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

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Abstract: This paper examines the impact the recently implemented risk-based standards have had on both bank capital and portfolio risk. To date, little if any attention has focused on how the risk-based capital standards have impacted bank risk and capital levels. Building on previous research, this paper uses 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 had a significant impact on capital and risk levels in well-capitalized banks, but little impact on undercapitalized banks.

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I. Introduction

Throughout the 1970s, the capital position of many banking institutions declined significantly. To address this decline, in December 1981, the bank regulators issued explicit minimum capital standards for banks and bank holding companies. These standards required banks to hold capital at least equal in amount to a fixed percentage of their assets. While these standards have been given credit for increasing bank capital ratios, the 1980s saw an increase in both the number and cost of bank failures. A weakness of the minimum capital standards is that they failed to take into account the risk in a bank's portfolio of assets; high-risk assets required the same amount of capital as low-risk assets.

In July 1988, the bank regulators, as part of the international Basle Committee on Banking Regulation and Supervisory Practices, announced the adoption of the risk-based capital standards.[1] The purpose of the risk-based standards was to make bank capital requirements sensitive to the risk in a bank's portfolio of assets and off-balance sheet activities. To date, the risk-based capital standards appear to have been at least partially effective in increasing bank capital ratios. Since 1991, the equity-asset ratio for all commercial banks increased from 6.75 percent to 8.01 percent in 1993, while the risk-based capital ratio increased from 10.67 percent to 13.17 percent over the same period.

Although adoption of the risk-based standards has focused attention on capital levels, little if any attention has been given to the corresponding level of risk in bank portfolios and how the adoption of the risk-based capital standards may have impacted bank risk levels. To date, some theoretical and empirical research suggests that increasing regulatory capital standards

[1] For a discussion of the history of capital standards, see Alfriend (1988).

might cause banks to increase, rather than decrease, portfolio risk. Furthermore, higher bank capital levels do not, by themselves, guarantee that banks are adequately capitalized. From a public policy perspective, what is important is the amount of capital a bank holds relative to its level of risk.

This paper contributes to the literature by examining the impact that the recently implemented risk-based standards have had on not only bank capital, but also portfolio risk. Modifying recent work by Shrieves 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 that 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 relationship between bank capital levels and portfolio risk. For example, using the mean-variance framework, Kahane (1977), Koehn and Santomero (1980), and Kim and Santomero (1988), have shown that regulatory capital standards may have the unintended effect of causing utility maximizing banks to engage in increasingly risky behavior. In contrast, Furlong and Keeley (1989) and Keeley and Furlong (1990), argue that the mean-variance approach is inappropriate because it ignores the effect of deposit insurance. Using a contingent-claims model, their results suggest that increased capital standards will not cause banks to increase portfolio risk. But Gennottee and Pyle (1991) find that even if the impact of deposit insurance

is accounted for, increased stringency in capital standards may lead banks to incur greater portfolio risk if the bank is not restricted to zero net present value investments.

With regard to risk-based capital regulation, Kim and Santomero (1988) and Kendall and Levonian (1992) have examined how the design of risk-based capital standards influences bank risk taking. The results of Kendall and Levonian are particularly interesting, because they find that a risk-based rule designed to minimize the probability of bank failure will lead banks to choose high-risk assets. Recent empirical work by Haubrich and Wachtel (1993) suggests that implementation of the Basle risk-based capital standards caused significant changes in the composition of bank portfolios, but does not address the impact of these changes on overall portfolio risk.

III. Risk-Based Capital Standards

In July 1988, the Basle Committee on Banking Regulation and Supervisory Practices, composed of representatives from 12 major industrialized countries, approved the adoption of a risk-based capital standard for banks in members' respective countries.[2] Prior to the implementation of the risk-based standards, U.S. banks were subject to a requirement that they hold a minimum fixed percentage of their assets in the form of capital, regardless of the level of risk in their portfolio.

