the vertical axis to the given point of tangency. The slope of this ray is equal to \(-z\), a positive number given that \( z \) is negative. Thus, the flatter the slope of the ray, the larger is \( z \), the closer the bank’s bankruptcy threshold looms, and hence the greater the probability of default.

As pictured in Figure 1, both the risk composition of the bank’s portfolio and its probability of bankruptcy increase in reaction to restricting leverage but as is easily
imagined, this need not generally hold. Yet despite this ambiguity, the fact that the marginal rate of substitution of risk for expected return unequivocally rises for newly constrained banks is viewed in the relevant literature as evidence that restricting leverage increases risk.

Furlong/Keeley (1987) and Keeley/Furlong (1990) rightly criticize the mean-variance approach for being inconsistent in attempting to analyze the effect of increased capital standards on the probability of default in a modeling framework that, by assuming banks can borrow unlimitedly at the risk-free rate of interest, rules out bankruptcy from the start. Furthermore, the authors note that in contrast to the assumptions of the mean-variance approach, the distribution of returns of a limited-liability bank is truncated at the bankruptcy threshold. In other words, the losses of a limited-liability bank cannot exceed the value of its equity. Any additional losses are ultimately borne by the holders of the bank’s debt. In this sense, a bank’s shareholders have a put option to sell the bank’s assets to the debt holders at the maturity value of debt, the implicit strike price, with the maturity of the put option corresponding to that of debt.

According to the Black-Scholes formula, the value $P$ of this put option is

$$
P = D \cdot \Phi(d_2) - A \cdot \Phi(d_1)
$$

where $D = \text{current face value of the bank’s dept}$

$A = \text{current market value of the bank’s assets}$,

$\Phi = \text{standard normal probability distribution}$,

$d_1 = \left[ \ln(D/A) - 0.5 \cdot \sigma^2(\text{ROA}) \right] / \sigma(\text{ROA})$

$d_2 = d_1 + \sigma(\text{ROA})$, and

$\sigma(\text{ROA}) = \text{volatility of ROA scaled up to the duration of the option}$.

As is easily seen from (7), increased leverage (i.e., higher $D$ vis à vis $A$) raises the value of the put option. This should be intuitively clear since greater leverage means that a broader range of potential losses to the value of a bank’s assets is borne by its debt holders. Furthermore, it is a well-known fact that the value of an option increases with the volatility $\sigma(\text{ROA})$ of the returns of the underlying asset. This can be seen by observing that (7) reduces to $P = D - A$ when the returns of a bank’s assets do not fluctuate [i.e., $\sigma(\text{ROA}) \to 0$]. In this case, the put option provides no added value.

Due to the option characteristics of debt, shareholders of a limited-liability bank have an incentive to increase the volatility of returns by having the bank invest in more risk once the level of debt has been set, since the bank’s equity holders reap the reward of

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6. This interpretation is due to Merton (1977).

7. The risk-free rate of interest does not appear in (7) since it merely serves to discount the strike price (here the value of debt at maturity) to the present. Discounting in (7) is not required, however, since the current face value of debt corresponds to its present value at maturity.

8. This is termed the vega effect in the finance literature.
higher returns if the economy evolves favorably and limit their losses if it does not. In general, debt holders will be aware of the risk incentives to borrowers and, by charging risk premiums and/or by writing covenants into debt contracts, will take measures to ensure that $A > D$, i.e., that $\Phi(d_1) = \Phi(d_2) = 0$, thereby eliminating the put value of debt. In banking, this natural corrective is typically missing, however, because implicit («too big to fail») or explicit (deposit insurance) non-risk-rated debt guarantees exist which prevent debt holders from incurring their losses in full. As a result, the risk premium demanded by debt holders in the absence of debt guarantees declines, providing the bank with an interest subsidy.

Unlike mean-variance approaches, value-maximizing models\(^9\) of the risk effects of capital adequacy regulation do take the put option value of debt guarantees into account. They assume that a bank’s management attempts to maximize shareholder value, which includes the value $P$ of the put option. Thus, when capital restrictions are sharpened, i.e., $D$ is lowered with respect to $A$, option models predict that banks will invest in more risk, i.e., increase $\sigma($ROA$)$, in an attempt to recover the loss in value to the put option that lower leverage engenders.

FURLONG/KEELEY (1987) and KEELEY/FURLONG (1990) have shown, however, that such a reaction need not ensue. They demonstrate that the marginal value of increasing portfolio risk decreases as the level of CAR rises. From this they conclude that tightening leverage restrictions should reduce the incentive of banks to take on additional risk.

This argument has met opposition from GENNOTTE and PYLE (1991), who observe within the same modeling framework that both portfolio risk and the probability of bank failure may increase in reaction to higher capital standards if investment in risk assets exhibit decreasing returns, as they may well do given the information-intensive, non-marketable nature of the loans in which banks typically specialize.

In short then, economic theory is unclear on whether restricting the leverage of banks increases or decreases the risk structure of bank asset portfolios. Hence empirical evidence must be called upon to resolve the issue.

