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Adjustment costs, errors in risk weights, and banks' balance sheets: the 1988 Basel Accord revisited

Abstract

Following implementation of the 1988 Basel Accord, U.S. banks altered their balance sheets in a variety of different ways including reallocating assets, reducing lending, and increasing capital. While much of the existing empirical research recognizes that fact, it fails to answer the question of why. In the context of a profit-maximization model that recognizes both non-homogeneous adjustment costs and errors in risk weights, this paper examines the question of why different banks exhibited different responses to implementation of the 1988 Accord. The results suggest that banks with different loan and capital adjustment costs exhibited very different responses to implementation of the 1988 Accord. Furthermore, errors in calibrating the risk weights played a significant role in banks' balance sheet changes. The results are sufficiently robust to explain the sometimes contradictory findings of other researchers.

Keywords: Basel Accord, risk-based capital, adjustment costs.
JEL Classification: G21, G28.

Introduction

In the late 1980s, the international Basel Committee on Banking Regulation and Supervisory Practices adopted risk-based capital standards for banks in members' respective countries. Also known as the Basel Accord, the risk-based capital standards served a number of purposes including making regulatory capital requirements more responsive to the credit risk in banks' portfolios of assets and off-balance sheet activities. To accomplish this goal, the risk-based capital standards explicitly linked regulatory capital requirements to risk by classifying banks' assets into one of four broad categories based primarily on credit risk[1].

In the United States, the years following the implementation of the Basel Accord witnessed unusual shifts in the composition of banks' balance sheets, a period often referred to as the credit crunch. Prior to the implementation of the risk-based standards, banks routinely held commercial and industrial loans in excess of their holdings of government securities. But in the three-year period following implementation of the Accord, banks' holdings of U.S. government securities rose by approximately 60% while holdings of commercial and industrial loans declined by over 8%.

Studies of the unusual behavior in banks' asset allocation in the 1990s have reached mixed conclusions. Some of the early research focused on a variety of possible causes including demand factors (Bernanke and Lown, 1991), more stringent supervision by bank regulators (Syron, 1991) and a secular decline in lending (Berger and Udell, 1994). Alternatively, a central focus of much of the existing research has been on the role of the risk-based capital standards, and Jackson et al. (1999) conclude that the existing research reaches a variety of conclusions concerning how banks responded to the risk-based standards. For example, Thakor (1996) and Furfine (2001) conclude that the standards resulted in banks decreasing lending, while Haubrich and Wachtel (1993) and Jacques and Nigro (1997) found that the risk-based capital standards resulted in banks shifting their portfolios from high risk-weighted assets to low risk-weighted assets. But the Haubrich and Wachtel and Jacques and Nigro results differ in that the former conclude that banks increased total assets and raised capital while the latter find that severely undercapitalized banks responded primarily by reducing total assets with less emphasis on raising capital. In contrast, Hancock and Wilcox (1994) found that undercapitalized banks shifted their portfolios in the opposite direction, decreasing government securities and increasing commercial loans.

In part, the mixed results may occur because, as discussed by Passmore and Sharpe (1994), much of the existing research is not derived from theoretical models of bank behavior. Rather, the existing research treats bank capital as exogenous, an assumption that is clearly inconsistent with the stylized fact that many banks altered their capital levels following implementation of the Accord.

For banks seeking to improve their risk-based capital ratios, Keeton (1989) and Haubrich and Wachtel (1993) note a number of different approaches banks can undertake. As has been discussed extensively in the existing literature, one possible response for banks is to alter the relative composition of their assets. Viewing the risk-based standards as a regulatory tax that places a higher tax rate on commercial loans than government securities

[1] The risk-weight categories are: 0% for assets that are considered to have no default risk, such as U.S. Treasury securities; 20% for low credit risk assets; 50% for assets with moderate credit risk; and, 100% for high credit risk assets such as commercial loans. Under the risk-based capital standards, banks were required to hold total capital equal to at least 8% of the total risk-weighted assets where total risk-weighted assets are defined as the summation of each asset multiplied by its corresponding risk weight.

