Risk-Based Capital, Portfolio Risk, and Bank Capital: A Simultaneous Equations Approach

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This paper examines the impact the risk-based capital standards had on bank capital and portfolio risk during the first year the risk-based standards were in effect. To date, insufficient attention has been focused on how the risk-based capital standards have impacted bank capital and risk. Building on previous research, this study used a three-stage least squares (3SLS) model to analyze the relationship between bank capital, portfolio risk, and the risk-based capital standards. The results suggest that the risk-based capital standards were effective in increasing capital ratios and reducing portfolio risk in commercial banks. © 1997 Temple University

Keywords: Risk-based capital; Capital ratios; Portfolio risk

JEL classification: G21; G28

I. Introduction

It has been widely observed that throughout the 1970s, the capital ratios of many banks declined significantly. In attempting to reverse this decline, in December 1981, the bank regulators issued explicit capital standards for banks and bank holding companies which required them to hold a minimum amount of capital equal to a fixed percentage of their total assets. Although these minimum regulatory standards have been given credit for increasing bank capital levels, the 1980s saw the number of bank failures rise to a level not seen since the Great Depression. As noted by Alfried (1988), a weakness of the minimum capital standards was that they failed to explicitly incorporate risk and, as a result, banks shifted their portfolios from low-risk assets to high-risk assets.

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In 1989, the three U.S. banking agencies (the Federal Deposit Insurance Corporation, the Federal Reserve Board, and the Office of the Comptroller of the Currency), as part of the international Basle Committee on Banking Regulation and Supervisory Practices, adopted the risk-based capital standards. The primary purpose of the risk-based standards was to make bank capital requirements more responsive to the risk in a bank’s portfolio of assets. Although capital ratios at commercial banks have increased since the risk-based standards took effect, the question is to what degree these increases are a response to risk-based capital. Furthermore, although adoption of the risk-based standards, and the recent credit crunch, have focused attention on capital levels and bank lending, insufficient attention has been given to how the adoption of the Basle risk-based standards may have impacted bank portfolio risk levels.\(^1\) In general, some theoretical and empirical research suggests that increasing regulatory capital standards might cause banks to increase, rather than decrease, portfolio risk. Furthermore, greater amounts of capital do not guarantee that banks are adequately capitalized. Rather, from a public policy perspective, what is important is the amount of capital a bank holds relative to the level of risk in its portfolio.

This paper contributes to the literature by examining the impact that the recently implemented risk-based standards had on not only bank capital, but also portfolio risk, during the first year the standards were in effect. Modifying recent work by Shriives and Dahl (1992), this paper uses a three-stage least squares (3SLS) model to recognize the relationship between bank capital, portfolio risk, and the risk-based capital standards. By using the 3SLS technique, the model explicitly recognizes the endogeneity of changes in capital and risk, and as such, is preferable to single-equation OLS models which assume either capital or risk is exogenous to the bank.

II. Previous Literature

In recent years, a number of theoretical and empirical studies have examined the impact of regulatory capital standards on bank portfolio risk. For example, using the mean-variance framework, Kahane (1977), Koehn and Santomero (1980), and Kim and Santomero (1988) have shown that increased regulatory capital standards may have the unintended effect of causing utility-maximizing banks to increase portfolio risk. Under these conditions, changes in capital and portfolio risk would be positively correlated. In contrast, studies such as those by Dothan and Williams (1980) and Benston et al. (1986) have noted that bank capital and portfolio risk may be negatively correlated, as banks maximize the option value of deposit insurance by reducing capital and increasing risk. Furthermore, Furlong and Keeley (1989) and Keeley and Furlong (1990) have argued that the mean-variance approach is inappropriate because it ignores the option value of deposit insurance. Using a contingent-claims model, their results suggest that increased capital standards will not cause banks to increase portfolio risk. This occurs because an increase in capital reduces the value of the deposit insurance put option, thereby reducing the incentive for banks to increase portfolio risk levels. However, Gennette and Pyle (1991) found that even if the impact of deposit insurance is accounted for, increased stringency

\(^1\) For recent studies addressing the impact of the risk-based capital standards on bank lending and the credit crunch, see Bernanke and Lown (1991), Berger and Udell (1994), Hancock and Wilcox (1994), and Shriives and Dahl (1995).
in capital standards may lead a bank to incur greater portfolio risk if the bank is not restricted to zero net present value investments.