3. CAPITAL ADEQUACY RULES IN PRACTICE

The theoretical models presented in the last section view capital adequacy rules as consisting of a fixed gearing or leverage ratio, requiring banks to hold a minimum fixed percentage of capital against their liabilities (liability-based gearing ratio) or assets (asset-based gearing ratio). Gearing ratios represent the oldest form of capital regulation. Today, however, risk-based ratios have taken the forefront, the Basle Accord being a case in point.

In contrast to gearing ratios, risk-based measures require banks to hold different minimum capital percentages against different categories of assets according to their perceived risks. These ratios can take two basic forms. Either the capital charge can vary by asset category; or a uniform rate can be levied on a weighted sum of all assets, where the weights serve as discounting factors, writing off assets in inverse proportion to their perceived level of risk. The outcome in both cases is essentially the same, however.

The Basle guidelines (cf. Cooke, 1991) adapt the second approach. They divide a bank’s on-balance-sheet assets into five categories, each carrying a different risk weight ranging from zero to one. The five asset categories encompass:

- cash as well as claims on, or guaranteed by OECD central governments,
- claims on, or guaranteed by other domestic public sector entities,
- claims on, or guaranteed by multilateral development banks or by OECD incorporated banks as well as cash items in the process of collection,
- loans fully secured by mortgage on residential property, and
- all other assets.

The first category of assets carries a weight of zero, i.e., they require no capital backing, while the last set has a weight of one.

The guidelines also impose risk-based ratios on off-balance sheet items, these ranging from credit commitments with a maturity of up to one year or with a clause permitting immediate cancellation, which carry a weight of zero, to direct credit substitutes such as stand-by letters of credit serving as financial guarantees for loans and securities, which carry a full weight of one. The guidelines represent minimum standards that can be exceeded by national supervisory authorities as they see fit.

It is difficult to predict what effect the implementation of the Basle guidelines had on banks within the theoretical framework set out above. For one, it is not clear to what extent the implementation of the guidelines even represented a constraint. At the time the guidelines were implemented most member countries already employed risk-weighted capital standards (Table 1). The degree of asset differentiation varied widely, however, ranging from four asset categories in Germany to 15 in Switzerland (Pecchioli, 1987, 122). In those countries in which risk-based capital standards were already in place, probably only the introduction of capital charges on off-balance-sheet items was in some sense revolutionary.
Table 1: Capital Adequacy Rules and the Effective Timetable of Basle Guideline Implementation\textsuperscript{10}

<table>
<thead>
<tr>
<th>Country</th>
<th>Prior Rule Type</th>
<th>Timetable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Belgium</td>
<td>risk-based ratio</td>
<td>1989</td>
</tr>
<tr>
<td>Canada</td>
<td>gearing ratio</td>
<td>1991</td>
</tr>
<tr>
<td>France</td>
<td>risk-based ratio</td>
<td>1989</td>
</tr>
<tr>
<td>Germany</td>
<td>risk-based ratio</td>
<td>1990-1993</td>
</tr>
<tr>
<td>Italy</td>
<td>risk-based ratio</td>
<td>1989</td>
</tr>
<tr>
<td>Japan</td>
<td>gearing ratio</td>
<td>1989-1992</td>
</tr>
<tr>
<td>Netherlands</td>
<td>risk-based ratio</td>
<td>1990-1992</td>
</tr>
<tr>
<td>Sweden</td>
<td>risk-based ratio</td>
<td>1990-1992</td>
</tr>
<tr>
<td>Switzerland</td>
<td>risk-based ratio</td>
<td>1990-1991</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>risk-based ratio</td>
<td>1989</td>
</tr>
<tr>
<td>United States</td>
<td>gearing ratio</td>
<td>1990-1992</td>
</tr>
</tbody>
</table>

In those countries (Canada, Japan, and the USA\textsuperscript{11}), on the other hand, in which simple gearing ratios were in force, the introduction of risk-based standards should, in principle, have curbed the risk substitution that some economic models fear lower gearing ratio minimums engender, since risk-based standards take the risk composition of a bank’s portfolio into account in assessing capital charges. Yet such a risk-reducing effect also depends on the extent to which the weighting system correctly reflects the risks associated with the various asset categories. On this score the guidelines appear to be quite deficient (GRENADIER/HALL, 1995). Moreover, the guidelines consider only credit or default risk, which pertains to the possibility that debtors may renge on their payment obligations, and ignore market risk or the risk associated with the vagaries of bank asset values, which the theoretical models presented in the last section address. Market risk is treated in a later supplement to the Accord.\textsuperscript{12}

In short, the effects of implementing the Basle guidelines are uncertain. Note, however, that the implementation period was longer in the majority of those countries (specifically Germany, which only distinguished between four risk asset categories, as well as Japan and the US) in which current capital standards differed from the Basle

\textsuperscript{10} Thanks are due to MATTIA RATTAGGI of the Swiss Bankers Association for compiling Table 1. Luxembourg, a further Committee member nation, is not included in the list because data on its banks, needed for the analysis below, were not available from the sources at our disposal.