(Berger and Udell, 1994), banks can increase their risk-based capital ratios by substituting 0% risk-weight assets, such as government securities, for 8% risk-weight assets, such as commercial loans. The benefit of such a strategy is that it allows banks to continue to increase their total assets while simultaneously helping them meet the 8% risk-based capital requirement.

A second possible response for banks is to shrink their total assets. While the benefits to reducing loans as a means of increasing capital ratios are well known, the benefit for reducing securities appears negligible as government securities, given their 0% risk weight, do nothing to alleviate regulatory capital pressures. But if banks incur increasing marginal costs for adjusting balance sheets items such as commercial loans or capital, then the profit-maximizing solution to implementation of a new regulatory capital standard may include a decrease in not only commercial loans, but also securities.

Finally, a third option for banks would be to raise capital. The benefit of raising capital is that it allows banks to meet the regulatory capital requirements, and signals to both regulators and the market that the banks are in compliance with regulatory capital requirements (Jacques and Nigro, 1997), while maintaining their existing asset portfolios.

Complicating the response of banks to implementation of the Basel Accord, the risk weights used in the risk-based standards are blunt instruments, as all commercial loans, irrespective of the credit quality of the borrowing entity, are assigned the same 8% risk weight. Although not thought of as a traditional form of regulatory capital arbitrage, the fact that the risk weights on commercial loans may deviate from the economically optimal capital requirement (Avery and Berger, 1991) creates an incentive for banks to adjust their assets.

While theory suggests a number of possible responses by banks to implementation of the risk-based standards, the stylized facts from the early 1990s reveal that U.S. banks exhibited diverse responses. And while much of the existing empirical research recognizes that fact, it fails to answer the question of why. One possible explanation is that banks faced different costs of adjusting their balance sheets.

The purpose of this paper is to develop a model that recognizes the role of adjustment costs in bank asset allocation following implementation of the 1988 Basel Accord. Jackson et al. (1999) address the importance of adjustment costs in the divergence of banks' responses when they state, "On balance, it seems reasonable to conclude that banks attempt to respond in the least costly way to binding capital constraints". While there are benefits to be achieved by reallocating assets or increasing capital, there are also costs to be incurred for such adjustments. That tradeoff is further complicated by arbitrage opportunities that reflect the difference between the regulatory capital requirement on an asset and its economic capital requirement. Our paper contributes to the research in that our model allows different banks, facing different adjustment costs, to have different responses to implementation of the 1988 Accord. In that sense, loan adjustment costs are particularly important as most existing research suggests that commercial loans were the focal point of bank asset adjustments to the 1988 Accord. Furthermore, in the sense of VanHoose (2007), our results go beyond the typical representative bank model where all banks are assumed to be homogeneous, thereby resulting in identical responses to regulatory capital standards.

1. The model

To address the issue of why different banks responded differently to the 1988 Accord, the static one-period banking-sector model developed by Kopecky and VanHoose (2004, 2006) is modified to account for the 1988 risk-based capital standards. Thus, the banking sector is modeled as:

$$L + S = D + K, \tag{1}$$

$$C_L = (f/2)L^2, \tag{2}$$

$$C_S = (g/2)S^2, \tag{3}$$

$$C_D = (d/2)D^2, \tag{4}$$

$$C_K = (e/2)K^2, \tag{5}$$

$$K \geq \theta_L L + \theta_S S. \tag{6}$$

Banks' balance sheets consist of commercial loans (L), government securities (S), non-transactions deposits (D), and capital (K)[1]. Equation (1) is the typical balance sheet condition. Equations (2) through (5) assume quadratic cost functions (C) associated with managing banks' assets, deposits, and capital, with marginal costs increasing as the quantity of the balance sheet item changes. Equation (2) recognizes that banks may incur significant costs in altering the size of their loan portfolios as increasing loans may result in additional origination, servicing, and monitoring costs (Estrella, 2004). In equation (3), the cost of adjusting securities is considerably less than that of adjusting loans (Kopecky and VanHoose, 2004) and a number of studies assume the cost to equal zero. Equations (4)