Addressing the issue of risk-based capital regulation, Kim and Santomero (1988) and Kendall and Levonian (1992) examined how the design of risk-based capital standards influences the level of risk in bank portfolios. The results of Kendall and Levonian (1992) are particularly interesting, because they found that a risk-based rule designed to minimize the probability of bank failure will lead banks to choose high-risk assets. Furthermore, recent empirical work by Haubrich and Wachtel (1993) suggests that implementation of the Basle risk-based capital standards caused poorly-capitalized banks to reconfigure their portfolios away from high-risk assets and toward low-risk assets. This result is consistent with Lavin et al. (1996) who found, in a survey of 205 banks, that 37% of the sampled banks raised their capital-asset ratio over the period 1989–1994, and that 46% of that group attributed the increase to the risk-based capital standards. In contrast, Hancock and Wilcox (1994) found that banks which had less capital than required by the risk-based standards shifted their portfolios toward high-risk assets. Finally, Laderman (1994) found that bank holding companies deficient in Tier 1 capital met the risk-based standards by decreasing asset growth rather than by issuing new common stock.

III. Risk-Based Capital Standards

In July 1988, the Basle Committee on Banking Regulation and Supervisory Practices approved the adoption of a risk-based capital standard for banks in members’ respective countries.\textsuperscript{2} Prior to the implementation of the risk-based capital standards, U.S. banks were subject to a leverage requirement which mandated banks hold a flat percentage of their assets as capital, independent of the level of risk in their portfolio.

Beginning on December 31, 1990, the risk-based capital standards supplemented the existing leverage requirement. Although the risk-based capital standards were designed to make capital standards similar across all countries on the Basle Committee, their primary purpose was to require banks to hold capital in accordance with the perceived credit risk in their portfolio. To accomplish this, the risk-based standards explicitly link capital to risk by assigning risk weights to broad categories of on- and off-balance sheet assets. Currently, the risk-based standards contain four risk-weight categories: 0% for assets such as U.S. Treasury bills which are considered to have no default risk; 20% for assets with low credit risk; 50% for assets with moderate credit risk, and 100% for higher credit risk assets such as commercial loans. After assigning assets to the appropriate risk-weight category, the bank calculates its total risk-weighted assets as the sum of the dollar value of each asset multiplied by its corresponding risk weight.\textsuperscript{3} As a final step, banks must hold capital equal to a certain percentage of the total risk-weighted assets. Under the risk-based standards, capital has two definitions. Tier 1 capital is comprised mainly of common stock, while Tier 2 includes certain types of preferred stock and subordinated debt.\textsuperscript{4}

\textsuperscript{2} The twelve countries are Belgium, Canada, France, Germany, Italy, Japan, Luxembourg, the Netherlands, Sweden, Switzerland, the United Kingdom, and the United States.

\textsuperscript{3} The risk-based capital standards also incorporate off-balance sheet activities. This is done by converting the dollar value of the off-balance sheet item to an on-balance sheet credit exposure equivalent. The on-balance sheet equivalent is then multiplied by the corresponding risk weight and added to the bank’s total risk-weighted assets.

\textsuperscript{4} Tier 1 capital also includes noncumulative perpetual preferred stock and minority interest in consolidated subsidiaries less goodwill, while Tier 2 includes perpetual preferred stock, perpetual and term subordinated debt, and loan loss reserves. For a more complete discussion, see Office of the Comptroller of the Currency (1989).
Effective December 31, 1990, banks were required to hold at least 3.25% of their risk-weighted assets as Tier 1 capital and a minimum of 7.25% of their risk-weighted assets in the form of total capital (Tier 1 + Tier 2). Beginning at the end of 1992, the minimum Tier 1 and total capital ratios were raised to 4% and 8%, respectively.

IV. Limitations of the Risk-Based Capital Standards

Under an ideal risk-based capital system, any increase in a bank’s portfolio risk would be accompanied by an increase in capital to act as buffer against possible losses arising from the additional risk. This implies that the risk-based capital standards should explicitly link changes in required bank capital with changes in earnings exposure risk. However, as currently written, conceptual weaknesses in the risk-based standards may undermine the relationship between changes in portfolio risk and changes in required capital. One reason for this is that the current risk-based capital standards account primarily for credit risk. Recent policy statements by the Shadow Financial Regulatory Committee (1992b, 1993) note that one of the major weaknesses of the risk-based standards is that they do not explicitly incorporate capital charges tied to interest-rate risk.\(^5\) Thus, a capital-deficient bank can, at the margin, improve its risk-based capital ratio by substituting interest-sensitive, low credit risk assets, such as long-term Treasury bonds, for shorter-term, higher credit risk assets such as commercial loans. As this example shows, by substituting interest-sensitive assets for higher credit risk assets, both a bank’s interest-rate risk and portfolio risk may increase, while its required capital level will decrease, thereby suggesting that flaws in the risk-based standards may result in a negative correlation between changes in capital and changes in risk.\(^6\) Furthermore, a recent study by Allen et al. (1996) confirms that banks substituted interest rate risk for credit risk in their portfolios to take advantage of an interest rate risk subsidy in the risk-based capital standards.\(^7\)