\textsuperscript{11} Interestingly, the US were probably the first to employ risk-based ratios when the Federal Reserve Board introduced the so-called ABC (Analysis of Bank Capital) approach in 1956. However, in the wake of the general deregulation in US banking during the 1980s, the bank regulatory authorities in 1981 imposed a uniform asset-based gearing ratio (FURLONG, 1988).

\textsuperscript{12} See Amendment to the Capital Accord to Incorporate Market Risks, Basle Committee on Banking Supervision, Basle, January 1996.
guidelines the most, suggesting that the introduction of the guidelines at least represented a change in those countries.

4. EMPIRICAL METHODOLOGY

Investigation of the effect of the implementation of the Basle guidelines on the risk-seeking behavior of banks requires time series on the volatility $\sigma(\text{ROA})$ of individual bank portfolio values. Data of this sort are not readily available, however, since most bank assets are not traded. Hence their values are not observable. To overcome this problem, we follow FURLONG (1988) and adopt a procedure developed by RONN and VERNA (1986). The approach is based on the observation of BLACK and SCHOLES (1973) that the equity of a firm can be thought of as a call option on the value of the assets of the firm with the same maturity as the debt of the firm and a strike price equal to the maturity value of the debt.

This view differs somewhat from the put option interpretation of a bank’s assets discussed in Section 2. There equity holders were pictured as owning the assets of the bank with a put option to sell them to the debt holders at the maturity value of debt. Here the debt holders are viewed as owning the assets, and the equity owners have the option to buy the assets at the maturity value of debt.

According to the BLACK-SCHOLES formula, the market value of equity viewed as a call option equals

$$C = A \cdot \Phi(-d_1) - D \cdot \Phi(-d_2),$$

where all variables carry the same meaning as in (7).

In principle, (8) could be solved for $A$ to obtain the market value of a bank’s assets, since $C$, the market value of the bank’s equity, and $D$, the book value of its debt, are readily observable. However, (8) contains an additional unknown, the volatility of the value of $A$ or $\sigma(\text{ROA})$, which is contained in $d_1$ and $d_2$. Thus a further equation is required to solve for both unknowns. RONN and VERNA (1986) employ

$$\sigma(\text{ROE}) = \lambda \cdot \sigma(\text{ROA}),$$

where $\lambda = \Phi(-d_1) \cdot A/C$.\textsuperscript{13} The expression for $\lambda$ is also known as lambda in the finance literature and measures the relative change of the value of the call option in reaction to a relative change of the value of the underlying asset, here $A$. Equations (8) and (9)

\textsuperscript{13} In contrast to footnote 4, equation (9) contains the term $\Phi(-d_1)$ in addition to CAR ($=C/A$) since the market value of a bank’s equity, viewed as a call option, is not a linear function of the market value of its assets.
Together build a non-linear equation system with two unknowns that can be solved by the newton-raphson technique.\textsuperscript{14}

On the basis of the solutions for \( A \) and \( \sigma(\text{ROA}) \) it is possible to generate a time series of the probability that a bank will fail. Since according to the assumptions underlying the black-scholes formula, the natural logarithm of \( A \) represents Brownian motion, the first difference of the natural logarithm of \( A \) (=ROA) must be normally distributed. Thus the probability that a bank will fail, based on (4), equals

\[
\text{Prob(\text{default})} = \Phi\left( \frac{-\text{CAR}-E(\text{ROA})}{\sigma(\text{ROA})} \right) = \Phi(z),
\]

where \( \text{CAR} \) = book value of the equity\textsuperscript{15} of a bank divided by the market value of its assets,

\( E(\text{ROA}) = \text{CAR} \cdot E(\text{ROE}) \), and

\( E(\text{ROE}) = \) mean annual market ROE of a bank.

Furlong (1988), in investigating the impact of the introduction of a uniform gearing ratio in the US in 1981 on the risk-seeking behavior of banks, calculates the probability of failure on the basis of (5) instead of (3), i.e., on the basis of the fluctuations in the market value of equity rather than on that of assets. This seems inappropriate since ROE is a non-linear function of ROA according to (9) and hence is not normally distributed, as ROA is. Moreover, proceeding as Furlong does rules out the possibility of investigating whether any increase in CAR which the Basle guidelines may have engendered was offset by an increased investment of banks in risk, as measured by the volatility \( \sigma(\text{ROA}) \) of the value of their assets. In fact, to better isolate this effect, we treat \( E(\text{ROE}) \) in (10) as a constant.

Implementation of the measurement concept outlined here requires stock market data on share prices [to calculate \( \sigma(\text{ROE}) \)] and equity market values \( C \), on the one hand, and accounting data on the book value of equity (to calculate \( \text{CAR} \)) and debt \( D \), on the other. The stock market data employed here were drawn from the Datastream on-line databank, and the accounting data from the IBCA databank\textsuperscript{17} available on CD-ROM. Only those banks with sufficient data available from both sources entered our sample of 219 banks, listed in the appendix. As one will notice, three quarters of the banks in our sample are Japanese or US institutions.