[1] Bank capital under the risk-based capital standards includes many different elements, the primary one being common stock equity. In this study, the terms equity and capital are used interchangeably thereby allowing us to use the parameter estimates of Kopecky and VanHoose (2004) for equity adjustment as our estimate as to the cost of banks' adjusting capital.

and (5) recognize the funding side of the balance sheet, with the costs of issuing deposits tending to be relatively low, while the cost of adjusting capital can be substantial (Berger et al., 1995). Profitable banks may increase capital by retaining earnings, as internally generated capital may be relatively cost effective compared to issuing new equity. Alternatively, for banks whose net income is negative or whose future prospects are bleak, internally generated capital may not be possible and raising capital externally may prove prohibitively costly (Keeton, 1989). Finally, equation (6) is the 1988 Basel Accord capital requirement where θ_L equals 8% for all commercial loans regardless of credit risk, while θ_S equals 0% for government securities.

Given equations (1) through (6), banks seek to maximize profits (π) such that:

$$\pi = r_L L + r_S S - r_D D - \frac{f}{2}L^2 - \frac{g}{2}S^2 - \frac{d}{2}D^2 - \frac{e}{2}K^2, \quad (7)$$

where r_L, r_S, and r_D are the interest rates on commercial loans, government securities, and non-transactions deposits, respectively. Equation (7) states that bank profits are the sum of interest income on commercial loans ($r_L L$) plus interest on government securities ($r_S S$) less interest paid on non-transactions deposits ($r_D D$) and adjustment costs associated with managing the balance sheet. Under the assumption that banks compete in a perfectly competitive market, the interest rates r_L, r_S, and r_D are market determined, and given that government securities are considered free of default risk, it is further assumed that $r_L > r_S$. In addition, the adjustment cost parameters *f, d,* and *e* are assumed to be positive. For the sake of this analysis, the cost of adjusting securities, *g*, is assumed equal to zero. While this creates portfolio separation as discussed in Elyasiani et al. (1995), setting *g* equal to zero is necessary for the mathematical tractability of the model[1].

Finally, one of the main criticisms of the 1988 Accord is that the risk-weight categories are too broad to adequately measure credit risk. Treacy and Carey (1998) note that while all business loans carry the same risk weight under the 1988 Accord, most banks' internal rating systems offer eight or more risk grades with corresponding capital requirements. This suggests that the 1988 Accord introduces errors, as internal credit risk models generally provide the most accurate assessments of risk (Jones and Mingo, 1998). To recognize this problem, an error term (ε) is introduced into the risk weight on commercial loans.

Given the conditions noted earlier, the Lagrangian becomes:

$$£ = r_L L + r_S S - r_D D - \frac{f}{2}L^2 - \frac{d}{2}D^2 - \frac{e}{2}K^2 + \lambda_1(D + K - L + S) + \lambda_2(K - \varepsilon\theta_L L). \quad (8)$$

Under the risk-based standards, the cost-benefit analysis of optimal asset allocation reflects not only the relative return on loans versus government securities, but also an explicit recognition of the capital that must be held against business loans and the fact that regardless of how banks choose to adjust their portfolios in response to the incentives created by the 1988 Accord, those adjustments entail costs that will reduce profitability.

2. Banking sector equilibrium

2.1. Non-binding requirements. In cases where the risk-based capital standards are not binding ($\lambda_2 = 0$), differentiating equation (8) with respect to L, S, D, K, and λ_1, the equilibrium conditions necessary for profit-maximizing banks facing adjustment costs are:

