



2006-WP-04
July 2006

BANK BEHAVIOR UNDER CAPITAL REGULATION: WHAT DOES THE ACADEMIC LITERATURE TELL US?

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Abstract: This paper reviews academic studies of bank capital regulation in an effort to evaluate the intellectual foundation for the imposition of the Basel I and Basel II systems of risk-based capital requirements. The theoretical literature yields general agreement about the immediate effects of capital requirements on bank lending and loan rates and the longer-term impacts on bank ratios of equity to total or risk-adjusted assets. This literature produces highly mixed predictions, however, regarding the effects of capital regulation on bank asset risk and overall safety and soundness. Research also indicates that bank capital regulation can have procyclical macroeconomic effects and can impinge on the effectiveness of monetary policy. Although empirical research provides some support for the macroeconomic and monetary policy implications of risk-based capital requirements, conclusions about actual bank balance-sheet and risk adjustments to capital regulation are also mixed. Thus, the intellectual foundation for the present capital-regulation regime is not particularly strong. The mixed conclusions in the academic literature on banking certainly does not provide unqualified support for moving to an even more stringent and costly system of capital requirements.

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Keywords: Bank capital regulation, Capital requirements

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1. Introduction

Since the 1950s, U.S. bank regulators have sought to develop formulas for determining ‘appropriate’ minimal levels of capital. Between the mid-1950s and the mid-1970s, regulators used a formula intended to compute minimum capital levels for different categories of assets. Various financial innovations that occurred during the 1960s and 1970s rendered these formulas useless, however. Thus, in 1981, regulators implemented explicit capital ratios. Regulators required a 5.5 percent minimum ratio of ‘primary capital’—common and perpetual preferred stock, surplus, undistributed profits, and capital reserves—to total assets, and they imposed a 6.0 percent minimum ratio of ‘total capital’—primary capital plus certain subordinated notes and debentures, other preferred stock, and mandatory convertible debt—to assets.

In 1989, in an effort to take into account heterogeneities of risks across different sets of bank assets, U.S. regulators joined with those of other nations to adopt the Basel Agreement imposing both a traditional capital-asset ratio requirement and ‘risk-based’ requirements relating measures of bank capital to a ‘risk-weighted’ measure of total assets. Nevertheless, by the mid-1990s, regulators had determined that banks had learned how to game the system through regulatory arbitrage that undermined the intent of the Basel risk adjustments.

Since then, considerable regulatory effort has been expended on the so-called Basel II system, which aims at constructing and implementing an overall regulatory framework built around three so-called ‘pillars’: Risk-based capital requirements, discretionary supervisory discipline, and market discipline. The Basel II framework

* I am grateful for comments on earlier drafts by Kenneth Kopecky, John Pattison, and Jack Tatum. Any errors are my own.

was originally scheduled for full implementation by the mid-2000s but currently is slated to go into effect gradually with a target completion date of January 2008. Most of the more than 100 adherents to the Basel I system of capital regulation have already expressed intentions, explained perhaps by club theory and individual self-interest (see Pattison, 2006) to adopt the Basel II standards.

In light of nearly five decades of regulatory effort based at least in part on minimum capital requirements, one might anticipate that a perusal of the academic banking literature would yield considerable agreement that capital requirements are a worthy tool within a bank regulator's arsenal. In fact, the literature is sharply divided about the effects of capital requirements on bank behavior and, hence, on the risks faced by individual banks and the banking system as a whole. Some academic work indicates that capital requirements unambiguously contribute to various possible measures of 'bank stability.' In contrast, other work concludes that if anything, capital requirements make banks 'riskier' institutions than they would be in the absence of such requirements.

The purpose of this paper is to evaluate why financial economists have reached such divergent conclusions about the 'riskiness' or 'stability' effects of capital requirements. Because researchers have applied such varied approaches to analyzing the effects of capital requirements on bank behavior, answering this question requires conducting a thorough review of the academic literature on bank capital regulation. Santos (2001) has provided one recent survey of the literature through the late 1990s. In contrast to his survey, however, this paper aims to direct a more critical focus upon the reasons for the literature's conflicting conclusions about capital regulation's effects on bank behavior. Furthermore, the present paper considers a considerable volume of additional academic research on the effects of capital regulation that has emerged since the late 1990s in conjunction with continuing discussion of the appropriate structure and implementation of the intended Basel II standards.

Early research on banks' responses to capital requirements viewed banks as portfolio managers. Consequently, the next section begins by evaluating the reasons for widely varying conclusions that different researchers have obtained regarding the response of banks' portfolio risks to capital regulation. More recent research has explored the effects of capital regulation in light of asymmetric-information problems that naturally exist in real-world banking systems. Section 3 considers studies that have emphasized moral hazard problems among banks, depositors, borrowers, and deposit insurers. In many of these analyses—particularly those contemplating moral-hazard problems banks face in their role as lenders—the monitoring function of the banking firm is viewed as central to understanding the ultimate effects of capital regulation on bank behavior. The first portion of section 4 examines research that has considered adverse-selection problems among agents in banking markets. This research focuses attention on how capital regulation may impinge both on banks' role in screening loans and on efforts by regulators to screen banks. Section 4 then considers an issue that naturally arises once the adverse selection problems in the banking system are taken into account, namely the potential importance of explicitly recognizing bank heterogeneities when evaluating the effects of capital regulation on overall 'riskiness' or 'stability' of the banking system. Evaluating research on the broader systemic implications of bank capital regulation is the subject of section 5, which considers both the potential for procyclicality to emerge in a capital-regulated banking system and for capital requirements to impinge on monetary policy, thereby impinging on economic as well as financial 'stability.' Section 6 considers empirical research aimed at determining the actual effects of capital regulation to date on overall bank equity decisions, balance-sheet choices and risks, and macroeconomic and monetary policy variables.

Section 7 briefly summarizes the main conclusions of this review, which are as follows. First, virtually all studies of the effects of bank capital regulation generate the following common conclusions:

1. Short-run effects of binding risk-based capital requirements are reductions in individual bank lending and, in analyses that include consideration of the adjustments in the overall bank loan market, increases in market loan rates.
2. Longer-run effects of risk-based capital regulation lead to absolute and relative increases in bank capital ratios.

Taken together, the widespread agreement about these two sets of conclusions indicates that risk-based capital requirements can bring about one oft-expressed objective: increasing the relative size of the ‘capital cushion’ protecting depositors and deposit insurers from losses in the event of isolated or widespread bank failures. Nevertheless, these results can be consistent with widely divergent conclusions about how risk-based capital regulation influences choices that banks *make on the margin*. This latter issue is, however, central to evaluating whether risk-based capital regulation truly makes individual banks and the banking system as whole ‘safer.’ After all, a relatively enlarged ‘capital cushion’ may be rapidly dissipated if banks respond to capital regulation by making riskier asset choices or failing to devote sufficient resources to evaluating adverse selection or moral hazard risks.

The predicted effects of capital regulation on marginal decision-making depend on which aspect of banking one emphasizes in an analytical banking framework. In traditional portfolio-selection models of the banking firm, whether or not capital regulation induces banks to choose less risky or riskier portfolios depends crucially on the option value of deposit insurance and whether managers or shareholders exercise most control over the bank’s decisions. With limited liability, if the main objective of a typical bank is to maximize shareholder utility, properly designed capital regulation

potentially can bring about a reduction in the bank's portfolio risk. Otherwise, the implications of capital requirements for portfolio risk are ambiguous.

In settings with asymmetric information, conclusions naturally hinge in part on the sources of asymmetric information. They also depend on the assumptions that researchers impose to simplify their models or, in many cases, in order to render their theories tractable in light of the complexities inherent in the analysis of capital regulation. On one hand, researchers who focus on asymmetric-information problems between banks and depositors (and/or deposit insurers) relating to banks' role as issuers of demandable debt often choose to simplify their analysis of the asset side of banks' balance sheets. Abstracting from responses of asset returns to bank capital regulation typically results in the rosiest predictions regarding the potential for risk-based capital requirements to generate unambiguous social-welfare improvements. On the other hand, researchers who instead place the spotlight on how capital requirements affect banks' lending and monitoring choices in the face of informational problems on the asset side of the balance sheet are more likely to conclude that risk-based capital regulation at best has ambiguous welfare effects.

Furthermore, bank capital regulation can exert effects extending throughout and beyond a nation's financial system. In principle, implementation of risk-based capital requirements adds to the procyclicality of bank credit and feeds back to generate procyclical impacts on economic activity. Thus, capital regulation potentially can create conflicts between bank regulators and monetary authorities.

Finally, empirical work evaluating the implications of the Basel I system of risk-based capital requirements at best provides weak evidence that capital regulation has affected the actual equity decisions of banks. The sparse empirical studies of the risk implications of capital regulation reach decidedly mixed conclusions. Only empirical analyses of the macroeconomic effects of capital regulation provide evidence generally

consistent with most theories regarding procyclicality and banking-system responses to monetary policy actions.

In short, a review of the academic literature reveals that bank regulation implemented through a system of risk-based capital requirements theoretically has both desirable and undesirable characteristics. Any suggestion that the current and proposed Basel systems of capital regulation must necessarily improve bank ‘safety and soundness’ can only be supported by reference to a relatively narrow slice of the academic literature. More generally, a good argument can be advanced that risk-based capital regulation has ambiguous effects on overall ‘safety and soundness. Indeed, the imposition of risk-based capital requirements could make at least some banks and potentially the entire banking system *less* ‘safe’ than it might be in the absence of this particular form of regulation. Thus, the academic banking literature fails to offer strong support for risk-based capital regulation as an instrument aimed at promoting bank safety and soundness and economic stability.

2. Capital-Constrained Portfolio Selection

One approach to analyzing the effects of bank capital requirements is to regard banks primarily as managers of portfolios of assets. From this point of view, the primary effect of any system of capital requirements—at least, capital requirements that actually bind the bank or, in an uncertain environment, that the bank anticipates will be binding—is to alter the portfolio leverage (asset-capital) ratio of the bank. Naturally, from the point of view of portfolio selection, the result typically is a change in the composition of the optimal asset portfolio.

2.1 The Bank as a Competitive, Mean-Variance Portfolio Manager Facing Capital-Constrained Asset Portfolios

The three seminal analyses of the portfolio impacts of binding capital requirements are the contributions of Kahane (1977), Koehn and Santomero (1980), and Kim and Santomero (1988). The first two of these contributions considers a mean-variance portfolio-selection model in which a representative bank takes prices and yields as given and determines its optimal portfolio with an aim to maximize the expected utility derived from end-of-period capital, which in turn depends on the degree of the bank's risk aversion as measured by the coefficient of relative risk aversion. To evaluate the safety-and-soundness implications of capital requirements in this setting, Kahane and Koehn and Santomero evaluate the effects of a binding leverage constraint on the probability of failure. A tightening of the required leverage ratio constrains the bank's efficient asset investment frontier, and the bank responds by altering the mix of assets in its portfolio per unit of capital. The way in which the composition of the optimal portfolio adjusts, however, depends crucially on the coefficient of relative risk aversion. In the context of their basic portfolio-selection frameworks, Kahane and Koehn and Santomero demonstrate that a bank that is sufficiently non-risk-averse will respond by choosing a riskier asset mix than before the increase in the leverage ratio, thereby creating a perverse—from a regulatory perspective—effect in which the probability of bankruptcy increases. As a consequence, the Kahane/Koehn-Santomero analyses indicate that the effect of capital requirements on the overall safety and soundness of the banking system as a whole depends on the distribution of risk aversion across banks. More stringent capital requirements could make some banks safer, some banks riskier, and the banking system as a whole either more or less safe.