Beginning on December 31, 1990, the risk-based capital standards supplemented the existing capital requirement. The primary purpose of the risk-based standards was to require

[2] These countries are Belgium, Canada, France, Germany, Italy, Japan, Luxemborg, the Netherlands, Sweden, Switzerland, the United Kingdom, and the United States.

banks to hold capital in accordance with the perceived credit risk in their portfolio. As such, the risk-based standards link capital to risk by assigning risk weights to broad categories of assets. Currently, the risk-based standards contain four risk-weight categories: 0 percent, 20 percent, 50 percent, and 100 percent. Low credit risk assets, such as cash and U.S. government securities, are considered to have no default risk and are assigned to the 0 percent risk category. At the other extreme, higher credit risk assets such as commercial loans, are assigned to the 100 percent risk weight category. Having assigned individual assets to the appropriate risk-weight category, the bank computes its total risk-adjusted assets by summing its risk-weighted assets (the dollar volume of each asset multiplied by the corresponding risk weight).[3] As a final step, capital must be held as a percentage of the total risk-weighted assets. Effective December 31, 1990, banks were required to hold a minimum 7.25 percent of their risk-weighted assets in the form of capital; beginning at the end of 1992, the minimum risk-based standard increased to 8 percent. Other things being equal, the greater the credit risk in a bank's portfolio, the greater the total risk-weighted assets, and the greater the level of capital that the bank must hold against its portfolio.

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

[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. The on-balance sheet exposure is then multiplied by the corresponding risk weight and added to the bank's total risk-weighted assets.

additional risk. This implies that the risk-based capital standards should explicitly link changes in required bank capital with changes in portfolio 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. As Benston (1991) notes, the risk-based standards do not explicitly incorporate capital charges tied to interest rate risk.[4] Thus, a capital-deficient bank can meet the minimum risk-based standards 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. By substituting assets in this manner, a bank's portfolio risk may actually increase while the dollars of capital required under the risk-based standards will decrease.

In addition, as Keeton (1989), Avery and Berger (1991), and Kaufman (1991) observe, 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 that 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 the actual risk of the asset is provided by Bradley, Wambeke, and Whidbee (1991) and Avery and Berger (1991). Furthermore, by ignoring the variance-covariance relationship between assets, the risk-based capital standards

[4] Section 305 of the FDIC Improvement Act (FDICIA) of 1991 requires the bank regulators to revise their risk-based capital standards to incorporate other types of risk such as interest rate risk. On September 14, 1993, the OCC, the FDIC, and the FRB published a joint Notice of Proposed Rule Making in the *Federal Register* that would introduce interest rate risk into the risk-based capital standards.

may not accurately differentiate between changes in asset composition that hedge portfolio risk and those that 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 credit risk in a bank's portfolio. In fact, as discussed above, 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. Recent empirical work by Shrieves and Dahl (1992) finds that bank capital levels and portfolio risk are simultaneously and positively related: increases in capital standards lead to increasing levels of portfolio risk, and increases in portfolio risk lead to increases in bank capital levels. In general, a positive correlation between portfolio risk and capital may occur when leverage and portfolio risk are substitutes while a negative correlation may result from the mispricing of deposit insurance. Our interest is not only in how portfolio risk and capital may be related, but also what impact the risk-based capital standards may have had on them.

To examine these issues, the simultaneous equation model developed by Shrieves and Dahl (1992) is modified to incorporate the risk-based capital standards. In the Shrieves 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:

(1) $\Delta CAP_{j,t} = \Delta^{d}CAP_{j,t} + E_{j,t}$

(2) $\Delta RISK_{j,t} = \Delta^{d}RISK_{j,t} + S_{j,t}$

where $\Delta CAP_{j,t}$ and $\Delta RISK_{j,t}$ are the observed changes in capital and risk levels, respectively, for bank j in period t. $\Delta^{d}CAP_{j,t}$ and $\Delta^{d}RISK_{j,t}$ represent the 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, Shrieves and Dahl model the discretionary changes in capital and risk using the partial adjustment framework such that:

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

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

where $CAP^{*}_{j,t}$ and $RISK^{*}_{j,t}$ 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 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:

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

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

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. Examples of factors exogenous to the bank that could influence capital or risk levels include changes in regulatory capital standards or macroeconomic conditions.