$$L^* = \frac{r_L - r_S}{f}, \quad (9)$$

$$S^* = \frac{ef(r_S - r_D) + (eh + fh)r_S - ehr_L}{efh}, \quad (10)$$

$$D^* = \frac{r_S - r_D}{h}, \quad (11)$$

$$K^* = \frac{r_S}{e}. \quad (12)$$

In equation (9), commercial loans are positively related to the loan interest rate and spread over government securities, but negatively related to the cost of adjusting the loan portfolio. Equilibrium holdings of government securities in equation (10) reflect an interaction between various elements of the balance sheet as security holdings are positively related to the interest rate on securities, as well as the spread over funding with deposits, but negatively related to the interest rate on loans. In equation (11), deposits are negatively related to both the interest rate and cost of adjusting deposits and positively related to the interest rate on securities. Equation (12) reveals that capital is positively related to the interest rate on government securities and negatively related to the cost of adjusting capital. Finally, the results of equations (9) through (12) show that for unconstrained banks the risk-based capital standards do not explicitly influence the optimal allocation of assets.

[1] This assumption is also made by other papers including Passmore and Sharpe (1994) and Kopecky and VanHoose (2006).

2.2. Binding capital requirements. Alternatively, banks will be explicitly constrained by the 1988 standards if their risk-based capital ratios are less than the regulatory minimum of 8% ($\lambda_2 \neq 0$). Furthermore, the existing research suggests that even some banks that were not explicitly constrained by the risk-based capital requirements behaved as if they were capital constrained. This may occur if banks desire to expand their business lines or engage in a merger (Haubrich and Wachtel, 1993), protect themselves against potential shocks to equity (Furlong, 1992), or signal that they are in compliance with the risk-based standards (Jacques and Nigro, 1997).

For capital-constrained banks, and those behaving as if they are constrained, deriving the first-order conditions and solving for the equilibrium levels yield:

$$L^* = \frac{r_L - (1-\varepsilon\theta_L)r_S}{f + e(\varepsilon\theta_L)^2}, \tag{13}$$

$$S^* = \frac{(f + e\varepsilon^2\theta_L{}^2)(r_S - r_D) + h(1-\varepsilon\theta_L)(r_S - r_L) + h\varepsilon\theta_L(\varepsilon\theta_L - 1)r_S}{h(f + e(\varepsilon\theta_L)^2)}, \tag{14}$$

$$D^* = \frac{r_S - r_D}{h}, \tag{15}$$

$$K^* = \frac{\varepsilon\theta_L(r_L - (1-\varepsilon\theta_L)r_S)}{f + e(\varepsilon\theta_L)^2}. \tag{16}$$

In this case, optimization of banks' balance sheets differs markedly from unconstrained banks in that the risk-based capital requirement on commercial loans, θ_L, and the error in risk-weight calibration, ε, enter the equilibrium equations, thereby, explicitly linking banks' profit-maximizing asset allocation with regulatory capital requirements. Banks now optimize their balance sheets, and maximize their profits, recognizing a cost-benefit analysis where the return on assets is weighed against costs that now include both the adjustment costs of altering balance sheet items as well as the differential cost in terms of regulatory capital required on commercial loans compared to securities. Furthermore, this cost-benefit analysis is complicated to the degree that the risk-based capital standards do not accurately assess credit risk.

To understand how banks responded to implementation of the 1988 Accord, similar to Furfine (2001), the change in the balance sheet is examined relative to a change in capital requirement on loans, θ_L. Specifically:

$$\frac{\partial L^*}{\partial \theta_L} = \frac{-2e\varepsilon^2\theta_L(r_L - r_S) + \varepsilon(f - e\varepsilon^2\theta_L^2)r_S}{(f + e\varepsilon^2\theta_L{}^2)^2} \gtrless 0, \tag{17}$$

$$\frac{\partial S^*}{\partial \theta_L} = \frac{\varepsilon(f + e\varepsilon\theta_L(2-\varepsilon\theta_L))r_L - 2\varepsilon(f + e\varepsilon\theta_L)(1-\varepsilon\theta_L)r_S}{(f + e\varepsilon^2\theta_L{}^2)^2} \gtrless 0, \tag{18}$$

$$\frac{\partial D^*}{\partial \theta_L} = 0, \tag{19}$$

$$\frac{\partial K^*}{\partial \theta_L} = \frac{\varepsilon((e\varepsilon^2\theta_L{}^2)(r_S - r_L) + f(r_L - (1-2\varepsilon\theta_L)r_S))}{(f + e\varepsilon^2\theta_L{}^2)^2} \gtrless 0. \tag{20}$$