Kahane (1977) suggests that capital regulation cannot reduce overall bank portfolio risk unless the asset composition of the bank's portfolio is also subjected to regulation. One way a regulator might try to address the potential for banks to choose a

riskier asset portfolio is to risk-weight the bank's assets, as in the Basel I system. Kim and Santomero (1988) extend the portfolio-selection approach to analysis of an asset-risk-weighted system and provide support for this approach, as long as the weights are optimally set [see Bradley *et al.* (1991), Carey (2002), Gjerde and Semmen (1995), Cordell *et al.* (1995), and Gordy (2003) for more detailed discussions of linking capital regulation to risk-weighted assets].

2.2 The Role of Deposit Insurance

Kim and Santomero open and close their study by noting that a key rationale for capital requirements is to redress the possibility of greater risk induced by mispricing of deposit insurance. Nevertheless, their analysis does not take into account the potential behavior-distorting effects of deposit insurance.

Keeley and Furlong (1990) suggest that when a bank's option value of deposit insurance is taken into account, the application of mean-variance analysis to analysis of the effects of capital requirements on the probability of failure becomes problematic. Specifically, when the option value of deposit insurance is recognized, the cost of borrowing is no longer constant, so that the effects of changes in the leverage ratio on risk and return are not linear. As a consequence, Furlong and Keeley argue, the variance of returns is not an adequate measure of risk once the option value of deposit insurance is taken into account, thereby rendering suspect that results obtained in Kahane's, Koehn and Santomero's, and Kim and Santomero's applications of mean-variance analyses. Separately, Furlong and Keeley (1989) incorporate the option value of deposit insurance into a state-preference model of a representative bank. Their conclusion is that an increase in bank capital is unambiguously associated with a reduction in the level of bank asset risk.

Flannery (1989) independently reaches a similar conclusion. He also takes into account the value of the FDIC put option within a model that allows for a broad range

of asset choices in the loan portfolio of a risk-neutral bank while simultaneously examining broader balance-sheet impacts of capital regulation. Simulations of the model indicate that although capital regulation tends to induce banks to diversify their portfolios less than they would if unregulated, overall risk in a bank's loan portfolio declines.

Genotte and Pyle (1991) consider a model in which banks raise a fixed amount of deposits and choose among a set of loan portfolios with differing net present values and risks. In contrast to the mean-variance approach utilized by previous authors who assumed banks specialized in traded assets with zero net present values, Genotte and Pyle explicitly allow for the possibility that loan assets have non-zero net present values. In their framework, the net present value of managers' claims on the bank equals the sum of the call value of the government subsidy plus the net present value of the bank's assets. Deposit insurance subsidizes banks, which invest to the point at which the subsidy on the marginal dollar offsets the negative present value of the marginal investment. To address the distorting effects of the deposit insurance subsidy, the government imposes a capital constraint in the form of a maximum deposit-to-asset value ratio.

The effects of capital requirements on bank risk-taking and scale implied by Genotte and Pyle's analysis are ambiguous, but if a bank's marginal costs increase with risk—which occurs when the asset portfolio is a combination of investments in safe and risky assets—then the bank responds by increasing the fraction invested in the risky asset, and its scale decreases. There are two effects of a capital tightening on the probability of bankruptcy: (1) reduced leverage, which reduces the bankruptcy probability and (2) increased asset risk, which increases the bankruptcy probability. Which effect dominates depends on a ratio of the elasticities of the net present value of investments with respect to the mean and variance of the present value. Genotte and Pyle show that if the ratio of marginal to average costs is constant and asset returns are

lognormally distributed, then asset risk definitely increases with a capital tightening. The probability of bankruptcy initially drops with a tougher capital requirement, but this probability ultimately rises as required capital ratios are increased further.

Boot and Thakor (1991) briefly consider the effects of capital requirements within the context of an analysis of loan commitments. They suggest that toughened capital regulation generally is associated with reduced risk in the long run but can induce banks utilizing loan commitments to boost their asset risk in the near term.

2.3 Accounting for the Mixed Implications of Portfolio-Management Models

What accounts for diverging conclusions about capital requirements effects on portfolio-managing banks? Rochet (1992) suggests that part of the answer depends on whether one assumes complete or incomplete markets. Throughout his analysis, Rochet assumes that capital is exogenously fixed. Representative banks choose the level of deposits, which are subject to increasing marginal costs, and hence their scale, and they also select a portfolio from a set of risky and riskless assets.

Rochet finds that when a capital requirement is unexpectedly introduced into a complete-markets setting with deposit-insured, value-maximizing banks, there are three possible outcomes: (i) no increase in capital but investment in a combination of one risky asset and the riskless asset, (ii) complete specialization in a single risky asset and just meeting the requirement, or (iii) no increase in capital but investment in a combination of two risky assets. As in earlier work based on mean-variance analysis, the risk of failure is most likely to increase in this setting. Indeed, Rochet concludes that risk-based deposit insurance premiums are likely to prove a more effective instrument for reducing portfolio risk than capital requirements.

Rochet finds, in contrast, in a setting with incomplete markets, limited liability, and shareholder-utility-maximizing banks, results similar to those obtained by Keeley and Furlong (1990) and Furlong and Keeley (1989): Capital regulation can potentially

reduce asset risk. Nevertheless, this condition follows only if risk weights in the required solvency ratio are proportional to the systematic risks of assets as measured by their market betas.

Recently, Jeitschko and Jeung (2005) have sought to consider the roles of managerial agency problems and higher-risk, higher-return assets in influencing the effects of capital requirements on risk at a portfolio-managing bank. Jeitschko and Jeung examine a framework that allows for asset risk orderings more general than mean-variance. They utilize this framework to evaluate responses of bank risk to greater capitalization depending on which agent—deposit insurer, shareholders, or managers—dominates bank decision-making. In the Jeitschko-Jeung model, exogenous capital and deposits are invested by the representative bank, with deposits paid back without risk and assets potentially shifted from one investment to another. In addition, Jeitschko and Jeung assume that regulation precludes a bank from investing in negative net-present-value projects, and their model allows for changes only about the center of the distribution of asset returns that result in a uniform shrinking or stretching of the distribution.

In the presence of deposit insurance subsidies, Jeitschko and Jeung find that a bank may choose a dominated risky asset rated either according to a mean-variance ordering implying a second-order stochastic dominance relationship or according to a mean-preserving spread. Expected value of bank equity equals the net return on investment plus the option value of deposit insurance, which is the expected cost of providing the insurance to the bank.

The implications of capital regulation of the Jeitschko-Jeung portfolio-management model of bank decision-making depend on which agent dominates in the portfolio decision:

- (i) The Deposit Insurer: If the deposit insurer has the power, say through regulation, to determine the portfolio, its goal is to choose a risk factor that

minimizes the option value of deposit insurance. Under traditional mean-variance ordering, the insurer prefers zero risk. In the presence of higher-return, higher-risk assets, the deposit insurer prefers greater risk as bank capital increases, because accompanying the higher risk is a higher mean return, which reduces the likelihood of failure.

- (ii) Shareholders: The goal of shareholders is to choose a risk factor that maximizes the expected value of bank equity. Under strict mean-variance ordering [as in Keeley and Furlong (1990) and Furlong and Keeley, (1989)], greater capital leads to a lower risk factor choice. In the presence of higher-return, higher-risk assets, this result does not necessarily follow, however.
- (iii) Managers: The goal of bank managers is to choose the risk factor that maximizes the expected value of the private benefit of control. The preferred asset risk that results is potentially increasing with greater capitalization, depending on parameter values.

Thus, Rochet and Jeitshko and Jeung have identified several factors that explain the divergent implications of portfolio-management models for the responsiveness of bank portfolio risk to capital regulation. Conclusions often depend on whether banks are viewed as value-maximizing versus utility-maximizing firms, whether or not bank ownership entails limited liability, and whether banks operate in complete or incomplete asset markets. Furthermore, the results of capital regulation depend on which perspective dominates in the principal-agent interactions among insurers, shareholders, and managers.

2.4 Portfolio-Management Models of Bank Capital Regulation: Summing Up

The profession has learned a great deal from portfolio-management models about the behavioral implications of bank capital requirements. When banks operate in competitive asset markets, binding capital regulation typically alters the composition of

optimal bank portfolios. More risk-averse banks typically respond by reducing their portfolio risk. Less risk-averse banks that seek to engage in positive net present value investments may respond by taking on more risk, although if they take into account the option value of deposit insurance this result is mitigated. Additional factors influencing banks' optimal responses to capital regulation include the potential for banks to operate in incomplete or imperfectly competitive asset markets, to be value-maximizing versus utility-maximizing, or to make decisions governed by the desires of regulating insurers, shareholders, or managers.

Taken together, the conclusions of research emphasizing the role of banks as portfolio managers offers qualified support for the idea that capital regulation might induce a number banks to hold less risky asset portfolios. Just how many banks would become less risky cannot be predicted. Thus, this approach leaves ambiguous the implication for the overall safety and soundness of the banking system.

3. Capital Requirements, Incentives, and Moral Hazard

In an alternative study utilizing a portfolio-choice approach to determine the effects of capital regulation, Milne (2002) suggests that previous analyses of the effects of capital requirements on portfolio risk are flawed because they fail to “treat banks as forward looking optimizers balancing the benefits of their lending decisions against the costs of a regulatory breach.” Certainly, most research broadening the focus of ranges of balance-sheet adjustments beyond asset risk composition has considered only single-period models. Nevertheless, a number of researchers have in fact given considerable attention, albeit most often in static banking frameworks, to the manner in which banks balance costs and benefits across the entire balance sheet when subjected to capital regulation.

3.1 Incentives and Capital Requirements

Early efforts to consider a broader range of bank balance-sheet adjustments in response to capital-regulation-altered incentives have been based on Klein (1971)-type models of the type surveyed in Baltensperger (1980). One of the first studies examining the implications of regulatory restraints in this type of framework is Mingo and Wolkowitz (1977). As in Klein, these authors contemplate a static model of the banking firm in which the public's loan demand and deposit supply are imperfectly elastic to an individual bank, thereby allowing within-firm solutions for both balance-sheet quantities and loan and deposit rates. Mingo and Wolkowitz propose a bank "soundness function" that is a weighted average of assets and liabilities, and they examine comparative-static effects on a bank's balance sheet and loan and deposit rates resulting from incentive effects created by a regulatory tightening of a soundness requirement.