In addition, as Keeton (1989), Avery and Berger (1991), and Kaufman (1992) have observed, if the risk weights used in the risk-based capital standards do not accurately reflect the true risk of an asset, then banks may actually have an incentive to increase portfolio risk. This situation occurs, in part, because the risk-based standards use simplified risk classifications which create an incentive for banks to arbitrage both between and within risk categories. Evidence that the risk weights used in risk-based capital differ from

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\(^5\) Besides interest-rate risk, other types of risk, such as credit-concentration risk, are not explicitly captured by the risk-based standards. In response, in December 1991, Congress passed the FDICIA which required bank regulators to explicitly incorporate interest-rate risk, credit-concentration risk, and the risk from nontraditional activities into the risk-based capital framework. To date, the regulators have taken steps to address these risks, but have not implemented a quantitative regulatory model to estimate risk and assign capital charges. In addition, the Basel Committee on Banking Supervision has proposed a model for estimating market risk in bank portfolios, but this proposal would only be applied to banks with large securities and foreign exchange portfolios.

\(^6\) This example assumes that bank regulators do not discover, through the supervisory process, that banks have substituted interest-rate risk for credit risk. As noted in Office of the Comptroller of the Currency (1989), if regulators discover through the supervisory process that other types of risk, such as interest-rate risk, have increased, then additional capital may be warranted and a bank’s risk-based capital ratio may be required to exceed 8%. Under these conditions, interest-rate risk is implicitly captured by the risk-based capital standards, and portfolio risk and bank capital will be positively correlated.

\(^7\) An interesting extension of this paper would be to examine to what degree banks in this study increased interest-rate risk in response to the risk-based standards. Unfortunately, Call Report data offers little information which can be used to assess a bank’s interest-rate risk using either gap analysis or duration. While bank regulators have made a proposal for changing the Call Report, any changes to improve interest rate risk reporting have not yet been incorporated.
actuarially fair premiums has been provided by Bradley et al. (1991) and Avery and Berger (1991). Furthermore, as noted by the Shadow Financial Regulatory Committee (1992a), by ignoring the benefits of portfolio diversification, the risk-based capital standards may not accurately differentiate between changes in asset composition which hedge portfolio risk and those which increase portfolio risk. Finally, it must be recognized that the minimum risk-based capital standards, by themselves, do not limit the amount of risk in a bank’s portfolio. Rather, the risk-based standards dictate how much capital a bank must hold, conditional upon the estimated level of primarily credit risk in a bank’s portfolio. In fact, as discussed in previous sections, the risk-based capital standards may actually cause banks to increase portfolio risk.

V. Model Specification

The preceding sections suggest that a relationship exists between bank capital and portfolio risk, and that the risk-based capital standards may have had an impact on both capital and risk. To examine these issues, the simultaneous equations model developed by Shriives and Dahl (1992) was modified to incorporate the risk-based capital standards. In the Shriives and Dahl model, observed changes in bank capital and risk levels are decomposed into two components, a discretionary adjustment and a change caused by factors exogenous to the bank such that:

$$\Delta \text{CAP}_{j,t} = \Delta^d \text{CAP}_{j,t} + E_{j,t};$$ (1)

$$\Delta \text{RISK}_{j,t} = \Delta^d \text{RISK}_{j,t} + S_{j,t};$$ (2)

where $\Delta \text{CAP}_{j,t}$ and $\Delta \text{RISK}_{j,t}$ are the observed changes in capital and risk levels, respectively, for bank $j$ in period $t$. Here, capital is measured as the ratio of total capital (Tier 1 + Tier 2) to risk-weighted assets, and risk is measured as the ratio of risk-weighted assets to total assets. The $\Delta^d \text{CAP}_{j,t}$ and $\Delta^d \text{RISK}_{j,t}$ variables represent discretionary adjustments in capital and risk, and $E_{j,t}$ and $S_{j,t}$ are exogenously-determined factors. In any period, banks may not be able to adjust their desired capital and risk levels instantaneously. Thus, Shriives and Dahl (1992) modeled the discretionary changes in capital and risk using the partial adjustment framework such that:

$$\Delta^d \text{CAP}_{j,t} = \alpha (\text{CAP}^*_j - \text{CAP}_{j,t-1});$$ (3)

$$\Delta^d \text{RISK}_{j,t} = \beta (\text{RISK}^*_j - \text{RISK}_{j,t-1}).$$ (4)

where $\text{CAP}^*_j$ and $\text{RISK}^*_j$ are bank $j$’s target capital and risk levels, respectively. In the partial adjustment framework, the discretionary changes in capital and risk are proportional to the difference between the target level and the level existing in period $t - 1$. Substituting equations (3) and (4) into equations (1) and (2), the changes in capital and risk can be written:

$$\Delta \text{CAP}_{j,t} = \alpha (\text{CAP}^*_j - \text{CAP}_{j,t-1}) + E_{j,t};$$ (5)

$$\Delta \text{RISK}_{j,t} = \beta (\text{RISK}^*_j - \text{RISK}_{j,t-1}) + S_{j,t}.$$ (6)

Thus, the observed changes in capital and risk in period $t$ are a function of the target capital and risk levels, the lagged capital and risk levels, and any exogenous factors. The
target levels of capital and risk are not observable, but are assumed to depend upon some set of observable variables.