Despite the simple structure of the model, the results are mathematically indeterminate for most of the balance sheet variables, the exception being the equation for deposits whose value equals zero, this being the result of the portfolio separation condition noted earlier. This indeterminacy may help explain why previous researchers have found such diverse results when examining U.S. banks' responses to the 1988 Accord. Allowing for the possibility of non-homogeneous marginal adjustment costs, one contribution of this paper is that different banks may exhibit different responses to implementation of the risk-based standards.

3. Simulation results

To address the issue of why different banks exhibited diverse responses, the impact of adjustment costs on banks' balance sheets is simulated. Previous studies by Kopecky and VanHoose (2004, 2006) that have employed the adjustment cost framework used parameter estimates from work by Elyasiani et al. (1995). Given the similarity of our model to their framework, this study follows that same approach. For the parameter estimates, Kopecky and VanHoose (2004) employ a range of 0.001 to 0.04

for loan adjustment costs (f) and 0.001 to 0.80 for equity adjustment costs (e). In addition, following the assumption of costless security adjustment, *g* is set equal to 0. With the risk-based standards becoming effective on December 31, 1990, interest rates for January 1991 are taken from monthly data in the Federal Reserve Bank of St. Louis FRED database. Thus, r_L is set at .0952 reflecting the prime rate, r_S equals .0770 reflecting the 5-year U.S. Treasury bond rate, and r_D equals .0717 reflecting the 6-month CD rate. Finally, the risk-weight on commercial loans under the risk-based capital standards (θ_L) equals 0.08[1].

3.1. Adjustment costs. To address the question of how adjustment costs influenced banks' balance sheets, and to introduce heterogeneity into the banking model, it is assumed that different banks face different costs for adjusting their loan portfolios. Justification for this assumption can be found in Berger and DeYoung (1997) who argue that these costs may differ across banks for a variety of reasons including monitoring of borrowers and collateral, the cost of disposing of collateral in the event of default, and costs arising from regulatory oversight.

Tables 1 through 3 detail simulations of $\partial L/\partial\theta_L$, $\partial S/\partial\theta_L$, and $\partial K/\partial\theta_L$ under a variety of different loan adjustment costs, with the second column ($\varepsilon\theta_L = 1$) in each table representing the response to the 8% risk-based capital requirement on commercial loans. As discussed earlier, differences in capital adjustment costs may also be important in how banks responded to the 1988 Accord. To account for this possibility, Table 1 simulates the response of banks when the costs of adjusting capital are high; in this case e = 0.8, a number at the top end of the range used by Kopecky and VanHoose (2004). Given that many of the capital-constrained banks at the time of implementation also had a negative return on assets (Jacques and Nigro, 1997), raising capital may have been extremely costly. Alternatively, for some banks raising additional capital may not have been as high. To account for this possibility, Table 2 assumes moderate capital adjustment costs (e = 0.4), this being the midpoint of the Kopecky and VanHoose range, while Table 3 assumes e = 0.1, this being the lower part of the Kopecky and VanHoose range.

[1] When the risk-based capital standards were initially implemented, the capital requirement on commercial loans was set at 7.25% as part of the phase in period. On December 31, 1992, the 1988 Accord was fully phased in with θ_L equal to 8.0%. In this study θ_L is set equal to 8% for the simulations as some of the existing research suggests that banks behaved as if the risk-based standards were fully implemented at that time.