Considerable work since Mingo and Wolkowitz has likewise contemplated bank models in which banks confront a capital requirement rather than a regulatory soundness requirement. In most cases—although there are exceptions noted below—the assumption of imperfect asset and liability elasticities is replaced with the assumption of perfectly elastic loan demand and deposit supply, implying that representative banks interact in perfectly competitive loan and deposit markets. Furthermore, various authors include other factors theorized to influence the impact of capital regulation on bank incentives and balance-sheet choices. To make models of the effects of capital regulation on bank decision-making more tractable, authors commonly simplify the range of available asset portfolio choices to model banking firms. It is commonplace, for example, to consider choices between a single "risky" asset and a single "riskless" asset, although some authors consider a slightly larger range of asset choices.

The original Klein-type model first utilized by Mingo and Wolkowitz is static. Modern models of constrained bank balance-sheet adjustments to capital requirements typically include dynamic elements. Naturally, they also focus on the effects of modern risk-based capital regulation. Estrella (2004a), for instance, develops a model of “staged” decisions by a bank facing elements of all three pillars of Basel II. In the first stage, the bank must meet a minimum risk-based capital requirement. In the second stage, the bank must raise funds in the debt market to acquire one of two risky investment assets. In the third stage, the bank obtains a signal about its performance that it may or may not fully pass along to a regulator. Market constraints limit the amount of debt that the bank can issue. The outcome is three types of banks: a bank that cannot raise sufficient funds to invest in an asset and closes down, a bank that meets the capital constraint and must issue debt, and a bank that has sufficient capital to invest without issuing debt and that by assumption invests “excess capital” in a riskless asset. A bank regulator’s problem is to try to induce a bank to make choices consistent with its own objectives. Higher capital pushes bank’s preferred outcomes closer to those of the regulator but fails to bring them into complete alignment. This gap can be further narrowed by greater regulatory effort focused on less-capitalized banks. Market discipline also helps close the gap, but it cannot guarantee the first-best result from the regulator’s point of view. Estrella suggests that regulatory precommitment to an ex post penalty theoretically could exactly close the gap but notes this approach may or may not be practical.

In addition, Blum (1999) offers a two-period approach showing that the value of equity in later periods is altered when risk-based capital requirements bind. In Blum’s model, banks can choose to hold either riskless or risky asset portfolios. Higher expected profits in the second period induce an unregulated bank to reduce risk in the first period to decrease the probability of failure and thereby improve the likelihood of receiving second-period profits. On the one hand, a tighter risk-based capital

requirement imposed in the second period reduces that period's profits in the case of success and hence induces more risk-taking in the first period. On the other hand, a tighter risk-based capital requirement imposed during either the first or second period induces a decline in the feasible allocation of funds to risky assets, thereby reducing risk. When capital requirements bind in the first period only, the latter effect dominates, and risk falls. When capital regulation constrains the bank only in the second period, however, risk increase. Blum finds that if capital requirements bind in both periods, the effect on risk is ambiguous.

Furthermore, Callem and Rob (1999) consider an infinite-horizon model in which a representative bank can expand equity only through retained earnings. Bank size is fixed at a normalized value of unity, so their analysis artificially abstracts from scale effects of capital regulation. Deposits are also fixed but costly. A bank can choose portfolio shares of a risky asset and a safe asset. It faces a capital surcharge if its capital is below a minimum standard amount. Both the asset portfolio and the capital position vary over time as a result of past choices and the realization of past risky investments.

The Callem-Rob infinite-horizon approach allows tracing through the effects of building up a capital cushion, which can ultimately lead a bank to take on more risk in the face of capital requirements, even though over a potentially large range of capital levels portfolio risk declines with increased capital. The authors consider calibrations of bank responses to capital regulation under various initial conditions using 1984-1993 data, which yields a cross section of calibrated investment choices of banks with different capital positions. This approach permits some consideration of heterogeneities in banks' responses but does not allow these heterogeneities to affect any market outcomes.

Callem and Rob find that a U-shaped relationship arises between capital position and risk-taking. Undercapitalized banks take on maximum risk. At first, risk declines

as capital increases, but risk can potentially increase as capital increases beyond a certain point. Also, premium surcharges on undercapitalized banks generate a widening of the range of capital levels over which undercapitalized banks take on maximum risk. Finally, market pricing of uninsured liabilities ("market discipline") may deter excessive risk-taking by undercapitalized banks, but only if risk is priced *ex ante* in response to changes in banks' portfolio risks.

Milne (2002) argues that the incentive effects generated by capital regulation have not received sufficient attention, because most of the literature assumes that capital requirements are viewed as *ex ante* binding constraints. He argues that the main effects of capital regulation operate through banks' efforts to avoid *ex post* penalties imposed by regulators if violations of capital adequacy standards take place. This perspective, Milne suggests, argues for seeking to reduce banks' risk-taking behavior by toughening regulatory penalties rather than assessing more stringent or more requirements tied to asset risks.

Although the above papers and most other recent work on bank capital regulation assume perfectly elastic supplies of assets and demands for liabilities on the part of the public, Hellmann, Murdock, and Stiglitz (2000) return to the original Klein/Mingo-Wolkowitz assumption of imperfect elasticities on the liability side of a bank's balance sheet. Specifically, Hellmann *et al.* consider a setting with monopolistically competitive deposit markets, in which the perfectly competitive limit of infinite elasticity of deposit supply yields a deposit rate equal to the riskless rate and a representative bank earns no profits. A representative bank can choose between holding a riskless ("prudent") asset with known return or a risky ("gambling") asset with a random return, which in a successful state is higher than the riskless asset's return. The opportunity cost of capital is higher than the rate of return on the riskless asset. If the bank chooses the risky asset and earns the lower return, it fails. In the general case of monopolistically competitive deposit markets, an equilibrium deposit

rate above a critical threshold yields each representative bank greater expected returns than investing in the risky asset. Hence, in an unregulated deposit-market equilibrium, banks hold undiversified portfolios consisting only of risky assets.

In the context of their model, Hellmann *et al.* find that imposing sufficiently stringent capital regulation reduces banks' incentive to mobilize as many deposits to fund risky assets and hence is Pareto improving, although when returns on assets and bank capital are endogenous, banks' incentives to take on greater asset risk increase when capital requirements are toughened. Hellmann *et al.* conclude, however, that combining a deposit rate ceiling [for an earlier examination of issues relating to deposit rate ceilings, see Lam and Chen (1985)] with capital regulation can unambiguously induce all banks to reduce investment in risky assets. Thus, their analysis provides a rationale for coupling capital regulation with deposit rate ceilings, effectively rejuvenating the old idea that unrestrained competition in bank deposit markets makes banks less safe.

Repullo and Suarez (2004) build on Hellmann *et al.*'s approach by applying a Salop-style model of spatial monopolistic competition to the market for deposits in a framework in which representative banks facing capital regulation choose between riskless and risky assets with exogenous returns. In the Repullo-Suarez model, banks are located equidistant along a unit circle, and overlapping-generations depositors face costs of moving between banks, which results in deposit demand that depends on the number of banks, the spread between banks' deposit rates, and the mobility cost. Each bank faces the resulting demand for its own deposits and chooses whether to invest in a riskless or risky asset in the face of a capital constraint. As in Hellmann *et al.*, Repullo and Suarez find that either imposing capital requirements or a deposit rate ceiling raises the bank's expected operating margin, which gives it greater incentive to invest in the prudent asset. In addition, however, risk-based capital requirements better constrain banks to prudent assets with less harm to depositors' welfare than deposit rate ceilings.

Repullo (2004) provides an alternative analysis of capital regulation in a Hellmann *et al.*-style setting with imperfect competition in deposit markets and moral hazard in lending, but in the context of overlapping generations of depositors. As in Repullo and Suarez, his basic conclusion is that capital requirements are always effective in controlling bank risk-taking incentives. He finds that deposit rate ceilings can potentially expand the range of equilibria in which banks choose high-risk portfolios. Repullo's analysis also suggests potential differences in effectiveness of risk- versus non-risk-based capital regulation. Furthermore, it indicates that regulations intended to discourage banks from selecting high-risk portfolios are more likely to be successful when banks' market power is greatest, so that banks have less incentive to gamble.

There are good reasons to wonder whether the idea of coupling capital regulation with deposit ceilings would actually achieve real-world welfare improvements forthcoming in the model banking systems proposed by Hellmann *et al.*, Repullo, and Suarez, and Repullo. In these papers, asset returns are unaffected by capital regulation, but in reality asset returns—for instance, market loan rates—should respond to market forces that depend in part on the decisions that banks make when faced by capital requirements. In addition, the presumed structures of deposit markets in both studies impose an implicit assumption that there are no close substitutes for bank deposits. Thus, both analyses hinge on the hypothesis that deposit rate ceilings can be imposed without inducing disintermediation, even though the U.S. experience with such ceilings during the 1960s and 1970s indicates that this hypothesis receives little empirical support.

3.2 Moral Hazard, Demandable Debt, and Capital Regulation

A large part of the banking literature emphasizes the various types of moral hazard problems confronted by banks, so it is not surprising that this topic receives

considerable attention in work analyzing bank capital regulation. Indeed, theories of bank capital increasingly focus on how agency and moral hazard problems influence a bank's capital choice and more broadly influence its entire balance sheet.

Obviously, when banks are constrained by capital requirements, regulator-determined capital and market capital are not equal. Berger, Herring, and Szegö (1995) provide a helpful discussion of various rationales for regulator-determined versus market capital ratios in light of the Modigliani-Miller theorem. In the absence of capital regulation, they argue, key motives for bank equity relate in part to a trade-off between providing a cushion by issuing equity and gaining tax advantages from debt issuance. Furthermore, Berger *et al.* suggest that in the presence of asymmetric information, (i) higher bank equity signals to capital markets that bank insiders consider their assets to be riskier; (ii) agency conflicts may develop among bank shareholders, managers, and creditors, such that “[h]igher capital avoids expropriation problems between shareholders and creditors but aggravates conflicts of interest between shareholders and managers” (p. 399). Nevertheless, government safety-net guarantees reduce the incentive to issue equity shares, causing market capital levels to be artificially reduced. Hence, banks face a number of agency problems and associated moral hazard risks that impinge on the capital decision without and with capital regulation.

One perspective emphasizes the role of moral hazard problems on the liability side of banks' balance sheets. Diamond and Rajan (2000, 2001) are important contributions in this vein. Building on earlier contributions by Diamond and Dybvig (1983) and Calomiris and Kahn (1991), Diamond and Rajan (2000) develop a theory of banking in which fragility to runs commits banks to creating liquidity, thereby enabling depositors to withdraw upon demand while buffering borrowers. In their view, financial fragility incorporated through demand deposits allows a bank to fund itself at low cost, disciplines bank rent extraction, and enables the bank to provide liquidity to both depositors and borrowers.

Diamond and Rajan (2001) build on this approach to develop a theory of bank capital. They trace decision trees for entrepreneur/borrowers, banks/lenders, capital/debt holders, and depositors, and work out conditions for various choices by all agents. A key implication of their emphasis on financial fragility on the liability side of the bank's balance sheet is that the demandable nature of deposits is crucial to explaining a bank's optimal capital choices. The potential for a deposit run serves to discipline the bank, and the main role of capital is to give a bank a party with which it can negotiate when a bad outcome occurs—essentially a rationale for the old "capital-as-cushion" idea. A clear-cut implication of their analysis is that a bank's leverage ratio should increase when the underlying liquidity of projects increases—which they note is consistent with the upward trend in leverage ratios over the past decades. The model yields separating equilibria in which, depending on their capital structures, banks seek out particular entrepreneurs to whom to lend.