In this study, the target capital ratio (CAP*) is influenced by a number of explanatory variables including: the size of the bank (SIZE), whether the bank is affiliated with a multibank holding company (BHC), income (INC), the bank’s leverage ratio (LEVD), and changes in risk (ΔRISK). In a similar fashion, the target risk ratio (RISK*) is influenced by size, multibank holding company status, the bank’s leverage ratio, and changes in capital (ΔCAP). Most of these variables were taken from Shrieves and Dahl (1992). Furthermore, the exogenous factor which could influence bank capital (C_j,t) or risk (R_j,t) is a change in regulatory capital standards, in this case modeled as the degree of regulatory pressure brought about by the risk-based capital standards.

Specifying variables to explain changes in capital and risk, the model is written:

\[ ΔCAP_{j,t} = \Gamma_0 + \Gamma_1 SIZE_{j,t} + \Gamma_2 BHC_{j,t} + \Gamma_3 LEVD_{j,t} + \Gamma_4 ΔRISK_{j,t} + \Gamma_5 INC_{j,t} \]
\[ - \Gamma_6 CAP_{j,t-1} + \Gamma_7 R}_{j,t} + \Gamma_8 RPL_{j,t} + \mu_{j,t}; \]
\[ ΔRISK_{j,t} = \theta_0 + \theta_1 SIZE_{j,t} + \theta_2 BHC_{j,t} + \theta_3 LEVD_{j,t} + \theta_4 ΔCAP_{j,t} - \theta_5 ΔRISK_{j,t-1} \]
\[ + \theta_6 R}_{j,t} + \theta_7 RPL_{j,t} + \omega_{j,t}, \]

where \( \mu_{j,t} \) and \( \omega_{j,t} \) are disturbance terms; SIZE is measured as the natural log of a bank’s total assets, and BHC is a dummy variable which equals unity for banks belonging to a multibank holding company. In addition, the ratio of income to total assets (INC) in period \( t-1 \) was taken from Dahl and Shrieves (1990) as a proxy for profitability in period \( t \).

The leverage ratio has been also included as an explanatory variable because, as Baer and McElravey (1994) noted, concurrent with the adoption of the risk-based capital standards came changes in the calculation of the leverage ratio. To account for the impact of changes in the leverage requirement on the capital ratio, a dummy variable for banks with less than a 5% leverage ratio (LEVD) has been included, because banks constrained by the leverage ratio would be expected to increase their total capital-asset ratio, independent of the risk-based standards.

Finally, the endogenous variables ΔRISK_\_t and ΔCAP_\_t have been included to recognize the possible simultaneous relationship between changes in capital and changes in risk.

As noted by Shrieves and Dahl (1992), a positive correlation between capital and risk may result from regulatory costs, the unintended impact of minimum capital requirements, bankruptcy cost avoidance, or risk aversion by bank managers, while a negative correlation may result from the mispricing of deposit insurance. In addition, as noted earlier, methodological flaws in the risk-based capital standards may account for a negative relationship between risk and capital.

Empirical estimation of equations (7) and (8) requires measures of both bank capital and portfolio risk. As noted earlier, given the regulatory requirements associated with risk-based capital, CAP is measured as the ratio of total capital (Tier 1 + Tier 2) to total

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8 Specifically, banks with a CAMEL rating of 1 were required to hold a minimum of 3% of their balance sheet assets as Tier 1 capital. Banks not rated CAMEL 1, or those with significant credit or other types of risk, were required to meet even higher leverage ratios, these being at least 100 basis points above the minimum. As Baer and McElravey (1994) noted, bank holding companies behaved as if the minimum leverage ratio were 7%. Using a 7% leverage ratio did not change the results of this study.

9 It is possible, however, that a bank could substitute equity capital for other types of regulatory capital, thereby increasing their leverage ratio but leaving their risk-based capital ratio unchanged.
risk-weighted assets. Measurement of portfolio risk is more problematic, and the previous literature suggests a number of alternatives, all of which are subject to some criticism. As noted in the previous section, the ratio of risk-weighted assets to total assets has been used to measure risk in this paper. Shriives and Dahl (1992) noted that a bank’s portfolio risk is primarily determined by its allocation of assets across risk categories and the quality of its loans, two features captured by the risk-weighted asset to total asset ratio, while Avery and Berger (1991) and Berger (1995) argued that this ratio is positively correlated with risk.