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

$$(7) \quad \Delta CAP_{j,t} = \Gamma_0 + \Gamma_1 SIZE_{j,t} + \Gamma_2 BHC_{j,t} + \Gamma_3 LEVD_{j,t} + \Gamma_4 \Delta RISK_{j,t} + \Gamma_5 INC_{j,t} + \Gamma_6 DEP_{j,t} - \Gamma_7 CAP_{j,t-1} + \Gamma_8 RPG_{j,t} + \Gamma_9 RPL_{j,t} + \mu_{j,t}$$

$$(8) \quad \Delta RISK_{j,t} = \theta_0 + \theta_1 SIZE_{j,t} + \theta_2 BHC_{j,t} + \theta_3 LEVD_{j,t} + \theta_4 \Delta CAP_{j,t} + \theta_5 DEP_{j,t} - \theta_6 RISK_{j,t-1} + \theta_7 RPG_{j,t} + \theta_8 RPL_{j,t} + \omega_{j,t}$$

where $\mu_{j,t}$ and $\omega_{j,t}$ are disturbance terms. In this study, changes in capital and risk are influenced by a number of explanatory variables including: the size of the bank (SIZE), whether the bank is affliated with a multibank holding company (BHC), changes in risk ($\Delta RISK_{j,t}$) and capital ($\Delta CAP_{j,t}$), lagged levels of capital (CAP_{t-1}) and risk ($RISK_{t-1}$), and the degree of regulatory pressure. These variables are taken from Shrieves and Dahl (1992), where SIZE is measured as the natural log of a bank's total assets and BHC is a dummy variable that equals unity for banks belonging to a multibank holding company. $\Delta RISK_{j,t}$ and $\Delta CAP_{j,t}$ are included to recognize the possible simultaneous relationship between changes in capital and changes in risk. In addition, the ratio of income to total assets (INC) in period t-1 is taken from Dahl and Shrieves (1990) as a proxy for profitability in period t and the change

in the deposit to asset ratio (DEP) is used to measure the impact of changes in deposits on capital and risk.

The leverage ratio is also included as a variable to explain changes in capital and risk. As Baer and McElravey (1993a) note, concurrent with the adoption of the risk-based capital standards came changes in the calculation of the leverage ratio. Specifically, U.S. banks with a CAMEL rating of 1 were required to hold a minimum of 3 percent of their balance sheet assets in the form of Tier 1 capital.[5] 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 to 200 basis points above the minimum. Thus, a dummy variable for banks with less than a 5 percent leverage ratio (LEVD) is included, because if a bank is constrained by the leverage ratio, it would be expected to increase its total capital-asset ratio, independent of the risk-based standards.[6]

Empirical estimation of equations (7) and (8) requires measures of both bank capital and portfolio risk. Following previous research, capital was measured as the ratio of equity capital to total assets. Measurement of portfolio risk is more difficult, and the literature on risk measurement suggests a number of different ways, all of which are subject to some criticism. Avery and Berger (1991), McManus and Rosen (1991), and Berger (1992), use total risk-weighted assets as a percentage of total assets (RWARAT) in measuring portfolio risk. Avery

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[5] Tier 1 capital is comprised mainly of common stockholders equity, but also includes noncumulative perpetual preferred stock and minority interest in consolidated subsidiaries less goodwill.

[6] Baer and McElravey (1993a) argue that bank holding companies behave as if the minimum leverage ratio is 7 percent. Specifying LEVD using 7 percent as the threshold leverage ratio did not alter the results of this study.

and Berger have shown that this ratio correlates with risky behavior while McManus and Rosen argue that it is superior to nonperforming loans, which reflect the ex-post outcome of lending decisions. Other studies, such as those by Berger (1992), Berger and Udell (1992), and Shrieves and Dahl (1992), use nonperforming loans, because that measure is less subject to criticisms of being a lagging indicator than are other measures, such as net charge-offs. Thus, nonperforming loans as a percentage of total assets, NONP, is used as an alternative measure of portfolio risk.