Within the Diamond-Rajan (2001) framework, the short-run effects of binding capital requirements are a credit crunch for cash-poor borrowers and smaller loan repayments for cash-rich borrowers. Thus, capital requirements have redistributive effects among borrowers. Diamond and Rajan also find that capital requirements can actually increase the chance of a run, because the requirements encourage banks to liquidate sooner, effectively reducing the amount they collect and their ability to honor deposit contracts. In the long run, Diamond and Rajan conclude (p. 2455), capital regulation has "...subtle effects, affecting the flow of credit and even making the bank riskier." They continue: "These effects emerge only when the capital requirements are seen in the context of the functions the bank performs rather than in isolation." Deposit insurance only complicates things when *all* deposits are insured, in which case, "deposits are essentially no different from capital" (pp. 2455-6). If some deposits are uninsured, then the basic results about capital in their paper still go through because the uninsured deposits provide a motivation for capital.

The Diamond-Rajan analysis has additional implications. One is that requiring so-called “narrow banking,” in which funds from long-term liabilities must be allocated to illiquid assets and funds from demand deposits must be allocated to highly liquid paper, would curtail bank liquidity creation and result in lower credit availability to borrowers. Another is that “prompt corrective action” is useful when deposit insurance exists, because it maintains discipline on banks.

Cooper and Ross (2002) draw on the liability-focused approach to evaluate the interplay of deposit insurance and capital regulation in an environment susceptible to liquidity crises and bank runs. In the context of a basic Diamond-Dybvig two-period consumption model with risk-averse depositors and moral hazard, depositor monitoring can induce the bank to adopt the depositors’ desired portfolios. Although deposit insurance removes the threat of bank runs, it reduces the incentive for depositors to monitor the bank’s asset choices. A sufficiently high capital requirement related to the level of deposits induces the bank to choose safer assets, thereby mitigating the moral hazard problem that depositors face.

In contrast, Dowd (2000) argues that maintenance of a sufficient capital cushion can in fact fully solve the financial fragility problem emphasized by Diamond and Rajan. Dowd re-evaluates the original Diamond-Dybvig motivation for deposit insurance by adding a third agent who provides capital and charges a liquidity insurance premium (implicit and deducted from the return paid to depositors). The provision of liquidity insurance by a capitalized “bank” prevents a “run” as long as sufficient capital is provided. Thus, in Dowd’s view sufficient capital prevents liquidity crises from occurring. A follow-up paper by Marini (2003) builds on Dowd’s analysis to argue as well that market-capitalized banks also should not experience insolvency crises. Taken together the Dowd and Marini arguments suggest that market-determined levels of bank capital can substitute for both regulatory oversight and a financial safety net.

3.2 Moral Hazard, Bank Lending and Monitoring, and Capital Regulation

Work by Diamond (1984, 1991) and others has emphasized the key role that banks play in monitoring loans for moral hazard risks on the asset side of banks' balance sheets. An interesting examination of how capital requirements alter the incentives that banks face in monitoring loan quality is contained in the analysis of Besanko and Kanatas (1996). Building on Gennotte and Pyle's analysis of bank portfolio management when non-zero net present value investments are considered, Besanko and Kanatas emphasize the joint effects of deposit insurance and capital requirements, with a representative bank able to fund itself at the risk-free rate and make net-positive-present value loans that ensure a positive surplus to shareholders. Besanko and Kanatas analyze a setting with a representative bank and four agents—bank insiders, bank outsiders, depositors, and a bank regulator. Existing “insider” shareholders own part of bank's equity, make loan portfolio decision in the first period from an endowment of risky loan opportunities, and make a decision about disutility-generating effort that increases the probability of loan repayment. Complying with a capital requirement requires raising more equity from new, “outsider” shareholders.

In the analysis of Besanko and Kanatas, requiring a bank to substitute equity for deposit financing through capital regulation cuts into shareholders' surplus. This creates a potential for an agency problem to arise when the bank must issue new equity to meet a capital adequacy requirement. New "outsider" shareholders help compensate existing, “insider” shareholders by paying a market rate of return on equity. Nevertheless, "insiders'" portion of the surplus contingent on loan repayment declines, which induces insiders to put less effort into realizing a positive-net-present-value loan outcome. Thus, faced with dilution of their surplus, inside shareholders have less incentive to monitor loans, so the probability of loss on loans increases. Because participants in the market for bank equity shares realize that insiders will become less productive monitors, the bank's market value drops. A subsidiary implication is that the

regulator must engage in costly monitoring to make sure that insiders do not cut back on monitoring. This places a burden on regulators that, together with the drop in banks' market values, give regulators an incentive to ignore the capital requirement.

Campbell, Chan, and Marino (1992) also consider a model in which monitoring for moral hazard risks is an important function of banks. They examine a representative-bank model in which depositors (or agents they hire, such as a deposit insurer) either monitor banks or impose capital requirements. In the Campbell *et al.* framework, all agents are risk-neutral, and banks can choose between two investment projects with the same returns in three states but with different probabilities of arising in the three states. Depositors/insurers choose the capital ratio and/or effort devoted to monitoring to obtain signals of the probability differences, but they do so not knowing the difference in underlying probabilities of project returns. A bank, which knows these probability differences, chooses the promised payment to depositors that maximizes the return on the bank's portfolio of projects, subject to the capital/monitoring choices of depositors/regulators and subject to a break-even condition in which the gross portfolio payoff is at least equal to the initial capital investment. In this setting, depositors/insurers desire to increase both monitoring and capital requirements when overall portfolio risk increases the incentive. If problems for monitoring become more severe, however, monitoring and capital requirements are substitutes. Then depositors/insurers prefer to increase capital requirements and engage in less monitoring.

In Santos (1999), two sources of moral hazard exist simultaneously: one moral-hazard issue involving the bank relative to the deposit insurance provider and another involving the borrower and the bank. In his model, risk-neutral entrepreneurs earn additional rents when projects succeed, and risk-neutral banks face a cost of capital that exceeds the risk-free rate and capital regulation. Payments to the bank from the entrepreneurs are negotiated in advance, and the bank cannot observe the entrepreneurs'

effort levels. Depositors are risk-averse, and a deposit insurer charges banks a flat-rate deposit insurance premium that is anticipated to allow the insurer to break even. The benchmark for evaluating outcomes under moral hazard is the first-best equilibrium in which there are no moral hazard problems. Santos applies this setup to an evaluation of first- and second-best contracts without and with sources of moral hazard in representative banks' lending and deposit-insurance relationships and of the manner in which tougher capital requirements affect those contracts.

Because capital is more expensive than deposits in Santos' framework, banks always choose the minimum capital level specified by regulators and hence are always bound. The optimal contract between a bank and an entrepreneur entails the bank extending a loan *and* having an equity stake in the firm, but the contract is distorted by deposit insurance. Increasing the required capital standard results in a contract adjustment that takes into account both higher costs that would have been incurred in bankruptcy when its leverage was lower and the higher cost of required capital. The result is lower bank risk of insolvency. Hence, capital regulation unambiguously reduces bank risk.

Decamps, Rochet, and Roger (2004) propose an alternative analysis of the interaction between capital regulation and bank monitoring based on continuous-time finance. The focus in this study is placed on continuous-time cash flows and implied market and book values of a representative bank with and without capital requirements. The ambitious Decamps *et al.* model also contemplates required issuance of subordinated debt and regulatory auditing of the bank's condition. In the model environment, a representative bank receives one of two cash flows, depending on whether it incurs a monitoring cost to use a "good technology" to monitor its cash flow. Not incurring this cost and choosing a "bad technology" always generates a negative cash flow. For a "not-too-small" monitoring cost, there is a region over which the market value of using bad technology exceeds the market value of using good

technology, so that a bank shirks and sets itself up for eventual failure. If the monitoring cost is sufficiently large, bank shareholders close the bank on their own when appropriate.

Decamps *et al.* apply their model to an analysis of the three pillars of the Basel II proposal. They find that implementing a capital (“solvency”) requirement, under which banks become illiquid before they become insolvent, can allow the regulator to determine when the cash flow is sufficiently small (or, equivalently, the monitoring cost is sufficiently high) that the bank will opt for the “bad technology” and close the bank. In addition, if banks’ cash flows are unobservable to regulators without prohibitively costly monitoring, then a higher capital ratio would be required to deter shirking; requiring the bank to issue subordinated debt with a payoff contingent on its cash flow would reveal the cash flow and save the regulator from having to incur the cash-flow monitoring cost. Requiring subordinated debt reduces the bank’s market value but allows for a lower capital requirement while inducing the bank to choose the good technology. Furthermore, they find that when subordinated debt is required, the regulator can infer a cash flow below which it will audit the bank. Mixing this audit policy and capital regulation yields an optimal mix of the two—provided that market securities prices are not so volatile that they fail to yield information about actual cash flows and that regulators are not subject to political interference.

3.4 Balance-Sheet Adjustments Induced by Bank Capital Regulation: Summing Up

Broadening the range of permitted balance-sheet adjustments and taking into account bank monitoring to contain moral hazard risks expands further the range of factors that ultimately influence banks’ responses to capital regulation. Banking theories offering more support for safety-and-soundness enhancements due to the imposition of capital requirements emphasize deposits’ role as demandable debt and the potential for deposit markets to be imperfectly competitive. This may be due in part to the emphasis

that these theories place on the potential for bank runs or adverse effects of excess competition in deposit markets and a de-emphasis on the risk implications for bank asset portfolios.

Models that reverse the relative emphases placed on the asset and liability sides of the balance sheet and that consider banks' role as monitors for moral hazard risks are typically more likely to indicate that capital regulation does not necessarily improve bank safety and soundness. Some theories indicate that capital regulation alone cannot usually produce a regulator's preferred outcome without supplementing capital requirements with supervisory or market discipline, thus implying that capital regulation complements other forms of regulation along lines assumed by the framers of the Basel II standards. Nevertheless, some theories indicate that capital requirements and other types of regulation may be substitutes instead of complements, implying perhaps that in some circumstances capital regulation could prove to be superfluous.

Most broad banking models indicate that banks respond to capital regulation by reducing lending. Whether the loans extended and the overall range of balance sheet risks declines or increases tends to be model-specific. Consequently, considering a range of balance-sheet adjustments in response to incentives created by capital regulation yields mixed implications of capital requirements for overall bank safety and soundness.

4. Capital Regulation, Adverse Selection, and Monitoring in a Diverse Banking System

Most of the literature examining the role of asymmetric information as a factor influencing the effects of capital regulation on bank decision-making focuses on moral hazard problems faced by representative banks. Nevertheless, some attention has also been given to how adverse selection problems influence the impacts of capital

regulation. In addition, recent work has begun exploring how differences among banks can affect market outcomes under capital requirements.