\textsuperscript{14} The non-linear module in Gauss was used in this study. The expressions \( C+D \) and \( \sigma(\text{ROE})\cdot\text{CAR} \) provided good starting values for the unknowns \( A \) and \( \sigma(\text{ROA}) \), respectively.

\textsuperscript{15} The book value of equity was chosen over its market value because capital regulations apply to it and not to its market value.

\textsuperscript{16} Theoretically, \( E(\text{ROA}) \) could also be calculated from \( \Delta \ln A \), where \( A \) stems from the solution of the non-linear equation system (8) and (9). In practice, such an approach is inappropriate, however, as \( \Delta \ln A \) also captures fluctuations in value due to quantity changes (stock splits etc.).

\textsuperscript{17} Thanks are due to IBCA for providing us the data free of charge.
C, CAR and D correspond to fiscal year-end values in our calculations. Calculations of $\sigma$(ROE) are based on the weekly (Wednesday-to-Wednesday) log change of a bank’s share price over the past fiscal year of the bank, annualized and adjusted for quantity changes and dividends. A weighted share price was employed in those cases where a bank had more than one type of traded equity.

5. RESULTS

The prediction of some economic models that restricting the leverage possibilities of banks will lead them to invest in more risk implies that the leverage restrictions cause banks to raise their book-value CAR, on the one hand, and to increase the risk composition of their portfolios, on the other. Thus in order to anticipate what effects the implementation of the Basle guidelines may have had on banks’ risk-seeking behavior, we begin by viewing the development of CAR and of the risk composition of the portfolios of the banks in our sample. Figures 2 and 3 provide the necessary time series information, which is summarized in Table 2.

Table 2: Capital-to-Assets Ratio and Risk Asset Ratio, 1987-1994

<table>
<thead>
<tr>
<th>Country</th>
<th>Banks</th>
<th>Car (in %)</th>
<th>Risk Asset Ratio (in %)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>mean</td>
<td>trend</td>
</tr>
<tr>
<td>Belgium</td>
<td>5</td>
<td>3.7</td>
<td>0</td>
</tr>
<tr>
<td>Canada</td>
<td>7</td>
<td>5.5</td>
<td>0</td>
</tr>
<tr>
<td>France</td>
<td>6</td>
<td>3.4</td>
<td>+</td>
</tr>
<tr>
<td>Germany</td>
<td>7</td>
<td>3.8</td>
<td>0</td>
</tr>
<tr>
<td>Italy</td>
<td>12</td>
<td>7.8</td>
<td>0</td>
</tr>
<tr>
<td>Japan</td>
<td>83</td>
<td>3.9</td>
<td>+</td>
</tr>
<tr>
<td>Netherlands</td>
<td>6</td>
<td>8.4</td>
<td>+</td>
</tr>
<tr>
<td>Sweden</td>
<td>2</td>
<td>5.5</td>
<td>0</td>
</tr>
<tr>
<td>Switzerland</td>
<td>14</td>
<td>9.6</td>
<td>0</td>
</tr>
<tr>
<td>UK</td>
<td>9</td>
<td>6.0</td>
<td>0</td>
</tr>
<tr>
<td>USA</td>
<td>68</td>
<td>7.1</td>
<td>+</td>
</tr>
</tbody>
</table>

18. A positive or negative sign indicates that the associated variable exhibits a statistically significant trend.
As is clear from Figure 2 and substantiated in Table 2, the implementation of the Basle guidelines appear to have had little impact on the trend development of book-value CAR\textsuperscript{19} of banks in the majority of the Committee member nations. Only the banks in France, Japan, the Netherlands, and the US exhibit statistically significant positive trends. Note, though, that Japan and the US are countries in which the implementation of the Basle guidelines represented a larger regulatory change. Hence, the trend increase in these countries supports the belief that the implementation of the Basle guidelines there generally served as a binding constraint on banks.

\textsuperscript{19} Capital in CAR is defined as total bank equity.
In contrast to their intertemporal variation, the CAR do differ considerably across countries, however. Switzerland, the Netherlands, Italy and the US exhibit the highest CAR values in the sample period; France, Belgium, Germany and Japan the lowest.

Interestingly, banks in national banking sectors that on average carry more capital, in turn tend to hold riskier asset portfolios. In other words, they appear to hold an amount

---

20. It goes without saying that international comparisons of accounting ratios may be flawed due to different accounting methods and different standards of disclosure. However, IBCA, a noted bank rating agency from which the accounting data stem, takes strides to ensure the international compatibility of such accounting aggregates as those used here.
of capital commensurate with the risk composition of their portfolios. This is seen by comparing the average CAR of a country's banks with their mean risk asset ratio. The rankings in both columns of Table 2 are similar. The relationship is not tight, however. Major exceptions are German banks, which exhibit high-risk asset ratios despite a low CAR, and Italian banks, that carry a large share of capital despite their low-risk portfolios.