Of particular interest in this study are the regulatory pressure variables, RPG and RPL. Previous studies have tended to use a dummy variable to signify the degree of regulatory pressure a bank is under. Unfortunately, this definition of regulatory pressure implicitly assumes that there is no response from banks above the minimum regulatory capital standards. Other authors, such as Peltzman (1970), Mingo (1975), Dietrich and James (1983), and McManus and Rosen (1991), use ratios involving a bank's capital level and the regulatory minimum standards as a way of calculating the degree of regulatory pressure. These methods allow banks above the minimum regulatory standards to respond and have the added benefit of recognizing the nonlinear relationship between the regulatory capital standards and either portfolio risk or changes in capital ratios.

In this paper, RPG and RPL signal the degree of regulatory pressure brought about by the risk-based capital standards. In order to recognize the nonlinear relationship between regulatory standards and the dependent variables, the regulatory pressure variable is defined as the difference between the inverse of bank j's risk-based capital ratio (RBC_j) and the inverse of

the regulatory minimum risk-based ratio of 7.25 percent.[7] Because banks with risk-based capital ratios above and below the 7.25 percent threshold may react to the standards differently, this study partitions the regulatory pressure variable into two variables, RPG and RPL. RPL equals $(1/RBC_j - 1/7.25)$ for all banks whose risk-based capital ratio is less than 7.25 percent and 0 for all banks with risk-based ratios above the minimum. These banks are under considerable regulatory pressure to increase their capital ratios since they did not meet the minimum risk-based capital standard at the end of 1990. Therefore, RPL should have a positive effect on capital ($\Gamma_9 > 0$) or a negative effect on portfolio risk ($\theta_8 < 0$), because banks can meet the minimum risk-based standards by either raising capital or reducing risk-weighted assets.[8]

A second regulatory pressure variable, RPG, equals $(1/RBC_j - 1/7.25)$ for all banks whose risk-based ratio is greater than or equal to 7.25 percent, 0 otherwise. While banks with risk-based capital ratios in excess of 7.25 percent were not explicitly capital constrained, implementation of the risk-based standards may have significantly affected their level of capital

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[7] Following previous authors, this definition of regulatory pressure recognizes the nonlinear relationship between regulatory standards and portfolio risk or capital. To see this note that:

$\partial \Delta CAP_t / \partial RBC_j = -\Gamma / RBC_j^2$

$\partial \Delta RISK_t / \partial RBC_j = -\theta / RBC_j^2$.

Thus, using $(1/RBC_j - 1/7.25)$ permits a nonlinear response in capital, as shown by Mingo (1975) and Dietrich and James (1983), and a nonlinear response in risk, as shown by McManus and Rosen (1991).

[8] For banks with risk-based capital ratios less than 7.25, $(1/RBC_j - 1/7.25)$ is positive. Therefore a positive value of Γ_9 and θ_8 implies an increase in the capital ratio and portfolio risk. Similarly, a negative value implies a decrease in these variables.

or portfolio risk. Since these banks already meet the minimum risk-based standards, they may choose to reduce capital ($\Gamma_8 > 0$) or increase their level of portfolio risk ($\theta_7 < 0$).[9] Alternatively, as Hancock and Wilcox (1992), Furlong (1992), and Baer and McElravey (1993b) note, banks may increase their capital position as a buffer against shocks to equity.[10] Because banks must meet the risk-based capital standards on a continuous basis, implementation of the risk-based standards may cause these banks to increase their capital ($\Gamma_8 < 0$) or reduce risk ($\theta_7 > 0$) as insulation against any uncertainty regarding whether the bank meets the regulatory minimum.

The partitioned definition of regulatory pressure has two advantages over those used in previous research. First, unlike many previous studies, this specification of regulatory pressure allows banks that are not explicitly capital deficient to also respond to the introduction of new regulatory standards. Second, partitioning the data set by whether or not a bank meets the minimum risk-based threshold allows banks that are undercapitalized to respond differently than those banks that are not explicitly undercapitalized. Previous models have tended to assume there is no regulatory response by well-capitalized banks or that their response is the same as that of undercapitalized institutions.

VI. Data and Empirical Estimation

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[9] For banks with risk-based capital ratios greater than 7.25 percent, ($1/RBC_j$ - 1/7.25) is negative. Therefore, positive estimates of Γ_8 and θ_7 imply a decrease in capital and portfolio risk, respectively. Negative parameter estimates imply increases in capital and risk.