4.1 Adverse Selection and Capital Regulation

Thakor (1996) offers a unique analysis of the effects of capital regulation on bank behavior that focuses attention on implications for bank screening of prospective borrowers in the face of the possibility of adverse selection (banks also monitor borrowers *ex post*). Thakor considers settings with both a monopoly bank and multiple, representative banks. In the latter case, a Nash equilibrium reflects each bank's strategy to select an interest rate at which it is willing to lend to a screened borrower in order to maximize its profits net of screening costs it incurs. In equilibrium, a loan applicant's probability of being rationed and receiving no credit increases with a higher cost of funds, which can result from a tightened capital adequacy requirement. Hence, a toughened capital requirement results in more loan rationing on the part of banks. Aggregate bank credit declines.

Deposit insurers and bank regulators must also screen applicants for banking licenses in an effort to combat adverse selection problems that they confront. This is the topic of a recent contribution by Morrison and White (2005) that emphasizes regulatory screening ability as a factor influencing the optimal setting of capital requirements. Morrison and White build on work by Holmström and Tirole (1997) to examine an economy inhabited by diverse agents, each of whom has a dollar to invest in projects that either succeed or fail. A fraction of agents with the capability to monitor projects ("sound" agents) are able to increase the probability of a higher return by so doing. Agents can alternatively deposit their endowments with other agents who act as "banks" and pay a fee to the bank for the opportunity to receive the return on a successful project, though neither banks nor depositors earn any gross return when projects fail. Thus, an agent can manage his own project, run a bank and raise deposits

to augment his own investment, or deposit his funds with (an)other agent(s). Naturally, because sound agents can earn higher returns, welfare is maximized when all funds are handled by sound agents. In a constrained-efficient equilibrium, every sound agent operates a bank and engages in monitoring. Monitoring must be incentive compatible for sound agents, requiring earnings derived from deposits—the differential between the bank’s return on investment and the lower rate it pays depositors—to be sufficiently large to cover their monitoring costs.

Morrison and White find that an unregulated (no entry restrictions) banking system can be efficient (only sound agents open banks) only if the cost of monitoring is sufficiently small. Thus, if monitoring costs are above a critical level consistent with efficiency, regulators may be able to increase efficiency by imposing capital adequacy requirements, restricting entry via screening and licensing, and/or auditing banks. Tight regulatory policy that includes relatively high capital requirements is more likely to improve efficiency if regulatory screening ability is low. If regulators have high screening ability, then looser regulatory policy with lower capital requirements can improve efficiency. In the event of a banking crisis arising from a shift from optimistic to pessimistic expectations (which only can occur if regulators are not of very strong ability), weaker-ability regulators will tend to toughen capital requirements, and stronger-ability regulators will tend to weaken capital requirements.

4.2 Capital Requirements and Heterogeneous Banks

By its nature, Morrison and White’s (2005) analysis of adverse selection effects of capital requirements requires consideration of heterogeneous banks. Contemplating different banks within the same model is a novel idea in the literature examining the effects of capital regulation on bank behavior. Studies have almost exclusively focused attention either on responses by a single, presumably “representative” bank or on a banking system made up of identical banks.

One recent effort to consider heterogeneous responses to capital regulation is provided by Almazon (2002). In Almazon's model, banks balance capital versus monitoring expertise, which is proxied by selected distance of bank from borrower. If the bank locates itself farther from a borrower, then it must commit more capital, so that "capital is a tool that allows a bank to offer lower loan rates without affecting its incentives to monitor" (p. 89). Almazon considers three types of agents—investors who own uninformed capital, entrepreneurs who lack capital but are endowed with projects yielding risky payoffs, and *two* banks endowed with capital and possessing monitoring technology. If a bank incurs a cost, it can reduce the borrower's private benefit from pursuing a higher-risk project.

Almazon considers two settings. One is an environment in which location (and hence expertise) is fixed. If there is just one bank, then the distance of the marginal project from the bank decreases (that is, bank's expertise increases) with increases in monitoring cost, the riskless interest rate and the size of entrepreneur's private benefit, or with decreases in the net present value of the entrepreneur's project and the bank's capital. In the case of two banks, with one bank endowed with more capital than the other, there are four possible equilibrium outcomes: scarce capital with no interactions between banks, plentiful capital with no rents to banks and hence no monitoring, a case in which only one bank monitors, and a case in which both banks monitor. Almazon focuses on the last equilibrium, in which greater overall capital leads to higher market share for a bank endowed with more capital and in which a rise in the riskless interest rate favors this bank also, with the implication that contractionary monetary policy hurts smaller banks more than larger banks.

In the second setting, location (expertise) is endogenously determined. The key finding in this setting is that the bank endowed with less capital prefers more "separation" from the other bank. Hence, the low-capital bank prefers to specialize in a niche involving less monitoring.

Kopecky and VanHoose (2006a,b) consider environments in which a portion of banks monitor their loans for moral hazard risks and a portion do not. Those banks that do monitor are able to reduce loan losses generated by moral hazard risks, but to obtain the resulting higher loan returns they must incur a monitoring cost that is increasing in the quantity of loans. In Kopecky and VanHoose (2006b), monitoring costs vary across banks that otherwise are identical in other respects, including exogenously predetermined levels of equity. Banks balance the costs of monitoring against the benefits, which depend on the market loan rate that in turn varies with the collective lending choices of both monitoring and nonmonitoring banks that sum to the aggregate supply of loans. Imposing capital requirements obviously alters the terms of the cost-benefit analysis of constrained banks contemplating whether or not to monitor. In addition, capital regulation influences the market loan rate and thereby affects the cost-benefit analysis of *unconstrained* banks as well. In the context of this framework, Kopecky and VanHoose (2006b) find that when capital requirements suddenly fully or partially constrain the banking system, lending declines, but so does the equilibrium share of banks that optimally choose to monitor their loans for moral hazard risks. On net, therefore, aggregate loan quality may improve or worsen.

Kopecky and VanHoose (2006a) consider a long-run horizon in which groups of banks with differing monitoring costs are able to determine equity levels that maximize market values depending on whether they monitor. Each group of banks compares the market value of equity with and without monitoring, thereby selecting *ex ante both* the value-maximizing amount of equity to issue *and* the mode of operation—costly monitoring versus nonmonitoring—to pursue. In equilibrium, both groups of banks may choose not to monitor, one group may choose to monitor, or both groups may choose to monitor. In any of these three equilibria, the model indicates that a binding capital requirement typically induces an inflow of equity into the banking system. Because the two groups of banks are different, however, equity flows differ between the

two groups. Kopecky and VanHoose find that *nonmonitoring* banks that face lower costs in expanding their scale receive a larger share of this equity inflow than monitoring banks. Thus, even in the long run, capital regulation does not necessarily lead to higher-quality aggregate lending by the banking system as a whole.

In the analytical frameworks considered by Kopecky and VanHoose, banks are endowed with different monitoring costs and benefits. In contrast, Boot and Marinc (2006) examine a setting in which diverse banks make costly investments in monitoring technologies. The magnitudes of these investments in turn alter the forthcoming benefits derived from monitoring. Boot and Marinc consider a capital-regulated environment throughout and hence do not compare their results with those that would follow in a capital-unconstrained banking system. In this capital-constrained setting, banks endowed with “good” or “bad” quality types take into account the behavior of all market rivals when choosing both loan rates to offer to borrowers and investment expenses to incur in monitoring technologies. “Good” banks choose to undertake more monitoring investment than “bad” banks.

In Boot and Marinc’s model, higher regulatory capital requirements reduces the size of the deposit insurance subsidy received by all banks and thereby gives banks a greater incentive to internalize risks. “Good” banks respond by seeking to reduce their risks by investing more in monitoring technologies, which enables them to reduce their per-unit costs and expand their market shares. In contrast, for “bad” banks the resulting changes in competition involving loan rates and monitoring technologies boosts per-unit costs and causes them to lose marginal borrowers. Hence, in the near term tougher capital regulation strengthens high-quality banks at the expense of low-quality banks, which suffer drops in their market values.

In the longer term, one possible implication—one of several interesting predictions—of the Boot-Marinc analysis is a strengthened banking system as capital regulation ultimately weeds out the weakest banks. Boot and Marinc show, however,

that at intermediate levels of quality and sufficiently high degrees of competition, a banking system open to entry could experience a reduction in monitoring incentives. Thus, as in Kopecky and VanHoose (2006a), but through a different set of channels, the impact of capital regulation on aggregate loan quality is ambiguous.

4.3 Adverse Selection and Monitoring with Heterogeneous Banks: Summing Up

Thakor focuses attention on adverse selection and banks' screening role and finds that capital regulation can also induce banks to restrict overall lending by screening out more borrowers. Morrison and White emphasize the adverse selection problems faced by regulators and conclude that the regulators most likely to rely on capital regulation are those who have the most difficulty performing their own screening and supervisory functions.

Almazan and Kopecky and VanHoose explore how capital requirements exert effects in diverse banking systems. Almazan's work indicates that low-capital banks may tend to choose to engage in less monitoring activity, which presumably indicates that regulation aimed at boosting capital at such banks may induce more monitoring for moral hazard risks. Kopecky and VanHoose, however, find that explicit consideration of heterogeneous banks' choices about whether to monitor does not favor the conclusion that capital regulation necessarily increases the percentage of loans subjected to monitoring, the share of banks that choose to monitor, or the proportion of equity flowing to monitoring banks. Boot and Marinc offer a generally more positive assessment of the long-run effects of capital regulation on the overall quality of loan monitoring throughout the banking system, though their analysis also suggests the potential for ambiguous outcomes.

In sum, taking into account adverse selection issues and institutional diversity within the banking system also yields ambiguous implications regarding how capital regulation might affect overall bank safety and soundness.

5. Systemic and Macroeconomic Implications of Capital Regulation

In the finance literature, the effects of capital regulation are typically examined at the level of individual banks and from time to time at the level of the banking system as a whole. Financial economic analyses of the implications of capital requirements tend to treat the rest of the economy as exogenous.

In fact, as noted by Bliss and Kaufman (2003), to the extent that the bank capital regulation impinges on the overall operation of and balance-sheet responses of the banking system as a whole, capital requirements potentially can affect the broader economy. Of course, such macroeconomic-level responses to capital requirements can, at least in principle, feed back to influence the safety and soundness of individual banks and of the banking system. Furthermore, to the extent that bank capital regulation might affect the manner in which monetary and real shocks are channeled to output and prices, the structure of capital requirements also can influence the monetary policy transmission mechanism. Indeed, bank regulators conceivably could find themselves in conflict with monetary authorities.

5.1 Procyclical Features of a Capital-Regulated Banking System

Borio (2003) notes that under Basel II, minimum capital would change alongside a bank portfolio's perceived riskiness. As a consequence, Borio suggests, capital requirements could increase considerably during periods encompassing economic downturns that in turn raise bank portfolio risks. As discussed above, one consequence of automatically stiffer capital requirements would likely be enhancement of the short-term decrease in lending already accompanying the recession. Another consequence would be a rise in the market loan rate, which in turn could, directly through a lending channel or indirectly through an interest-rate channel, reinforce the economic downturn. In this way, risk-based capital regulation might add to the

procyclical relationship already inherent in bank credit markets and the economy.

Borio proposes factors that might limit procyclical dimensions of bank capital regulation, such as greater market transparency and more supervisory discretion—the other two pillars of Basel II—which he suggests could help limit the extent to which capital actually responds to downturn-induced boosts in risks. Nevertheless, as noted by both Borio and Bliss and Kaufman (2003), the fact remains that by design, risk-based capital regulation has a procyclical tendency.