Needless to say, the risk asset ratio employed here provides only a rough approximation of the true risk composition of a bank portfolio. Unfortunately, more informative data were not available. Nevertheless, it is interesting to observe that the risk asset ratios of banks in Japan and the US, where one would expect the implementation of the Basle guidelines to have had the greatest impact, exhibit a strong positive trend in line with the prediction of some theoretical models that reducing the leverage of banks leads them to invest in more risk. In fact, the banks in Japan and the US are the only ones that display a positive trend both with respect to CAR and the risk asset ratio.

The results in Table 3 and Figure 4 pertaining to the volatility (ROA) of the market value of bank assets tell a different story, however. Whereas positive trends prevail with respect to CAR and the risk asset ratio, negative trends predominate with regard to the volatility of bank asset values, a result that runs counter to the risk-seeking literature. The decline in the volatility of the value of bank-held assets could of course be due to a general reduction in market volatility, which overrode the composition effect stemming from a shift in the risk structure of bank portfolios. We will investigate this matter further below.

21. Measured as the share of total assets not consisting of cash, interbank deposits, or short-term (e.g., money market) investments.

22. On the other hand, Hall (1993) demonstrates in a more detailed analysis for the US and with a richer data base that US banks' shares of risky assets actually declined over the period 1987-91. That would imply that the implementation of the Basle guidelines decreased the risk-taking of banks in the US.
Table 3: Bank Volatility and Default Threshold, 1987-1994

<table>
<thead>
<tr>
<th>Country</th>
<th>Banks</th>
<th>$\sigma$ (ROA)</th>
<th>Default Threshold (Z)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>mean</td>
<td>trend</td>
</tr>
<tr>
<td>Belgium</td>
<td>5</td>
<td>0.007</td>
<td>-</td>
</tr>
<tr>
<td>Canada</td>
<td>7</td>
<td>0.010</td>
<td>0</td>
</tr>
<tr>
<td>France</td>
<td>6</td>
<td>0.009</td>
<td>0</td>
</tr>
<tr>
<td>Germany</td>
<td>7</td>
<td>0.011</td>
<td>-</td>
</tr>
<tr>
<td>Italy</td>
<td>12</td>
<td>0.024</td>
<td>0</td>
</tr>
<tr>
<td>Japan</td>
<td>83</td>
<td>0.026</td>
<td>-</td>
</tr>
<tr>
<td>Netherlands</td>
<td>6</td>
<td>0.027</td>
<td>0</td>
</tr>
<tr>
<td>Sweden</td>
<td>2</td>
<td>0.028</td>
<td>0</td>
</tr>
<tr>
<td>Switzerland</td>
<td>14</td>
<td>0.036</td>
<td>0</td>
</tr>
<tr>
<td>UK</td>
<td>9</td>
<td>0.023</td>
<td>0</td>
</tr>
<tr>
<td>USA</td>
<td>68</td>
<td>0.022</td>
<td>0</td>
</tr>
</tbody>
</table>

Of further interest is the high volatility of the market-valued ROA of Japanese banks. This finding stands in stark contrast to the results book values yield, where the ROA of Japanese banks appear to be the lowest (cf. SHELDON, 1996). The results achieved here obviously conform better with what we know of the current crises in Japanese banking. Nevertheless, according to our results, even in Japan the volatility of bank asset values declined over the sample period. The crises experienced in Swedish banking in 1992/93 is also reflected in Figure 4, although this finding rests on a sample of just two banks.

23. A positive or negative sign indicates that the associated variable exhibits a statistically significant trend.
According to equation (10), trend increases in CAR and trend declines in volatility \( \sigma(\text{ROA}) \) should result in falling bank failure probabilities. Table 3 and Figure 5 confirm this. Yet despite its trend decline, the average failure probability of Japanese banks still remains high. A default threshold value of -1.88 implies a default probability of 3%, which gives the average probability that the market value of a Japanese bank's assets one year hence will be so low that the decrease wipes out the book value of its assets.

24. Note that CAR in (10) equals book-value equity divided by market-value assets, whereas CAR in Table 2 pertains solely to book values. However, since the development of the book value and the estimated market value of assets closely parallel one another, the distinction is of no substantial importance.
equity. By comparison, the mean default threshold of -3.7 for the two Swedish banks studied implies a failure probability of 0.01%.

Figure 5: Bank Default Thresholds, 1987-1994

The evidence up to this point suggests that the implementation of the Basle guidelines did not increase the volatility of bank portfolios, but these results are far from conclusive. In an attempt to obtain more clear-cut evidence we subdivided the banks in Japan and the US, respectively, into four categories, depending on whether their book-value CAR increased or decreased and whether their risk asset ratios rose or fell from the year prior to implementation of the Basle guidelines to the year after implementation was completed (cf. Table I). We then tested whether the average value of $\sigma(\text{ROA})$ and of the
standardized default threshold \((z)\) changed in a statistically significant manner\(^{25}\) across the period of implementation. Unfortunately, our sample does not contain enough banks from the other signatory countries to carry out a similar test for them. However, as pointed out before, if the implementation of the Basle guidelines had any impact on bank portfolio volatilities and default probabilities, the effect should appear in Japan and the US since the introduction of the guidelines represented a greater regulatory change there than in the other member countries. The same reasoning lies behind the division of banks into four categories. Should the Basle guidelines have increased bank portfolio volatilities and raised the probability of failure, as some economic models predict, then these effects are more likely to emerge among those banks that increased CAR and their risk asset ratio in line with the framework of these models. Our test results appear in Figures 6 (US) and 7 (Japan).