[10] There are other reasons why banks may choose to hold capital above the regulatory minimum. For example, Buser, Chen, and Kane (1981) discuss regulatory costs as a motive while Orgler and Taggart (1983) discuss tax considerations.

Effective December 31, 1990, banks were required to hold 7.25 percent of their risk-weighted assets in the form of capital. This study covers the first year the risk-based capital standards were in effect (1991), using call report data on 2,570 FDIC-insured commercial banks with assets greater than $100 million, from year end 1990 (period t-1) and year end 1991 (period t). The model is estimated using the 3SLS procedure, which recognizes the endogeneity of both bank capital ratios and risk levels in a simultaneous equation framework. Unlike ordinary least squares, the 3SLS technique provides consistent estimates of the parameters.

The results of estimating equations (7) and (8), using the various measures of portfolio risk, are presented in Tables 1 and 2.[11] The size of the bank (SIZE) appears to significantly increase both capital and risk levels, whereas the multibank holding company variable (BHC) was found to have a negative and signficant impact on risk. The parameter estimates on the lagged levels of capital and risk in Tables 1 and 2 range between 0.248 and 0.305, thus implying slow adjustment of both capital and risk to a bank's desired levels. The income-asset ratio variable yielded mixed results, and the negative coefficient on DEP suggests that banks with more stable deposit bases tended to hold less capital. Finally, the results suggest

Table 1

Three-Stage Least Squares Estimates of Risk-Based Capital
on Portfolio Risk (RWARAT) and Bank Capital

[11] One possibility is that since banks knew the 8 percent risk-based capital requirement would be effective at the end of 1992, they began adjusting to 8 percent, instead of 7.25 percent, in 1990. Estimates of equations (7) and (8) using 8 percent as the threshold are contained in Appendices 1 and 2.

Variable	ΔCAP_t	$\Delta RWARAT_t$
INTERCEPT	-2.285*	-1.602
	(-2.59)	(-0.67)
SIZE	0.260*	1.563*
	(4.03)	(9.92)
BHC	-0.113	-0.823*
	(-0.74)	(-1.96)
LEVD	0.319	-0.692
	(1.22)	(-0.96)
CAP_{t-1}	-0.296*	------
	(-11.21)	
$RWARAT_{t-1}$	------	-0.251*
		(-16.59)
ΔRWARAT	-0.115*	------
	(-5.03)	
ΔCAP	------	-0.911*
		(-3.66)
INC	-0.012	------
	(-0.23)	
DEP	-0.096*	-0.144*
	(-6.87)	(-3.32)
RPL	-1.364	3.987
	(-0.58)	(0.61)
RPG	-17.685*	104.308*
	(-5.11)	(10.60)

Number of banks:	2,570
System weighted R^2	0.108

t-statistics in parentheses; * indicates significance at the 5 percent level; ** indicates significance at the 10 percent level.

Table 2

Three-Stage Least Squares Estimates of Risk-Based Capital
on Portfolio Risk (NONP) and Bank Capital

Variable	ΔCAP_t	$\Delta NONP_t$
INTERCEPT	0.300	0.821*
	(0.42)	(2.45)
SIZE	0.096**	0.046**
	(1.79)	(1.82)
BHC	-0.061	-0.245*
	(-0.41)	(-3.60)
LEVD	0.089	-0.005
	(0.36)	(-0.05)
CAP_{t-1}	-0.248*	------
	(-10.52)	
$NONP_{t-1}$	------	-0.305*
		(-15.96)
$\Delta NONP$	-0.254**	------
	(-1.69)	
ΔCAP	------	-0.180*
		(-4.20)
INC	0.119**	------
	(1.77)	
DEP	-0.077*	0.015*
	(-5.59)	(2.08)
RPL	-1.706	1.936**
	(-0.76)	(1.82)
RPG	-10.550*	13.148*
	(-2.88)	(10.24)

Number of banks:	2,570
System weighted R^2	0.103

t-statistics in parentheses; * indicates significance at the 5 percent level; ** indicates significance at the 10 percent level.