To examine the potential for procyclicality, Estrella (2004b) examines a dynamic, forward-looking model in which a bank chooses an optimal path for its balance sheet based on its rational expectation of loan losses. He presumes that the mean path for these losses is cyclical and shows via simulations that a risk-based capital requirement applied to a bank's overall capital level is likely to have procyclical effects on bank lending. Estrella suggests that the procyclical tendency can be mitigated by “judicious calibration” of minimum capital requirements during a downturn.

Pennacchi (2005) suggests that the procyclical features of risk-based capital regulation can be reduced through risk-based deposit insurance. By combining both approaches to constraining the deposit insurance guarantee and subsidy, Pennacchi argues, regulators could require less adjustment in bank capital to a recession-induced increase in asset risk, with banks required instead to pay higher deposit insurance premiums via a system involving a moving average of deposit insurance contracts. Of course, increased deposit insurance premiums induce declines in deposits that can also generate a decrease in lending (though this effect would be offset somewhat by somewhat lower insurance premium payments on the lower deposit base). Nevertheless, Pennacchi concludes that the result would be less procyclicality than under capital regulation alone. He utilizes U.S. bank data for the period 1987 to 1996 to illustrate how adoption of such a scheme would smooth out cyclical influences, thereby dampening the inherent procyclicality of risk-based capital regulation.

Pederzoli and Torricelli (2005) offer an alternative suggestion for reducing the procyclical tendencies of bank capital regulation. They suggest adjusting capital requirements based on *ex ante anticipations* of asset risk changes instead of *ex post observations* of altered risks. Even though procyclical effects would remain under their proposal, Pederzoli and Torricelli argue using 1971-2002 U.S. data that forward-looking adjustments of risk-based capital requirements would considerably smooth peaks and troughs of the requirements over the business cycle.

Catarieneu-Rabell *et al.* (2003) suggest that the rating system that banks utilize to implement risk-based capital requirements could greatly influence procyclicality under the proposed Basel II system. Utilizing rating schemes that are more stable over cycles, they argue, such as those produced by external rating agencies, would not contribute to the procyclical tendencies of capital regulation. Catarieneu-Rabell *et al.* conclude that, in fact, banks would have greater short-run profit incentives to adopt a rating system conditioned on the current point in the cycle, which could substantially add to lending procyclicality, potentially contributing to macroeconomic instability. Thus, capital regulation coupled with banks' of rating systems conditioned on points in cycles could have an unintended effect of boosting procyclicality, which macroeconomic policymakers would have to take into account.

Gordy and Howells (2004) conduct simulations of bank portfolio volatility under different rating systems and reach more sanguine conclusions. They find that "empirically realistic" rules guiding banks' reinvestment strategies considerably reduce the additional procyclicality associated with capital regulation.

5.2 Monetary Policy Implications of a Capital-Regulated Banking System

To the extent that monetary policy actions operate through a bank lending channel as well as through real-balance, interest-rate, and open-economy channels, bank capital requirements can potentially impinge on the monetary policy transmission

mechanism. One of the earliest attempts to examine the macroeconomic implications of bank capital regulation is Blum and Hellwig (1995). In their model, desired investment depends on output prices, the interest rate, firms' profits (which in turn depend on real income), and the supply of bank loans. With bank lending constrained by a risk-based capital adequacy requirement, desired investment ultimately must be constrained as well, and the *sensitivity* of desired investment to changes in output and prices is also altered. When the standard income-expenditure-equilibrium condition is satisfied and assuming an unchanged price level, under specific parameter configurations the response of real income to an expenditure shock is larger in the presence of capital requirements. By implication, aggregate demand is more volatile in the face of capital requirements, which will tend to add to output and price-level volatility.

Cecchetti and Li (2005) introduce three additional features into the Blum-Hellwig approach: an optimizing central banker, a supply shock, and a revised deposit demand specification. Financial-sector framework essentially consists of an *IS-LM*-style macro model supplemented by inclusion of a binding capital requirement ratio, an interest-rate-based monetary policy procedure, and an upward-sloping aggregate supply function with a linear supply shock. Essentially, binding capital requirements constrain lending and investment and thereby can enhance the response of equilibrium income to demand and supply shocks. The monetary authority regards the main potential effects of binding capital requirements as induced changes in the shape and/or volatility of the *IS* schedule. One consequence, as in Blum-Hellwig, is that capital requirements can potentially amplify demand-side shocks. Another is that capital regulation can also enlarge the effects of supply-side shocks. Through both demand- and supply-side channels, therefore, capital regulation can add to the effects of shocks on economic activity.

Cecchetti and Li assume that the monetary authority minimizes a weighted sum of inflation and output gaps. It sets an interest-rate instrument—that is, determines the

position of the resulting horizontal *LM* schedule—in a manner that takes into account any procyclical bias arising from regulatory capital requirements. This requires expanding the monetary base sufficiently in response to capital-requirement-enhanced negative demand or supply shocks to compensate for the resulting capital and credit deterioration. In this way, the monetary authority stabilizes aggregate demand in the face of demand shocks, and it moves aggregate demand into the proper position to balance central bank inflation and output objectives optimally in the face of aggregate supply shocks. Hence, Cecchetti and Li view capital regulation as requiring adjustments by monetary authorities but do not view such requirements as an impediment to the effective conduct of monetary policy.

Of course, the interplay between a bank regulator and a monetary authority could be more complex than in the analyses of Cecchetti and Li, which presumes that the monetary authority can react more quickly to events than a bank regulator. In contrast, Seater (2001) provides a macroeconomic framework in which a bank regulator and the monetary authority simultaneously conduct regulatory and monetary policies. Seater's analysis suggests that *coordinated* bank regulatory and monetary policies both influence the mean and variance of aggregate output.

An obvious theoretical limitation of the Blum-Hellwig/Cecchetti-Li approach is that it fails to fully account for endogenous responses of the banking system to regulation. Chami and Cosimano (2001) explicitly account for such responses by banks in the context of a dynamic representative-bank model in which oligopolistic banks recognize in the current period the *potential* for capital requirements to be binding in a future period. In their framework, banks at each time base their lending on forward-looking marginal returns on and marginal costs of loans, which take into account responses of capital in the presence of capital regulation. Thus, even banks that are not currently constrained by binding capital requirements must take into account the probability that capital requirements might bind in future periods. Consequently,

monetary policy's effects on net interest margins influence choices by *all* banks, including those not currently facing binding capital requirements, when they determine dynamic lending paths. Furthermore, the Chami-Cosimano model indicates that banks have an incentive to respond to capital regulation by holding *more* capital than required, thereby maintaining a capital buffer that permits a contemporaneous expansion of lending when desired without necessarily placing themselves in a position of being bound by capital regulation in a later period.

As in Blum and Hellwig and in Cecchetti and Li, Chami and Cosimano's analysis indicates that capital requirements make lending more procyclical. Chami and Cosimano also conclude, however, that capital regulation generates *asymmetric* monetary policy effects depending on whether policy actions are expansionary or contractionary. They suggest that in the case of an expansionary monetary policy action, there is a single, "financial accelerator" effect that occurs as the demand for loans increases. This generates a rise in banks' net interest margins, thereby inducing them to expand capital and loans.

This financial accelerator effect also works in reverse in the case of a contractionary policy action. In the case of a monetary contraction, however, Chami and Cosimano propose the existence of a second, "bank capital accelerator" effect, in which the banks' option value of issuing capital decreases because the capital constraint is less likely to be binding in the future. This induces direct balance-sheet responses within the banking system that reinforce the financial accelerator effect. Banks reduce both capital and loan supply, hence both loan demand and loan supply contract. Because monetary contractions give rise to both financial accelerator and bank capital accelerator effects while monetary expansions yield only financial accelerator effects, monetary contractions induce stronger effects on bank credit than monetary expansions.

Van den Heuvel (2002, 2003) also considers a forward-looking dynamic model of a capital-regulated financial system. Van den Heuvel's model, however, emphasizes

the potential for loans to go bad at future dates together with maturity mismatching issues. As a consequence, capital regulation can cause even banks not facing immediately binding capital requirements to adjust the dynamic path of their lending. Total bank lending thereby responds differently to monetary policy actions when capital adequacy regulations are in force, with low- and high-capitalized banks choosing different lending paths.

Most studies predict that the immediate effect of binding risk-based capital requirements is an unambiguous reduction in aggregate bank lending. Thakor (1996) suggests capital regulation also potentially reduces the ability of monetary policy expansions to boost bank lending. This possibility exists because in his framework capital requirements induce tougher screening by banks, which thereby fail to respond to a monetary expansion by increasing lending as much as they would have in a capital-unrestricted setting. Instead, banks are more likely to respond to a monetary expansion by boosting deposits and security holdings, thereby operating more like mutual funds.

In the context of a basic credit-multiplier framework with representative profit-maximizing banks but unchanged market interest rates, Kopecky and VanHoose (2004b) also conclude that binding capital requirements induce a decline in aggregate loans and alter the effects of monetary policy actions in the short run. In addition, binding capital regulation tends to induce banks to engage in a net expansion of non-loan, security assets. To make this net asset expansion via increased security holdings possible, banks also expand their deposit liabilities in the short run and thereby come to look more like mutual funds, as suggested by Thakor. This conclusion suggests that expansionary monetary policy conducted in a banking system bound by risk-based capital requirements would, at least in the short run, lead to a rise in total bank security holdings and deposits. In contrast, in the long run an expansionary monetary policy induces banks to expand equity, which under risk-based capital regulation thereby enables bank credit to expand.

Within a broader banking-sector framework that allows for interest-rate adjustments, Kopecky and VanHoose (2004a) find that, in the short run when bank equity cannot be readily adjusted, capital regulation does not affect banks' desired liability mix. In the long run, however, when banks are able to adjust their equity, they are able to engage in more lending than in the fixed-equity case because they are able to issue more equity to satisfy capital regulations. Costs banks incur by expanding equity more than they would have in the absence of capital adequacy regulations can potentially act as a drag on lending even in the long run, but when both effects of capital requirements on the market loan rate and induced changes in the composition of bank liabilities are taken into account, the long-run scale of the banking system, including aggregate bank lending, responds ambiguously to the presence of capital requirements. Under some circumstances, aggregate deposits can also increase, although in general the long-run effect of capital regulation on total deposits in the banking system is ambiguous.

Jacques and Shirm (2004) examine the monetary policy implications of capital regulation in a somewhat simpler banking-sector framework, but in contrast to other studies they include a role for varying risk weights across bank asset categories. This leads to the conclusion that the extent to which monetary policy actions influence market interest rates and exert effects on bank loan and security holdings depends crucially on the credit qualities of borrowers and security issuers. Jacques and Shirm also conclude that the effects of monetary policy actions depend as well on the relative shares of loans and securities in banks' asset portfolios. As a result, monetary policy effects potentially differ depending on whether credit qualities of borrowers are depreciating or improving at the time monetary policy actions are implemented.