**Figure 6: Test Results for the US, 1989 vs. 1993**

\[
\begin{array}{c|c|c}
\text{CAR +} & \text{risk +} & 41 \\
\text{CAR -} & \text{risk -} & 2 \\
\end{array}
\]

\[
\begin{array}{c|c|c}
\text{CAR +} & \text{risk +} & 0.018 \\
\text{CAR -} & \text{risk -} & 0.020 \\
\end{array}
\]

**σ(ROA)**

\[
\begin{array}{c|c|c|c|c|c}
\text{CAR +} & \text{risk +} & 0.014 & \text{CAR +} & 0.028*** & 0.028*** \\
\text{CAR -} & \text{risk -} & 0.033 & \text{CAR -} & 0.027 & 0.045 \\
\end{array}
\]

default threshold

\[
\begin{array}{c|c|c|c|c|c}
\text{CAR +} & \text{risk +} & -4.64 & \text{CAR +} & -3.30*** & -3.10*** \\
\text{CAR -} & \text{risk -} & -4.78 & \text{CAR -} & -3.03 & -1.39 \\
\end{array}
\]

**BEFORE**

**AFTER**

*** change statistically significant with less than a 1% risk of error

25. In other words, we control for the variability due to different sample size. Note that our test procedure eliminates any firm-specific fixed effects that may exist as a result, e.g., of sample selection bias.
The findings for the US indicate that 41 or roughly two thirds of the banks examined increased their CAR and risk asset ratios in the wake of the Basle guideline implementation from 1990 to 1992. These same banks also exhibit a statistically significant increase in the volatility of their portfolios (from 0.018 to 0.028) and in their default thresholds (from -4.64 to -3.30), the latter result implying an increase in their average probability of failure. However, the same holds true for the other groups of banks, although the increases for banks that exhibited a lower book-value CAR after the implementation of the Basle guidelines are not statistically significant due to the small sample size. Since all banks, whether they raised CAR and/or their risk asset ratios or not, experienced the same increase in asset value volatility and default probability, it appears that factors other than the introduction of the guidelines underlie the changes presented in Figure 6. Interestingly, Furlong (1988) makes a similar discovery using the same approach but different data in a test of the effect of the introduction of a uniform gearing ratio for all US banks in 1981. At that time, asset value volatility rose too, but irrespective of whether the new capital standard represented a binding constraint for a bank or not.

Figure 7: Test Results for Japan, 1988 vs. 1993

\[
\begin{array}{|c|c|}
\hline
\text{CAR} & \text{risk} + \text{risk} - \\
\hline
\text{CAR} & 60 & 9 \\
\text{CAR} & 7 & 1 \\
\hline
\end{array}
\]

\[\sigma(\text{ROA})\]

\[
\begin{array}{|c|c|}
\hline
\text{CAR} & \text{risk} + \text{risk} - \\
\hline
\text{CAR} & 0.024 & 0.018 \\
\text{CAR} & 0.023 & 0.017 \\
\hline
\end{array}
\]

\[
\begin{array}{|c|c|}
\hline
\text{CAR} & \text{risk} + \text{risk} - \\
\hline
\text{CAR} & 0.019 & 0.019 \\
\text{CAR} & 0.019 & 0.026 \\
\hline
\end{array}
\]

\[
\begin{array}{|c|c|}
\hline
\text{default threshold} & \text{risk} + \text{risk} - \\
\hline
\text{CAR} & -1.46 & -1.96 \\
\text{CAR} & -1.88 & -2.50 \\
\hline
\end{array}
\]

\[
\begin{array}{|c|c|}
\hline
\text{default threshold} & \text{risk} + \text{risk} - \\
\hline
\text{CAR} & -2.33*** & -2.18 \\
\text{CAR} & -2.44 & -1.60 \\
\hline
\end{array}
\]

BEFORE \hspace{5cm} AFTER
The results for Japan present a different picture (Figure 7) than those for the US. In Japan an even larger proportion of the banks increased their CAR and risk asset ratios, yet the volatility of their portfolios and their default thresholds fell. Hence, it appears that if the implementation of the guidelines had a risk-increasing effect on bank portfolios in Japan, it was not a dominant force.

6. SUMMARY AND CONCLUSIONS

Increasing the capital that banks must hold against their assets is generally expected to lower the probability that a bank will fail, since capital acts as a buffer to absorb losses to bank assets. Yet economic theory questions whether restricting leverage reduces the probability of bank default, as forcing banks to carry more capital may encourage them to invest in more risk, thus partially or completely offsetting the stabilizing effect increased capital should ensure.