The main emphasis of this study is on the regulatory pressure variables, denoted by RPG and RPL. Following Hancock and Wilcox (1994), this study focuses on the response of banks to the 7.25% risk-based capital standard. Here, RPG and RPL signal the degree of regulatory pressure brought about by the risk-based capital standards and, with the variables included in equations (7) and (8) to control for other factors, RPG and RPL isolate the impact of the risk-based standards on bank risk levels and capital ratios. Specifically, the regulatory pressure variables equal the difference between the inverse of bank j’s total risk-based capital ratio (\(RBC_j\)) and the inverse of the regulatory minimum risk-based ratio of 7.25%. These measures are similar to the regulatory pressure variable used by McManus and Rosen (1991) and have been used because they recognize the nonlinear relationship between the regulatory capital standards and either changes in portfolio risk or capital ratios. Because banks with total risk-based capital ratios above and below the 7.25% regulatory minimum may react to the standards differently, this study partitioned regulatory pressure into two variables, RPG and RPL. RPL equals (1/\(RBC_j\) - 1/7.25) for all banks with a total risk-based capital ratio of less than 7.25%, and 0 for all banks with risk-based ratios above the minimum. These banks are under considerable regulatory pressure to increase their capital ratios, as they did not meet the regulatory minimum risk-based standard by December 31, 1990. Therefore, RPL should have a positive effect on capital ratios (\(\Gamma_x > 0\)) or a negative effect on portfolio risk (\(\theta_x < 0\)), because banks can meet the regulatory minimum risk-based standards by either raising capital or reducing risk-weighted assets.

A second regulatory pressure variable, RPG, equals (1/7.25 - 1/\(RBC_j\)) for all banks with a total risk-based ratio greater than or equal to 7.25%, 0 otherwise. Although banks with risk-based capital ratios in excess of 7.25% were not explicitly constrained by the regulatory minimum, the risk-based standards may have significantly influenced their capital ratios or the risk in their portfolio of assets. Because these banks hold capital in excess of the regulatory minimum, they may reduce their capital ratios (\(\Gamma_x < 0\)) or increase their level of portfolio risk (\(\theta_x > 0\)). Alternatively, as Hancock and Wilcox (1992), Furlong (1992), and Bauer and McElravey (1993) noted, these banks may increase their capital ratios as a buffer against shocks to equity. Because banks must meet the regulatory minimum standards on a continuous basis, the risk-based capital standards may

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10 This study examines the response of banks to the 7.25% standard because it is the primary focus of bank regulators and because only 15 of the 2570 banks in the sample were constrained by the Tier 1 ratio.

11 For banks with risk-based capital ratios less than 7.25%, (1/\(RBC_j\) - 1/7.25) was positive. Therefore, a positive value of \(\Gamma_x\) or \(\theta_x\) implies that greater amounts of regulatory pressure, as measured by RPL, correspond to larger increases in the capital ratio or portfolio risk. Similarly, a negative value implies that these variables decrease with greater regulatory pressure.

12 There are other reasons why banks may choose to hold capital above the regulatory minimum. For example, Bauer et al. (1981) discussed regulatory costs as a motive while Orgler and Taggart (1983) discussed tax considerations.
cause these banks to increase their capital ratios ($\Gamma_7 > 0$) or reduce portfolio risk ($\theta_6 < 0$) as insulation against any uncertainty regarding whether the bank meets the regulatory minimum. In addition, increasing capital ratios or reducing risk for these banks may serve as a signal to both the market and bank regulators that these banks are in compliance and, in doing so, may lead to a reduction in regulatory costs.

VI. Empirical Estimation

Beginning December 31, 1990, banks were required to hold a minimum of 7.25% of their total risk-weighted assets as capital. Similar to Hancock and Wilcox (1994), this study covers the first year the risk-based capital standards were in effect (1991). Since the risk-based capital standards were formally announced by the U.S. bank regulators in 1989, it would be desirable to examine the impact of the risk-based standards not only during the first year the standards were in effect, but also the period after the standards were announced but prior to when they took effect. Unfortunately, risk-based capital data from bank call reports is unavailable prior to the end of 1990, thereby limiting our ability to assess how banks responded to the announcement of risk-based capital and to assess how their risk-based portfolios looked during normal times. But as Haubrich and Wachtel (1993) noted, the impact of the risk-based standards appeared more clearly after the December 1990 implementation date. They argued that this occurred because the composition of bank portfolios can be quickly and easily changed and because banks experienced a significant period of learning in adapting to the risk-based standards. Nonetheless a word of caution is required. This analysis is complicated by other factors, such as allegedly tougher bank examination standards and the 1990–1991 recession, which make it difficult to assess the impact of the risk-based standards. Therefore, care should be taken in drawing definitive conclusions about how risk-based capital influenced bank behavior.