An analogous conclusion is reached by Tanaka (2002), who analyzes the effects of capital regulation within an *IS-LM*-style framework. As in Cecchetti and Li, Tanaka finds that the immediate effect of binding capital requirements is to alter the interest

sensitivity and position of the economy's desired investment relationship and hence the shape and position of the *IS* schedule. Thus, monetary (*LM*) policy actions or shocks have smaller effects on equilibrium income, but, as in Cecchetti and Li, expenditure shocks have large impacts. Similarly to Jacques and Shirm, however, Tanaka allows for variations in credit risk in response to changing economic conditions that feed back to influence the toughness of capital regulation. His conclusion is that when borrower credit risk worsens during business cycle downturns, monetary policy actions become even less effective under capital regulation and that expenditure shocks have even larger negative effects on real income.

Likewise, Zicchino (2005), who extends the Chami-Cosimano (2001) model, also considers a Basel II-style capital adequacy ratio that is a decreasing function of current macroeconomic conditions. In addition, Zicchino allows for the possibility of borrower default. One key implication of Zicchino's analysis is that during periods of expansion, banks are more likely to have to maintain lower levels of capital under Basel II than they would be required to maintain under Basel I. As a consequence, it is more likely under Basel II than under Basel I that a credit crunch will result following a contractionary monetary policy action or as a result of other negative macroeconomic shocks.

Miyake and Nakamura (2006) provide a very different analysis of the macroeconomic effects of bank capital regulation. They utilize a dynamic overlapping-generations model in which there is a strategic complementarity between bank equity and the capital of other firms in the economy. As a consequence, the short-run effect of the imposition of bank capital regulation is a reduction in equilibrium income, as well as an enlargement in the effects of productivity shocks (the only shocks considered in the Miyake-Nakamura framework) on income. In the long run, however, tougher capital requirements boost bank capital, and, via the strategic complementarity with

capital at other firms, boosts increased equilibrium income while promoting greater income stability.

5.3 Macroeconomic and Monetary Policy Implications: Summing Up

To the extent that there is a bank lending channel of monetary policy, reductions in bank credit brought about by capital requirements can constrain real investment expenditures. On one hand, the result is that any procyclical bias inherent in capital regulation can contribute to procyclicality of aggregate expenditures. On the other hand, constraining investment spending can also alter the sensitivity of aggregate expenditures to external shocks. Taken together, these potential macroeconomic effects of capital regulation translate into a potential for bank capital requirements to alter both the average performance of a nation's economy and the stability of real GDP and employment. Furthermore, these effects indicate an altered responsiveness of aggregate expenditures to monetary policy actions, including likely asymmetries of monetary policy effects on bank lending. Specifically, capital-constrained banks will tend to cut back on their lending more sharply than unconstrained banks in response to a monetary tightening but will tend to be less responsive to a monetary easing.

In contrast to the various ambiguities summarized earlier regarding various bank balance-sheet and risk adjustments to capital regulation, studies are largely in agreement about the short-run macroeconomic and monetary policy implications. Only predictions about longer-run effects on the level of aggregate expenditures and the sensitivity of aggregate spending to monetary policy actions and external shocks are mixed.

6. Empirical Evidence

The variety of mixed predictions about bank balance-sheet and risk responses to capital regulation suggests a significant research agenda for empirically inclined researchers. We now consider what the extant empirical research suggests about the effects of capital requirements on bank decisions and risks and on the broader economy.

6.1 Evaluating Effects of Capital Regulation on Bank Behavior

Berger and Udell (1994) examine whether the risk-based capital requirements put into place in the late 1980s contributed to the so-called “credit crunch” that occurred in the United States in the early 1990s. They find evidence that other sources of loan supply reduction or declines in loan demand during the early 1990s played much more prominent roles in reducing bank lending. In contrast, Peek and Rosengren (1995a, b) conclude that there is considerable evidence, at least for New England, that both lower loan demand and a capital-crunch-induced decline in loan supply *together* brought about a decline in lending. Brinkmann and Horvitz (1995) also find evidence of significant loan supply responses to the Basel I capital requirements.

Chiuri, Ferri, and Majnoni (2002) extend the approach of Peek and Rosengren (1995) to examine a panel of data for 572 banks in 15 developing countries. They find consistent evidence—after seeking to control for banking crises that occurred in 10 of the nations—that the imposition of capital regulation induced a reduction in loan supply and, hence, in total lending in these countries. Furlong (1992), Haubrich and Wachtel (1993), and Lown and Peristiani (1996) also conclude that capital regulation contributed to a decrease in lending that helped fuel a post-capital-requirements U.S. credit crunch. Wagster (1999) reaches the same conclusion for Canada and the United Kingdom. He fails to find support, however, for this result in the cases of Germany, Japan, and the United States, where he concludes that a number of factors played a role in generating a credit crunch.

Not all researchers agree that capital regulation has had significant effects on bank lending. Jackson *et al.* (1999) review a number of prior studies investigating how capital adequacy regulations influence actual capital ratios; such as Peltzman (1970), Mingo (1975), Dietrich and James (1983), Shrieves and Dahl (1992), Keeley (1988), Jacques and Nigro (1997), Aggarwal and Jacques (1997), Hancock and Wilcox (1994), Rime (2001), and Wall and Peterson (1987, 1995). Jackson *et al.*'s conclusion is that in the near term banks mainly respond to toughened capital requirements by reducing lending and that there is little conclusive evidence that capital regulation has induced banks to maintain higher capital-to-asset ratios than they otherwise would choose if unregulated. Likewise, Ashcraft (2001) finds little evidence that capital regulation during the 1980s materially influenced bank capital ratios. Flannery and Rangan (2004) find some influence of capital regulation on actual bank capital ratios, but they credit greater bank risk aversion and actual risk increases as the main factors accounting for rising U.S. capital ratios in recent years.

In a creative study, Furfine (2001) develops an intertemporal model that yields optimizing conditions that guide bank decision-making with and without capital regulation. His approach is then to utilize data from FDIC call reports for 362 banks with assets exceeding \$1 billion to estimate these optimizing conditions directly. Furfine then utilizes these estimated conditions to conduct simulations of the effects of changes in capital requirements. Based on his simulation analysis, Furfine's conclusion is that while capital regulation does matter, generally toughened supervisory scrutiny, rather than explicit capital requirements, has a larger influence banks' balance-sheet choices and particularly was more likely to have explained the early-1990s U.S. credit crunch.

Barrios and Blanco (2003) develop partial-adjustment models of bank capital in response to market forces versus capital constraints. They estimate these alternative partial-adjustment frameworks using unbalanced annual panel data for seventy-six

Spanish commercial banks between 1985 and 1991. Barrios and Blanco find that for their sample of banks, the market-based model better fit the data, indicating that the banks they considered were unconstrained by capital regulation during the period of study.

Beatty and Gron (2001) examine data for 438 publicly traded U.S. bank holding companies between 1986 and 1995. For the entire sample as a whole, they find results similar to those of Barrios and Blanco; their analysis suggests that pre-and post-regulation behavior of the entire set of banks was not materially affected by the advent of risk-based capital regulation. Beatty and Gron do find evidence of different responses by the banks with lowest capital levels, however. For these banks only, increases in equity were associated with higher lending, and these banks also exhibited significant responses to alterations in capital requirements applying both to total assets and to risk-weighted assets. Interestingly, Beatty and Gron also find that banks with greater initial proportions of riskier assets responded to the implementation of Basel I regulation with smaller increases in equity and larger increases in risky assets. They suggest that these banks were not necessarily bound by capital regulation aimed at credit risk but did respond on the margin to regulatory incentives to increase capital.

6.2 Evidence on Capital Regulation and Bank Safety and Soundness

Is there any evidence that bank capital regulation makes banks and the banking system as a whole safer? Hendricks and Hirtle (1997) suggest that the answer is yes, but they also contend that the ultimate risk benefits are likely to be slight. Based on estimates derived from value-at-risk models, and consistent with the conclusions of Jackson *et al.* noted above, they conclude that capital regulation is likely to boost capital levels only very slightly at most institutions (and possibly reduce capital at some banks), so that any risk-reducing benefits also are likely to be small.

One attempt to directly assess the risk implications of capital regulation is Furlong (1988), who examines data from 98 U.S. bank holding companies over the interval from 1975 to 1986. Furlong exploits the Black-Scholes implication that the equity market capitalization of a bank should be equivalent to the value of a call option written on the bank's asset valuation. Furlong concludes that asset risk increased at both banks that were initially well capitalized as well as at banks that were not, suggesting that the introduction of capital regulation in the 1980s did not lead risk-averse banks to increase their asset risk as suggested by Koehn and Santomero (1980).

Sheldon (1996) examines cross-country data on bank asset and equity volatilities for the period from 1987 to 1994 that encompasses implementation of the Basel I regulations. He also finds a rise in bank asset volatility both for banks that increased their capital ratios and those that did not. Sheldon's conclusion is there is little evidence that capital regulation reduced the riskiness of banks assets.

As noted by Jackson *et al.* (1999), neither the Furlong nor Sheldon studies controls for a number of potential influences on bank risk-taking, which potentially limits the strength of their conclusions. Barth, Caprio, and Levine (2004, 2006) examine objective and survey data from 107 countries, which allows them to try to control for the effects that various supervisory and regulatory policies may have on banking system outcomes. On one hand, they find that tougher capital requirements are associated with fewer nonperforming loans. On the other hand, they also find that stiffer capital regulation is not robustly related to the likelihood of a banking crisis after controlling for the regulatory and supervisory regime. Thus, Barth *et al.* reach a mixed conclusion about whether capital regulation induces banks to reduce their exposures to risk.

In a panel study of 251 banks located in 36 countries, Gonzalez (2005) examines two measures of bank risk. One, which he terms "credit risk," is measured by the ratio of nonperforming loans to total loans. The other, which he refers to as "market risk," is

measured by the standard deviation of daily bank stock returns. Gonzalez does not explicitly consider effects of capital requirements, but he suggests that any factors that reduce the charter value of banks, such as more stringent regulation and absence of deposit insurance, may reduce the incentives for banks to engage in prudent behavior, thereby increasing their risks. He finds support for this hypothesis, but with the caveat that endogeneities between bank charter value and the effects of charter value on bank risk taking require controlling for factors that affect charter value when assessing effects of regulation on bank decision-making.

Finally, Wagster (1999) has sought to explore the impact of the Basel I requirements on systematic risk during the late 1980s and early 1990s at large international banks in Canada, Germany, Japan, the United Kingdom, and the United States. He finds that systematic risk increased markedly at Canadian, U.K., and U.S. banks, indicating that capital regulation did little to reduce bank risks in those nations, and he suggests that exploring the possibility that capital regulation actually caused the increase in systematic risk should be considered.

6.3 Evidence on Procyclicality and Monetary Policy Effects

In practice, is capital regulation procyclical? Ayuso, Perez, and Saurina (2004) seek to address this question using panel data from the Spanish economy and banking system for the period from 1986 to 2000. Using a variety of business-cycle measures, they find evidence of an economically and statistically significant negative relationship between bank capital and the phase of the business cycle. Thus, Ayuso *et al.* conclude that, at least in Spain, bank capital regulation tended to create procyclical movements in actual capital.