This study examined the risk-seeking effects of the implementation of the capital guidelines of the 1988 Basle Accord on banks in the signatory nations. Our results provide little evidence that implementation of the guidelines had a risk-increasing impact on bank portfolios. In Japan and the US, two countries in which the implementation of the Basle guidelines was most likely to have represented a binding constraint, capital and investment in risk did indeed appear to rise. Yet in the US, the volatility of bank asset values rose irrespective of whether the banks increased their capital and/or invested in more risk, whereas in Japan, bank asset volatility fell although most banks increased their capital and investment in risk.

Hence, our results do not appear to support the claim of those who maintain that restricting bank leverage will lead to more risk in banking. Several caveats are in order, however. For one, it is not clear what effect the guidelines of the Basle Accord should have had. In principle, the risk-based capital standards underlying the guidelines should have helped to prevent risk substitution. Yet risk-based standards were already in place in most signatory countries before the guidelines were implemented. And whether the introduction of risk-based capital standards limited risk-taking in those countries (such as Japan and the US) without such standards is uncertain, since the risk weights of the guidelines are very crude. Moreover, they only apply to the risk of loan default and ignore the volatility of bank asset values.

Furthermore, our results could be clouded by forces other than capital adequacy rule changes that were active during the sample period. It is well known, for example, that the Federal Reserve Bank engineered a sharply upward sloping yield curve during the sample period to recapitalize the US banks. In turn, the banks were expected to exceed the capital standards set down by the Basle Accord. Such implicit understandings could have overridden any effects the Basle Accord might have produced.

Our empirical methodology is also not free of deficiencies. Increasing capital-to-asset ratios and rising risk asset ratios, for example, unfortunately say too little about whether
the Basle guidelines were in fact binding or whether the risk composition of bank portfolios did indeed increase. In addition, our estimates of the volatility of bank asset values is based on a BLACK-SCHOLES interpretation of bank equity, which might not be appropriate. Yet a more effective approach, given current data restrictions, is not available.

In the event that our results, despite these unavoidable shortcomings, are in fact accurate and hence the implementation of the guidelines of the Basle Accord did indeed not induce banks to invest in more risk, one should nonetheless not take this finding as evidence that implementing the 1996 Amendment to the Basle Accord will prove to be similarly «harmless». In contrast to the guidelines of the 1988 Accord, those of the Amendment do represent a Big Bang for most signatory countries as they apply capital standards for the first time to market risk and, with respect to non-in-house models, in decidedly more detail than previous guidelines. Given the limited knowledge on the effects of increasing capital standards on bank risk-taking, it would seem advisable for the regulatory authorities to proceed with caution in implementing the new guidelines.

REFERENCES


SUMMARY

Economic theory is unclear on the effects of capital regulation on the risk-seeking behavior of banks. This paper attempts to shed light on the issue by examining the impact of the implementation of the guidelines of the 1988 Basle Capital Accord on a large sample of individual banks drawn from the signatory countries. The empirical methodology is based on the call option interpretation of firm equity stemming from BLACK/SCHOLES. The results provide little evidence that the implementation of the Basle guidelines increased the probability of bank failure.

ZUSAMMENFASSUNG

APPENDIX

BELGIUM

Banque Belgo-Zaïroise BELGOLAISE
Bank Brussel Lambert BBL
Crédit général, Société anonyme de Banque Générale Bank - Générale de Banque
Kredietbank KB

CANADA

Bank of Montreal
Bank of Nova Scotia SCOTIABANK
Canadian Imperial Bank of Commerce CIBC
Laurentian Bank of Canada
National Bank of Canada
Royal Bank of Canada RBC
Toronto Dominion Bank

FRANCE

Banque Paribas
Crédit commercial de France
Crédit Lyonnais
Crédit National
Société Générale
Union Européenne de CIC

GERMANY

Bayrische Hypotheken- und Wechsel-Bank AG
Bayrische Vereinsbank AG
Berliner Handels-und Frankfurter Bank Commerzbank AG
Deutsche Bank AG
Dresdner Bank AG
Trinkaus & Burkhardt KGaA

ITALY

Banca nazionale del lavoro BNL (Gruppo)
Banca Popolare di Bergamo
Banca Popolare di Milano SCaRL
Banca Toscana SpA
Banco Ambrosiano Veneto SpA
Banco di Chiavari e della Riviera Ligure SpA
Banco di Napoli
Credito Bergamasco
Credito Italiano
Credito Lombardo
Mediobanca SpA