Table 3

Summary Statistics for Sample Banks
(1990 - 1991)

Variable	Banks with RBC ratio < 7.25%	Banks with RBC ratio > = 7.25%
Number of banks	67	2,503
Median RBC ratio 1990	6.71%	11.59%
Median income-asset ratio 1991	-0.94%	+ 0.95%
Equity and Assets		
Median equity-asset ratio (K/TA) 1990	3.68%	7.41%
Median (K/TA) 1991	4.18%	7.47%
Median change 1990-91	+ 0.50	+ 0.06
% change equity capital	2.02%	6.61%
% change total assets(TA)	-7.26%	4.14%
% change risk-weighted assets(RWA)	-14.84%	-5.35%
Risk ratios		
Median (RWA/TA) 1990	77.11%	69.95%
Median (RWA/TA) 1991	72.15%	63.43%
Median change (RWA/TA)	-4.96	-6.52
Median nonperforming loans-total assets (NONP) 1990	4.27%	0.82%
Median NONP 1991	4.05%	0.85%
Median change NONP	-0.22	+ 0.03

that changes in risk and changes in capital are negatively related. Changes in risk have a negative impact on changes in capital when risk is measured using RWARAT (-0.115 in Table 1) and NONP (-0.254 in Table 2). In addition, changes in capital have a negative influence on risk in both risk equations (-0.911 in Table 1 and -0.180 in Table 2). Consistent with previous research, this result suggests that banks may have exploited the mispricing of deposit insurance.

Of primary interest in this study is what impact the risk-based capital standards had on changes in bank capital and portfolio risk. An examination of the capital and risk equations in Tables 1 and 2 suggests some rather surprising results. First, banks that were not explicitly constrained by risk-based capital responded to implementation of the standards by increasing their capital-asset ratios and reducing their portfolio risk. To see this, note that the parameter estimate for regulatory pressure (RPG) is significant in both Tables 1 and 2 and equals -17.685 using RWARAT (Table 1) as the measure of risk. For the median bank in this group, with a risk-based capital ratio of 11.59 percent (Table 3), this equals an increase in its capital-asset ratio by 92.0 basis points as a result of the risk-based standards.[12] Coupled with an increase in median bank equity capital of 6.61 percent (Table 3), these findings suggest that risk-based capital was effective in raising capital and is consistent with the theory that well-capitalized banks increased capital to provide a buffer against shocks to equity.

In addition, banks with risk-based capital in excess of 7.25 percent responded to the new

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[12]This result is derived by noting that:

$$RPG = (1/11.59 - 1/7.25) = -0.052.$$

Multiplying this estimate by -17.685 (Γ_8) equals 0.920, or 92 basis points.

capital standards by significantly decreasing their level of portfolio risk. The parameter estimate on RPG is positive and significant in both risk equations. Using θ_7 = 104.308 from Table 1, the median bank reduced its portfolio risk by 5.42 percentage points (-0.052 * 104.308) from its year-end 1990 value of 69.95 percent. This result suggests that regulatory pressure led to a reduction in portfolio risk even for banks that were not capital constrained.

On the other hand, the results in Tables 1 and 2 suggest that banks that were explicitly constrained by the risk-based standards did not significantly increase their equity-asset ratios in response to implementation of the risk-based capital standards. While the median constrained bank raised its equity-asset ratio by 50 basis points during this period (Table 3), the parameter estimates on RPL in Tables 1 and 2 are not significantly different from zero.[13] Given that these banks had a median return on assets of -0.94 percent in 1991, and that raising capital from external sources is costly, constrained banks may have been extremely limited in their ability to meet the risk-based standards by raising capital.[14] Rather, the increase in the equity-asset ratios for constrained banks appears to be explained by a decrease in total assets and portfolio risk. An examination of Table 3 shows that the median bank in this group decreased total assets by 7.26 percent and total risk-weighted assets by 14.84 percent, thereby shifting the composition of their portfolios toward lower risk-weighted assets. This result is confirmed by noting that the parameter estimate on ΔRWARAT equals -0.115 (Table 1) and is significant at

[13] One possibility is that the parameter estimates on RPL in the capital and risk equations are insignificant due to multicollinearity. An examination of regressions that excluded selected explanatory variables and correlation coefficients between variables found no evidence that RPL was insignificant due to multicollinearity.