Tables 1 through 3 reveal some interesting results concerning both the magnitude and diversity of banks' responses to implementation of the risk-based standards. First, assuming the cost of adjusting loans (f) is low, banks generally responded by decreasing loans and increasing securities. This is particularly true in the case where equity adjustment costs (e) are high (Table 1). These results are consistent with much of the existing empirical research in that as regulatory capital requirements increased, banks responded to the economic incentives inherent in the risk-based standards by decreasing their holdings of the risky asset, commercial loans, and increasing their holdings of the safe asset, U.S. Treasury securities. A priori, this result is to be expected. When it is relatively inexpensive for banks to adjust their holdings of commercial loans, shifting to a less risky portfolio helps banks meet the risk-based capital standards despite the fact that commercial loans offer a higher rate of return.

It is interesting to note that the results generally found in the literature also suggest that banks increased capital does not necessarily hold in this case. In cases where loan adjustment costs are very low (f = .001), and capital adjustment costs are in the moderate to higher end of the range (Tables 1 and 2), banks responded by decreasing loans more than securities, thus, signifying a decrease in total assets and a decrease in capital. This result is consistent with Keeton's (1989) argument that some banks would reduce total assets and decrease capital in response to the 1988 Accord.

Table 1. Impact of loan adjustment costs and errors in risk weights on assets and capital (High cost of adjusting equity e = 0.8)

Loan adjustment costs (f)	$\varepsilon\theta_L$= .08	$\varepsilon\theta_L$=.024	$\varepsilon\theta_L$=.12
Loans			
f = .001	-70.67	-92.42	-41.19
f =.01	-8.55	0.10	-11.70
f = .02	-1.88	0.58	-4.29
f = .03	-0.34	0.51	-1.80
f = .04	0.18	0.43	-0.73
Securities			
f = .001	69.00	94.31	39.54
f = .01	9.47	0.48	12.21
f = .02	2.70	-0.27	5.08
f = .03	1.00	-0.30	2.58
f = .04	0.38	-0.27	1.45
Capital			
f = .001	-1.67	1.90	-1.66
f = .01	0.93	0.58	0.51
f = .02	0.82	0.31	0.79
f = .03	0.67	0.21	0.78
f = .04	0.55	0.16	0.71

Table 2. Impact of loan adjustment costs and errors in risk weights on assets and capital (Moderate cost of adjusting equity e = 0.4)

Loan adjustment costs (f)	$\varepsilon\theta_L$= .08	$\varepsilon\theta_L$=.024	$\varepsilon\theta_L$=.12
Loans			
f = .001	-101.39	-57.50	-69.38
f =.01	-3.75	1.15	-8.58
f = .02	0.35	0.86	-1.47
f = .03	0.89	0.64	0.14
f = .04	0.95	0.50	0.64
Securities			
f = .001	100.12	61.01	67.14
f = .01	5.39	-0.54	10.16
f = .02	0.76	-0.54	2.89
f = .03	-0.07	-0.42	1.03
f = .04	-0.30	-0.34	0.34
Capital			
f = .001	-1.27	3.51	-2.24
f = .01	1.64	0.62	1.58
f = .02	1.11	0.32	1.42
f = .03	0.82	0.21	1.17
f = .04	0.65	0.16	0.98

Table 3. Impact of loan adjustment costs and errors in risk weights on assets and capital (Low cost of adjusting equity e = 0.1)

Loan adjustment costs (f)	$\varepsilon\theta_L$= .08	$\varepsilon\theta_L$=.024	$\varepsilon\theta_L$=.12
Loans			
f = .001	-97.96	-3.97	-118.59
f =.01	3.79	2.01	2.55
f = .02	2.82	1.08	3.24
f = .03	2.10	0.74	2.67
f = .04	1.66	0.56	2.21
Securities			
f = .001	104.98	9.56	121.23
f = .01	-1.20	-1.37	1.36
f = .02	-1.41	-0.75	-0.93
f = .03	-1.14	-0.52	-1.04
f = .04	-0.93	-0.40	-0.95
Capital			
f = .001	7.02	5.59	2.64
f = .01	2.59	0.65	3.90
f = .02	1.41	0.33	2.31
f = .03	0.96	0.22	1.63
f = .04	0.73	0.16	1.26