JAPAN

77 Bank
Aichi Bank
Akita Bank Ltd.
Aomori Bank Ltd.
Ashikaga Bank Ltd.
Awa Bank
Bank of Fukuoka Ltd.
Bank of Ikeda
Bank of Iwate, LTD
Bank of Kinki, Ltd.
Bank of Kyoto
Bank of Nagoya
Bank of Osaka, Ltd.
Bank of Saga, Ltd.
Bank of the Ryukyus Ltd.
Bank of Tokyo Ltd.
Chiba Bank, Ltd.
Chiba Kogyo Bank
Chugoku Bank, Ltd.
Chukyo Bank
Chuo Trust & Banking Co., Ltd.
Dai-Ichi Kangyo Bank Ltd. DKB
Daisan Bank, Ltd.
Daishi Bank LTD
Ehime Bank, Ltd.
Eighteenth Bank
Fuji Bank Ltd.
Fukui Bank Ltd.
Fukuoka City Bank, Ltd.
Fukutoku Bank
Gunma Bank Ltd.
Hachijuni Bank
Hanshin Bank
Higashi-Nippon Bank
Higo Bank
Hiroshima Bank Ltd.
Hiroshima-Sogo Bank
Hokkaido Bank
Hokkaido Takushoku Bank Ltd.
Hokkoku Bank Ltd.
Hokkutetsu Bank Ltd.
Hokuriku Bank Ltd.
Hyakugo Bank Ltd.
Hyakujushi Bank Ltd.
Hyogo Bank
Industrial Bank of Japan Ltd.
Iyo Bank Ltd.
Joyo Bank Ltd.
Juroku Bank Ltd.
Kagoshima Bank Ltd.
Keiyo Bank
Kiyo Bank
Long Term Credit Bank of Japan Ltd.
Michinoku Bank
Mitsubishi Bank Limited
Mitsubishi Trust and Banking Corporation
Mitsui Trust & Banking Company Limited
Miyazaki Bank
Musashino Bank
Nanto Bank Ltd.
Nippon Credit Bank Ltd.
Nishi-Nippon Bank Ltd.
North Pacific Bank
Ogaki Kyoritsu Bank
Otta Bank LTD
San-In Godo Bank, Ltd.
Sanwa Bank Ltd.
Shiga Bank, LTD.
Shikoku Bank Ltd.
Shinwa Bank Ltd.
Shizuoka Bank
Sumitomo Bank Ltd.
Sumitomo Trust & Banking Company Ltd.
Suruga Bank Ltd.
Toho Bank Ltd.
Tokai Bank Ltd.
Tokyo Sowa Bank Ltd.
Tokyo Tomin Bank, Ltd.
Toyo trust and Banking Co., Ltd.
Yamagata Bank Ltd.
Yamaguchi Bank
Yamanashi Chuo Bank Ltd.
Yasuda Trust & Banking Co.

NETHERLANDS

Bank Mendes Gans NV
Crédit Lyonnais Bank Nederland NV
Kas-Associatie NV
Kempen & Co. NV
Nationale Investeringsbank NV (de)
Staal Bankiers NV

SWEDEN

Skandinaviska Enskilda Banken
Svenska Handelsbanken

SWITZERLAND

Basellandschaftliche Kantonalbank
Compagnie Financière Tradition
Coop Bank, Basel
Crédit Foncier Vaudois
Graubündner Kantonalbank
Luzerner Kantonalbank
Luzerner Landbank AG
Neue Aargauer Bank
Rothschild Bank AG
Swiss Bank Corporation
Union Bank of Switzerland UBS
Unigestion Holding
Zuger Kantonalbank
UNITED KINGDOM

Bank of Scotland
Cater Allen Holdings plc and Subsidiary Companies
Close Brothers limited
Gerrard & National Holdings plc
Hambros Plc
National Westminster Bank Plc
Royal Bank of Scotland plc
Schröders Plc
Standard Chartered Plc

UNITED STATES

AmSouth Bancorporation
Banc One Corporation
Bank of Boston Corporation
Bank of Hawaii
Bank of New York
Bank South Corporation
Bankamerica Corporation
Bankers Trust New York Corp.
Barnett Banks Inc.
Baybanks Inc.
Boatmen’s Bancshares, Inc.
Central Fidelity Banks, Inc.
Chase Manhattan Corporation
Chemical Banking Corporation
Citicorp Holdings, Inc.
Comerica Incorporated
Commerce Bancshares, Inc.
Compass Bancshares, Inc.
CoreStates Financial Corp.
Crestar Financial Corporation
Fifth Third Bancorp
First American Corporation
First Bank System, Inc.
First Commerce Corporation
First Empire State Corporation
First Fidelity Bancorporation
First Hawaiian Inc.
First Interstate Bancorp
First of America Bank Corp.
First Security Corporation
First Tennessee National
First Union Corporation
First Virginia Banks INC
Firstar Corp.
Fleet Financial Group
Fourth Financial Corp.
Hibernia Corporation
Huntington Bancshares Incorporated
Integra Financial Corp.
J.P. Morgan Holdings Inc.
KeyCorp
Marshall & Ilsley Corporation
Mellon Bank Corporation
Mercantile Bancorporation Inc.
Mercantile Bankshares Corporation
Meridian Bancorp
Midlantic Corporation
National City Corporation
NationsBank Corporation
Northern Trust Corporation
Norwest Corporation
Old Kent Financial Corp.
PNC Bank Corp.
Regions Financial Corporation
Republic New York Corporation
Signet Banking Corporation
Southern National Corp.
Southtrust Corporation
Star Banc Corporation
State Street Boston Corp.
Suntrust Banks Inc.
Synovus Financial Corp.
UJB Financial Corp.
Union Bank
Union Planters Corporation
Wachovia Corporation
Wells Fargo & Company
Wilmington Trust Company