[14] Baer and McElravey (1993b) show that raising capital from external sources is very costly for banks with deteriorating capital positions.

the 5 percent level. Multiplying this estimate by the change in RWARAT (-4.96) for the median constrained bank results in an increase in the equity-asset ratio equal to 57.0 basis points. Thus, the increase in capitalization of constrained banks appears to be the direct result of changes in the size and composition of bank portfolios, and not the introduction of the risk-based capital standards.

Although it appears that implementation of the risk-based standards had no direct effect on the capital levels of constrained banks, it is possible that the risk-based standards indirectly affected capital ratios by causing a reduction in portfolio risk. However, the results of the portfolio risk equations are mixed. The parameter estimate on the regulatory pressure variable (RPL) in the risk equations is not significant using RWARAT as a measure of risk but is significant when NONP is utilized as the risk measure. The parameter estimate of 1.936 on RPL in Table 2 is significant at the 10 percent level, but of the wrong sign. For the median constrained bank, with risk-based capital of 6.71 percent, this result suggests an increase in NONP of 0.02 percentage points (0.011 * 1.936).[15] While extremely small, this result implies that implementation of the risk-based capital standards may have had the unintended result of increasing, rather than decreasing, portfolio risk.

VII. Conclusion

This study examines the impact of the risk-based capital standards during the first year of implementation. Modifying the 3SLS model developed by Shrieves and Dahl (1992), the

[15] Here, RPL = (1/6.71 - 1/7.25) = 0.011.

results suggest that the risk-based capital standards brought about significant increases in capital and decreases in portfolio risk of well-capitalized banks. Risk-based capital constrained banks also showed increases in the equity-asset ratio, but these increases appear to be primarily the result of decreasing portfolio risk and a reduction in total assets. Finally, while the overall level of portfolio risk in constrained banks decreased, implementation of the risk-based standards appears to have had little effect on the portfolio risk of these banks.

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Appendix 1

Three-Stage Least Squares With Minimum RBC at 8%

Variable	ΔCAP_t	$\Delta RWARAT$
Intercept	-2.044*	-2.630
	(-2.35)	(-1.12)
SIZE	0.258*	1.561*
	(4.00)	(9.85)
BHC	-0.109	-0.859*
	(-0.71)	(-2.03)
LEVD	0.254	-0.219
	(0.98)	(-0.31)
CAP_{t-1}	-0.298*	------
	(-11.19)	
$RWARAT_{t-1}$	------	-0.252*
		(-16.58)
$\Delta RWARAT$	-0.114*	------
	(-4.99)	
ΔCAP	------	-0.955*
		(-3.80)
INC	0.003	------
	(0.061)	
DEP	-0.095*	-0.149*
	(-6.84)	(-3.41)
RPL	-1.624	4.764
	(-0.70)	(0.73)
RPG	-17.955*	108.241*
	(-5.04)	(10.65)

Number of banks:	2,570
System weighted R^2	0.109

t-statistics in parentheses; * indicates significance at the 5 percent level; ** indicates significance at the 10 percent level.

Appendix 2

Three-Stage Least Squares Estimates With Minimum RBC at 8%

Variable	ΔCAP_t	$\Delta NONP$
Intercept	0.423	0.629**
	(0.60)	(1.91)
Size	0.097**	0.047**
	(1.79)	(1.87)
BHC	-0.060	-0.246*
	(-0.40)	(-3.62)
LEVD	0.057	0.048
	(0.23)	(0.43)
CAP_{t-1}	-0.249*	------
	(-10.50)	
$NONP_{t-1}$	------	-0.302*
		(-15.86)
$\Delta NONP$	-0.257**	------
	(-1.70)	
ΔCAP	------	-0.174*
		(-4.05)
INC	0.129**	------
	(1.91)	
DEP	-0.076*	0.015*
	(-5.57)	(2.14)
RPL	-1.765	2.342*
	(-0.80)	(2.23)
RPG	-10.785*	12.946*
	(-2.88)	(9.87)
Number of banks:	2,570	
System weighted R^2	0.102	

t-statistics in parentheses; * indicates significance at the 5 percent level; ** indicates significance at the 10 percent level.