Alternatively, some banks are likely less efficient in managing their loan portfolios and, therefore, face higher loan adjustment costs. For example, in Table 1 loans generally decreased although the larger the loan adjustment costs, the smaller the decrease in loans in response to θ_L. Correspondingly, as loan adjustment costs increased, banks continued to increase securities, albeit to a much smaller degree, and also increase capital. And in the case where f = 0.04, the top end of the Kopecky and VanHoose range, loans and securities both increased in response to an increase in θ_L. While contrary to much of the existing research, these results are rational because if the cost to adjust a loan portfolio is sufficiently high, and it is very costly to adjust capital, then reducing loans and reallocating the portfolio toward less risky assets is not necessarily a profit-maximizing decision as it would entail reducing higher interest earning assets while simultaneously incurring increased costs. Rather, under these conditions banks may find it more profitable and more cost efficient to raise capital, with the increase in capital being used to support the existing asset portfolio.

Finally, comparing Tables 1 through 3 it should be noted that higher costs of adjusting capital are generally associated with larger reductions (or smaller increases) in loans. This suggests that as it becomes more costly to adjust capital, banks make smaller changes to their capital levels and instead attempt to meet the minimum risk-based standards by altering the composition of their asset portfolios. Recognizing that in the period after implementation of the 1988 Accord, many banks likely faced high capital adjustment costs, and with government securities having a 0% risk weight under the 1988 Accord, this result is not surprising as decreasing the loan portfolio became the only viable means for banks to meet the minimum risk-based capital requirements.

3.2. Errors in risk weights. To complicate the analysis of how U.S. banks' asset allocation responded to the risk-based capital standards, the question is how does the presence of errors in the risk weights change our earlier analysis. In recognition of the calibration error in the risk weight on commercial loans, two cases are examined.

One possibility is that the 8% risk weight on commercial loans is too high. This may occur because the 1988 Accord fails to recognize the effects of diversification in a loan portfolio (Office of the Comptroller of the Currency, 1998) or if the loan portfolio is comprised of high credit quality commercial loans. To this latter point, work by Altman and Saunders (2001) using default loss data on corporate bonds concludes that good credit quality (BBB- and above) commercial loans should be slotted in a 30% risk-weight category, this corresponding to a 2.4% risk weight.

To examine this question, Tables 1 through 3 also detail for a portfolio of high credit quality loans how errors in the risk weights influenced the balance sheet adjustment process. These results are shown in the column $\varepsilon\theta_L = 0.024$. Assuming moderate or high costs of adjusting capital (Tables 1 and 2), the simulations generally suggest that banks with good credit quality loan portfolios would have responded by exhibiting small increases in loans, a reduction in

securities and smaller increases in capital. Recognizing the difference between these results and the results corresponding to the 1988 Accord ($\varepsilon\theta_L$ = 0.08), the simulations generally suggest that setting the risk weight on all commercial loans at 8% resulted in banks undertaking a decrease in loans that would not have occurred or would have been less severe had the risk weights been more accurate. Offsetting this, banks also responded to the error in risk weights by undertaking smaller increases or larger reductions in securities. Taken together, these results suggest that inaccuracies in calibrating the risk weight on commercial loans played an important role in the reallocation of U.S. banks' assets and the U.S. credit crunch of the 1990s.

In addition, the simulations also suggest that the increase in capital was larger under the 8% risk weight than would have occurred had regulators set the risk weight at 2.4%. This result is interesting in that it signifies a beneficial effect to the errors in the risk weights in the 1988 Accord. By setting risk weights on high credit quality commercial loans too high, bank regulators created an incentive for banks to reduce business loans to good credit quality companies. Banks in turn responded to those incentives by not only reducing commercial loans, but also by undertaking larger increases in capital than would have been undertaken had the risk weights been more accurately set.