This study examined 2570 FDIC-insured commercial banks with assets greater than $100 million, using call report data from year end 1990 (period $t - 1$) and year end 1991 (period $t$). Table 1 shows bank characteristics, including changes in risk and capital, for banks which were and were not constrained by the risk-based capital standards when they went into effect. For example, as of December 31, 1990, 67 of the 2570 banks had risk-based capital ratios less than 7.25%, with the median risk-based ratio equal to 6.71%. During 1991, these banks experienced a median 2% increase in total capital, a median 7.26% reduction in total assets, a median 14.84% decrease in risk-weighted assets, a median return on assets (ROA) equal to −0.94%, and a median reduction in risk of almost 500 basis points. In contrast, the 2503 banks which met the risk-based standards experienced a median 6.61% increase in total capital, a median 4.14% increase in total assets, a median 5.35% reduction in risk-weighted assets, and a median decrease in portfolio risk equal to 652 basis points. Although only summary statistics, these results are consistent with earlier research which suggests that the risk-based capital standards led to an increase in capital and a decrease in portfolio risk.

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13 This paper does not include data after 1991 because, in December 1991, the Federal Deposit Insurance Corporation Improvement Act (FDICIA) defined different levels of bank capitalization in terms of the bank’s risk-based capital ratios and leverage ratios. Under these conditions, it is unclear at what level of risk-based capital a bank experiences regulatory pressure.
Table 1. Summary Statistics for Sample Banks (1990–1991)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Banks with RBC Ratio &lt; 7.25%</th>
<th>Banks with RBC Ratio &gt; 7.25%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of banks</td>
<td>67</td>
<td>2,503</td>
</tr>
<tr>
<td>Median total assets 1990</td>
<td>$325.4 million</td>
<td>$179.3 million</td>
</tr>
<tr>
<td>Median income-asset ratio 1991</td>
<td>-0.94%</td>
<td>+0.95%</td>
</tr>
<tr>
<td>Capital and Capital Ratios:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Median total capital-risk-weighted asset ratio (CAP/RWA) 1990</td>
<td>6.71%</td>
<td>11.59%</td>
</tr>
<tr>
<td>Median (CAP/RWA) 1991</td>
<td>7.46%</td>
<td>13.00%</td>
</tr>
<tr>
<td>Median % change total capital (CAP)</td>
<td>2.02%</td>
<td>6.61%</td>
</tr>
<tr>
<td>Median % change total assets</td>
<td>-7.26%</td>
<td>4.14%</td>
</tr>
<tr>
<td>Median % change risk-weighted assets (RWA)</td>
<td>-14.84%</td>
<td>-5.35%</td>
</tr>
<tr>
<td>Risk Ratios:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Median risk-weighted assets to total assets 1990</td>
<td>77.11%</td>
<td>69.95%</td>
</tr>
<tr>
<td>Median risk-weighted assets to total assets 1991</td>
<td>72.15%</td>
<td>63.43%</td>
</tr>
</tbody>
</table>

In this study, the results of estimating equations (7) and (8) are presented in Tables 2 and 3. As noted earlier, Table 2 presents the results when RPL and RPG were defined relative to the 7.25% risk-based capital ratio.14 Table 3 shows the results when both the 3.25% Tier 1 capital requirement and the 7.25% total risk-based requirement were introduced into the model; following Hancock and Wilcox (1994), both standards were introduced into the model by using whichever requirement was most binding (see Appendix for details). The simultaneous system formed by equations (7) and (8) was estimated using the 3SLS procedure, which recognizes the endogeneity of both bank capital ratios and risk levels in a simultaneous equations framework. Unlike ordinary least squares (OLS), estimation by 3SLS provides consistent estimates of the parameters. In addition, 3SLS is preferable to two-stage least squares (2SLS) because, unlike 2SLS, 3SLS is a full-information estimation technique which estimates all parameters simultaneously. Thus, because 3SLS incorporates the cross-equation correlations, it produces parameter estimates which are asymptotically more efficient than 2SLS.

As for the results, bank size (SIZE) appears to be inversely related to changes in capital and directly related to changes in risk, while the multibank holding company variable (BH/HC) had a negative and significant impact on changes in capital and risk. The parameter estimates on the lagged capital ratios and risk in Tables 2 and 3 ranged between 0.035 and 0.235, thus implying very slow adjustment of both capital ratios and risk to a bank’s desired levels. The income-asset ratio variable was positive and statistically significant; this result was to be expected, because in equilibrium, riskier banks should have a higher expected income, and to the extent that a higher return was realized, they would tend to have had larger changes in capital. Finally, the results in Table 2 suggest that changes in capital and risk are negatively related, which is consistent with recent work by Gunther and Robinson (1990), McManus and Rosen (1991), and Berger (1995), while the positive parameter estimate on ΔCAP in Table 3 is consistent with Shriev and Duhl (1992). Because these results occurred during a time of changing regulatory requirements, it is

14 One possibility is that, because banks knew the 8% risk-based capital requirement would be effective at the end of 1992, they began adjusting to 8%, instead of 7.25%, in 1990. Estimating equations (7) and (8) using 8% as the threshold did not significantly alter the results.
Table 2. Three-Stage Least Squares Estimates of Total Risk-Based Capital Standard on Portfolio Risk and Bank Capital

<table>
<thead>
<tr>
<th>Variable</th>
<th>$\Delta CAP_c$</th>
<th>$\Delta RISK_c$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>1.935*</td>
<td>-0.388</td>
</tr>
<tr>
<td>SIZE</td>
<td>-0.128**</td>
<td>1.338*</td>
</tr>
<tr>
<td>BHC</td>
<td>-0.382*</td>
<td>-1.145*</td>
</tr>
<tr>
<td>LEVD</td>
<td>1.596*</td>
<td>0.152</td>
</tr>
<tr>
<td>CAP$_{t-1}$</td>
<td>-0.086*</td>
<td>-0.235*</td>
</tr>
<tr>
<td>RISK$_{t-1}$</td>
<td>-</td>
<td>(-18.70)</td>
</tr>
<tr>
<td>$\Delta RISK$</td>
<td>-0.008</td>
<td></td>
</tr>
<tr>
<td>$\Delta CAP$</td>
<td>-</td>
<td>(-0.864*)</td>
</tr>
<tr>
<td>INC</td>
<td>0.263*</td>
<td></td>
</tr>
<tr>
<td>RPL</td>
<td>-7.572*</td>
<td>-1.915</td>
</tr>
<tr>
<td>RPG</td>
<td>44.296*</td>
<td>-67.126*</td>
</tr>
</tbody>
</table>

Number of banks: 2570
System-weighted $R^2$: 0.111

$t$ statistics in parentheses; * indicates significance at the 5% level; ** indicates significance at the 10% level.

difficult to generalize the results to banks during normal times. However, the negative relationship between changes in capital and risk during the first year of the risk-based standards is not surprising because an undercapitalized bank can meet the risk-based requirement by raising capital, reducing portfolio risk, or both, while a bank with a ratio above the risk-based minimum may decrease capital or increase risk.

The primary purpose of this study is to assess what impact the risk-based capital standards had on changes in bank capital ratios and portfolio risk during the first year the standards were in effect. To this question, an examination of the results in Tables 2 and 3 provides some rather surprising insights. First, banks which had capital ratios in excess of the minimum risk-based requirement at the end of 1990, responded to risk-based capital by increasing their capital-asset ratios and reducing their portfolio risk. In both Tables 2 and 3, the parameter estimate on regulatory pressure ($RPG$) in the capital equations was positive and significant, with the coefficient on $RPG$ in Table 2 equal to 44.296. Applying this estimate to the median bank in this group, with a risk-based capital ratio of 11.59% (Table 1), yielded an increase in its total capital to risk-weighted asset ratio of 229 basis points as a result of the risk-based standards.\footnote{This result was derived by noting that:} $RPG = (1/7.25 - 1/11.59) = 0.052$.

Furthermore, the positive parameter
estimate on \( R\text{PG} \) suggests that banks with capital ratios significantly above the risk-based minimum experienced larger increases in their capital ratios than did banks only marginally above the risk-based threshold. This result could reflect either the desire of very-well capitalized banks to maintain a larger buffer stock of capital, or the desire of these banks to signal to both regulators and the market that they not only met, but clearly exceeded, minimum regulatory capital standards. Coupled with the earlier findings in Table 1, these results are consistent with Haubrich and Wachtel (1993) in suggesting that risk-based capital was effective in raising capital ratios among banks which were already in compliance with the minimum risk-based standards at the end of 1990.

In addition, banks with risk-based capital ratios in excess of 7.25% also responded to the new capital standards by significantly decreasing their portfolio risk. The parameter estimate on \( R\text{PG} \) was negative and significant in both risk equations. Using the \( R\text{PG} \) estimate of \( \theta_p = -67.126 \) from Table 2, the median bank reduced its portfolio risk by 3.49 percentage points from its year-end 1990 value of 69.95% as a result of the regulatory pressure brought about by the risk-based standards.\(^{16}\) Furthermore, the negative parameter estimate on \( \theta_p \) suggests that banks with capital ratios significantly above the risk-based capital minimum threshold decreased their level of portfolio risk more than did banks which were only marginally above the risk-based minimum. Coupled with the results in Table 1, these results suggest that the risk-based capital standards were effective in

\(^{16}\) As noted in the previous footnote, \( R\text{PG} \) for the median bank equaled 0.052. Multiplying by the parameter estimate we got: \((0.052 \times -67.126) = -3.49\).
bringing about a reduction in portfolio risk even for those banks which were not constrained.