Finally, the fourth column of Tables 1 through 3 ($\varepsilon\theta_L$ = 0.12) details a second possible case for errors in risk weights. This is consistent with these companies being of poor credit quality, and Altman and Saunders (2001) suggest that 12% is the more appropriate risk weight. Again assuming the cost of adjusting capital is at the mid to high level of the Kopecky and VanHoose range (Tables 1 and 2), the simulations suggest that had the risk weights for these loans been set at 12%, banks generally would have responded by undertaking larger decreases or smaller increases in commercial loans. The exception is in the case where the cost of adjusting loans is extremely low (f = 0.001). Given the larger decrease at the 12% risk weight, there exists a correspondingly larger increase in government securities. Again, the exception is the case where f = 0.001. Taken together these results suggest that had regulators more accurately differentiated the risk weights on commercial loans in the 1988 Accord, an even larger contraction in lending and greater shift to government securities would have occurred at those banks with poor credit quality in their commercial loan portfolios.

The fourth column of Tables 1 through 3 also simulates what would have happened to capital levels if regulators have more accurately calibrated the risk weights on commercial loans. If we assume loan adjustment costs are in the lower portion of the range ($f \leq 0.01$), the results suggest that the increases in capital would have been smaller or decreases larger than occurred with an 8% risk weight on commercial loans. Given that the 8% risk weight on loans is too low, and that loan adjustment costs are also low, banks would have been very aggressive in contracting their lending portfolios as a means of meeting the minimum regulatory capital requirements. And with every $1.00 reduction in commercial lending leading to a $0.12 reduction in required capital, there is a correspondingly smaller need to raise capital in order to meet the risk-based standards.

Alternatively, the case where the cost of adjusting loans is in the mid to high portion of the cost range ($f \geq 0.02$) is probably a more realistic simulation as these banks have a portfolio of lower credit quality loans, and as noted earlier, may face additional costs. In these cases, the simulation results in Tables 1 and 2 suggest that banks would have responded by undertaking larger increases in capital. Given that loan adjustment costs are high and the risk weight on these loans is too low at 8%, banks would have incurred significant cost increases for reducing loans yet gained only an $0.08 reduction in required capital for each $1.00 of reduction in loans. Thus, despite the fact that it may be expensive to increase capital, these banks would have undertaken larger increases in capital than occurred at the 8% risk weight. This suggests a weakness in the 1988 Accord that has previously achieved only limited attention. Much of the existing research notes that for poor credit quality loans the 8% risk weight was too low. Our finding suggests that had the risk weight been set at 12 percent for these loans, banks with poor credit quality loan portfolios would likely have exhibited even larger increases in capital than they exhibited in response to the 1988 standards.

Conclusion

The purpose of this study has been to examine how U.S. banks' asset portfolios responded to implementation of the 1988 Basel Accord. Banks constrained by the risk-based capital standards, or those not explicitly constrained who behaved as if they were, had a number of options in how they could adjust their balance sheets. And while numerous studies have already examined this question, they often fail to explain why different banks responded to implementation of the standards in different ways. This study modifies existing work on quadratic cost functions by Kopecky and VanHoose (2004, 2006) and applies it to the question of banks' balance sheet changes in the response to the 1988 Accord. In doing so, one of the contributions of this study is that it not only provides possible

explanations for why different banks exhibited diverse responses, but in doing so it moves past the existing literature where all banks tend to exhibit similar responses to regulatory capital requirements. In this study, banks with different loan and capital adjustment costs exhibited very different responses to implementation of the 1988 Accord.

This is an important point to recognize as it relates to the forthcoming revised Basel Accord. The standardized approach to the revised Accord explicitly incorporates credit ratings into the regulatory capital standards, adds a 150 percent risk weight category for poor credit quality commercial loans, and allows regulatory capital requirements to migrate as the underlying credit rating of the borrowing entity changes. In addition, for banks with more advanced risk measurement systems, the revised Accord allows for use of banks' internal credit risk models. By making the risk-based capital requirements more granular in terms of risk weights and credit ratings, the revised Accord should reduce the reallocative balance sheet effects of the 1988 Accord. But to the degree that capital requirements on commercial loans in the revised Accord still deviate from the true risk, balance sheet reallocation should still be expected to occur.

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