On the other hand, although the results in Tables 2 and 3 continue to support the significance of risk-based capital, they are less conclusive about the impact of the risk-based standards on constrained banks. While the median constrained bank increased its total capital to risk-weighted asset ratio by 75 basis points, and increased its total capital by 2.02% during 1991 (Table 1), the parameter estimates on RPL in Tables 2 and 3 were either not significantly different from zero or were negative and significant at the 5% level.\(^{17}\) In fact, the parameter estimate on RPL in the capital equation in Table 2 equaled \(-7.572\) and was significant at the 5% level. However, this result is not inconsistent with either the summary statistics in Table 1 or the notion that risk-based capital had an impact on undercapitalized banks. Rather, it suggests that banks with capital ratios slightly below the risk-based minimum experienced relatively large increases in their capital ratio, either by raising capital or reducing risk-weighted assets, while those banks most severely undercapitalized experienced relatively small increases. One possible explanation for this is that because constrained banks had a median return on assets (ROA) of \(-0.94\%\) in 1991, and because raising capital from external sources is costly, severely constrained banks may have been extremely limited in their ability to meet the risk-based standards by raising capital, while mildly constrained banks may have been more successful. Rather, the increase in the capital ratio, and the reduction in portfolio risk, for constrained banks appears to be explained by a decrease in total assets, which may itself be a function of the risk-based standards. This is not surprising because banks which cannot raise sufficient external capital will respond to the risk-based standards by reducing assets or reconfiguring their portfolio toward lower risk-weighted assets. An examination of Table 1 shows that the median constrained bank decreased total assets by 7.26% and total risk-weighted assets by 14.84% during 1991, thus reducing portfolio risk by shifting the composition of their portfolios toward lower risk-weighted assets. This is consistent with recent findings by Laderman (1994) that bank holding companies which were deficient in risk-based capital, decreased asset growth rather than issue new common stock, because issuing new stock would have resulted in negative wealth effects for shareholders.

VII. Conclusion

This study has examined the impact of the risk-based capital standards during the first year they were in effect. Modifying the 3SLS model developed by Shrieves and Dahl (1992), the results suggest that the risk-based capital standards brought about significant increases in capital ratios and decreases in portfolio risk of banks which already met the new risk-based standards. Risk-based capital-constrained banks also experienced increases in their capital ratios, and reductions in portfolio risk, and although the results suggest that the risk-based capital standards played a significant role, their responses showed surprisingly little connection to the degree to which they fell short of the standards. Clearly, more research is needed to further examine how the degree of capital deficiency influenced their decision to alter the size and risk of their portfolio of assets.

\(^{17}\) One possibility is that the parameter estimates on RPL in the equations were insignificant due to multicollinearity. An examination of regressions which excluded selected explanatory variables found no evidence of this.
Appendix

Table 3 shows the results for equations (7) and (8) when both the minimum Tier 1 and total (Tier 1 + Tier 2) risk-based capital were introduced into the model. Incorporating both standards separately introduced significant multicollinearity problems. To reduce this problem, we followed the technique of Hancock and Wilcox (1994) in using the most-binding capital standard. Here $RBC_j$ and $Tier1_j$ are bank $j$'s total risk-based capital and Tier 1 ratios, respectively. Thus $RPL$:

$$
= 0 \text{ if a bank met both the 3.25 Tier 1 and the 7.25 total standard;}
= (1/RBC_j - 1/7.25) \text{ if a bank met the 3.25 Tier 1 ratio but failed the 7.25 standard;}
= (1/Tier1_j - 1/3.25) \text{ if a bank met the 7.25 standard but failed the 3.25 standard;}
= \text{whichever value was greater if a bank failed both standards.}
$$

This allows banks to be constrained by whichever standard is most binding. In a similar manner, $RPG$ measures the least excess capital. Thus, $RPG$:

$$
= 0 \text{ if a bank failed either the 3.25 Tier 1 or the 7.25 total standard.}
$$

If a bank met both the Tier 1 standard and the 7.25 total standard, then $RPG$:

$$
= (1/7.25 - 1/RBC_j) \text{ if a bank met the 3.25 Tier 1 ratio by more than it met the 7.25 standard;}
= (1/3.25 - 1/Tier1_j) \text{ if a bank met the 7.25 standard by more than it met the 3.25 standard.}
$$

In this case, the regulatory pressure was measured using whichever capital ratio was closest to a regulatory minimum.

References