Kashyap and Stein (2004) utilize alternative models for estimating probabilities of default to examine the period from late 1998 through 2002, in an effort to determine how bank capital charges would vary in responses to changing risks over the course of a

business cycle. Simulations based on these data suggest a potential for capital regulation to generate greater procyclicality both for the banking system and, in particular, individual banks. Indeed, their simulations indicate banks lending to lower-quality borrowers are less susceptible to cyclical influences, because they are already most affected by risk-adjusted capital regulation. Banks that regularly lend to higher-quality borrowers, in contrast, are more likely to experience procyclical capital adjustments as changes in economic conditions move initially less-risky assets into riskier classifications.

To evaluate how capital regulation affects monetary policy, Cecchetti and Li (2005) develop Taylor-rule-type reaction functions, which they proceed to estimate using U.S., German, and Japanese data. These reaction functions specify central bank interest-rate settings as functions of inflation, the central bank's inflation target, and the output gap, and the aggregate asset-capital (leverage) ratio of the banking system. Cecchetti and Li find that the Fed optimally pushed down the federal funds rate in response to a higher leverage ratio—interpreted as an indicator of greater banking-system stress under capital regulation—but that the Bundesbank and Bank of Japan did not.

Does capital regulation alter the effects that monetary policy actions have on the banking system? Gambacorta and Mistrulli (2004) explore this question using Italian banking data over the interval from 1992 to 2001. They find evidence of a bank capital channel in the monetary policy transmission mechanism, in which well capitalized banks are less constrained in their responses to monetary policy and other macroeconomic shocks than banks with relatively lower levels of capitalization.

Kishan and Opiela (2000 , 2006) evaluate the responses to monetary policy actions of high- and low-capital banks. In their initial contribution, Kishan and Opiela (2000) find evidence of a bank lending channel for monetary policy. They examine various categories of banks based on relative sizes and levels of capitalization and

determine that the lending of smaller, low-capital banks is most susceptible to contractionary monetary policy.

In their more recent study, Kishan and Opiela (2006) focus specifically on the lending responses of banks to policy actions depending on their levels of capitalization and whether policies are contractionary or expansionary. Utilizing quarterly balance-sheet data of U.S. banks between 1980 and 1999, Kishan and Opiela conclude that since the advent of risk-based capital regulation, contractionary monetary policy actions most adversely affect the lending of low-capital banks, and expansionary monetary policy actions fail to stimulate lending by low-capital banks.

6.4 Empirical Evidence on Effects of Capital Regulation: Summing Up

Aggregate bank capitalization relative to total assets and risk-weighted assets increased noticeably during the 1990s, suggesting on the surface a line of causation beginning with the implementation of the Basel system of capital regulation. Indeed, some studies find evidence that implementation of the Basel I requirements may have contributed to a credit crunch in the early 1990s. A number of studies, however, find less compelling evidence of a link between capital regulation and credit curtailments, and some researchers conclude that market forces may have played a greater role in bringing about the overall increase in bank equity. Studies are somewhat mixed in their conclusions about just how much of an effect capital requirements had on the equity upswing, but the general theme running through most work is that capital regulation probably contributed only slightly to the rise in overall bank equity.

Remarkably little work has been done to explore arguably the most important empirical issue, namely the actual effects of capital regulation on measures of bank risk. As in the theoretical work on this issue, the few studies contemplating the risk effects of capital requirements reach mixed conclusions. These tend to agree that overall bank risk increased following the implementation of capital regulation under the Basel I

framework, although other factors such as the coincident recession during the early 1990s surely contributed to this risk upswing. Only a couple of studies find evidence suggesting that capital regulation helped to mitigate this risk expansion. Others suggest that capital requirements either had little effect or actually may have contributed to the observed rise in overall risk.

In addition, only a few studies have considered the macroeconomic and monetary policy effects of bank capital regulation. These tend to support several of the short-run predictions of theory, suggesting both that to the extent it has been binding for the banking system as a whole, capital regulation likely has at least mildly procyclical effects. They also support the prediction that that monetary policy impacts exerted through the banking system have been asymmetric, depending on whether or not banks are capital-constrained.

7. Conclusion

What are the effects of capital regulation on a nation's banking system? There is widespread agreement in the theoretical academic literature that the immediate effects of constraining capital standards are likely to be a reduction in total lending and accompanying increases in market loan rates and increases in holdings of alternative assets. There is also broad agreement that the longer-term effect of capital regulation is likely to be an increase in capital ratios, which may or may not be accompanied by a rise in total lending.

On other points, the theoretical literature offers mixed predictions. Models of banks as portfolio managers yield contrasting conclusions on the portfolio-risk effects depending on a variety of factors, including whether markets are complete or incomplete and perfectly or imperfectly competitive, whether banks are value- or utility-maximizing, and whether bank decisions are dominated by one agent or another. Theories contemplating broader balance-sheet adjustments to capital requirements also provide differing predictions that typically depend crucially on whether the focus of the analysis of adjustment is placed on the asset or liability side of banks' balance sheets. Theoretical models emphasizing moral hazard and banks' monitoring role also produce mixed conclusions that are only further complicated once adverse selection and screening or bank heterogeneities are considered. In addition, so far, there is little empirical support for the view that bank capital regulation helps to explain recent expansions of bank equity or that it has contributed to a significant (if any) reduction in overall bank risk.

The ultimate implication of this review is that the intellectual foundation for bank capital regulation in general and for the proposed Basel II system specifically is not particularly strong. Instead of expanding the scope and complexity of the current system of capital regulation, it may be time to contemplate alternative approaches to bolstering the safety and soundness of the banking system.

REFERENCES

- Aggarwal, Raj, and Kevin Jacques. 1997. A simultaneous equations estimation of the impact of prompt corrective action on bank capital and risk. In *Financial Services at the Crossroads: Capital Regulation in the 21st Century*, Federal Reserve Bank of New York Conference Proceedings, February 26-17.
- Almazan, Andres. 2002. A model of competition in banking: Bank capital versus expertise. *Journal of Financial Intermediation* 11, 87-121.
- Ashcraft, Adam. 2001. Do tougher bank capital requirements matter? New evidence from the eighties. Manuscript, Federal Reserve Bank of New York, July 23.
- Ayuso, Juan, Daniel Perez, and Jesus Saurina. 2004. Are capital buffers pro-cyclical? Evidence from Spanish panel data. *Journal of Financial Intermediation* 13, 249-264.
- Baltensperger, Ernst. 1980. Alternative approaches to the theory of the banking firm. *Journal of Monetary Economics* 6, 1-37.
- Barrios, Victor, and Jan Blanco. 2003. The effectiveness of bank capital adequacy regulation: A theoretical and empirical approach. *Journal of Banking and Finance* 27, 1935-1958.
- Barth, James, Gerard Caprio Jr., and Ross Levine. 2006. *Rethinking Bank Regulation*. Cambridge: Cambridge University Press.
- Barth, James, Gerard Caprio Jr., and Ross Levine. 2004. Bank regulation and supervision: What works best? *Journal of Financial Intermediation* 13, 205-248.
- Beatty, Anne, and Anne Gron. 2001. Capital, Portfolio, and Growth: Bank behavior under risk-based capital requirements. *Journal of Financial Services Research* 20, 5-31.
- Berger, Allen, Richard Herring, and Giorgio Szego. 1995. The role of capital in financial institutions. *Journal of Banking and Finance* 19, 393-430.

- Berger, Allen, and Gregory Udell. 1994. Did risk-based capital allocate bank credit and cause a 'credit crunch' in the United States? *Journal of Money, Credit, and Banking* 26, 585-628.
- Besanko, David, and George Kanatas. 1996. The regulation of bank capital: Do capital standards promote bank safety? *Journal of Financial Intermediation* 5, 160-183.
- Bliss, Robert, and George Kaufman. 2003. Bank procyclicality, credit crunches, and asymmetric monetary policy effects: A unifying model. *Journal of Applied Finance*, Fall/Winter 2003: 23-31.
- Blum, Jürg. 1999. Do capital adequacy requirements reduce risks in banking? *Journal of Banking and Finance* 23, 755-771.
- Blum, Jürg, and Martin Hellwig. 1995. The macroeconomic implications of capital adequacy requirements for banks. *European Economic Review* 39, 739-749.
- Boot, Arnoud, and Matej Marinc. 2006. Competition and entry in banking: Implications for Stability and Capital Regulation. Tinbergen Institute Discussion Paper TI 2006-015/2, January 22.
- Boot, Arnoud, and Anjan Thakor. 1991. Off-balance-sheet liabilities, deposit insurance, and capital regulation. *Journal of Banking and Finance* 15, 825-846.
- Borio, Claudio. 2003. Towards a macroprudential framework for financial supervision and regulation. *CESifo Economics Studies*, 49, 181-215.
- Bradley, Michael, Carol Wambeke, and David Whidbee. 1991. Risk weights, risk-based capital, and deposit insurance. *Journal of Banking and Finance* 15, 875-893.
- Brinkmann, Emile and Paul Horvitz. 1995. Risk-based capital standards and the credit crunch. *Journal of Money, Credit, and Banking* 27, 848-863.
- Calem, Paul, and Rafael Rob. 1999. The impact of capital-based regulation on bank risk-taking. *Journal of Financial Intermediation* 8, 317-352.

- Calomiris, Charles, and Charles Kahn. 1991. The role of demandable debt in structuring optimal banking arrangements. *American Economic Review* 81, 497-513.
- Campbell, Tim, Yuk-Shee Chan, and Anthony Marino. 1992. An incentive-based theory of bank regulation. *Journal of Financial Intermediation* 2, 255-276.
- Carey, Mark. 2002. A guide to choosing absolute bank capital requirements. *Journal of Banking and Finance* 26, 929-951.
- Catarieneu-Rabell, Eva, Patricia Jackson, and Dimitrios Tsomocos. 2003. Procyclicality and the new Basel Accord: Banks' choice of loan rate system. Bank of England Working paper No. 181.
- Cecchetti, Stephen, and Lianfa Li. 2005. Do capital adequacy requirements matter for monetary policy? NBER Working Paper No. 11830, December.
- Chami, Ralph, and Thomas Cosimano. 2001. Monetary policy with a touch of Basel. Working Paper, IMF Institute and University of Notre Dame.
- Chiuri, Maria Concetta, Giovanni Ferri, and Giovanni Majnoni. 2002. The macroeconomic impact of bank capital requirements in emerging economies: Past evidence to assess the future. *Journal of Banking and Finance* 26, 881-904.
- Cooper, Russell, and Thomas Ross. 2002. Bank runs, deposit insurance, and capital requirements. *International Economic Review* 43, 55-71.
- Cordell, Lawrence, and Kathleen Kuester King. 1995. A market evaluations of the risk-based capital standards for the U.S. financial system. *Journal of Banking and Finance* 19, 531-562.
- Decamps, Jean-Paul, Jean-Charles Rochet, and Benoit Roger. 2004. The three pillars of Basel II: Optimizing the mix. *Journal of Financial Intermediation* 13, 132-155.
- Dietrich, J. Kimball, and Christopher James. 1983. Regulation and the determination of bank capital changes: A note. *Journal of Finance* 38, 1651-1658

- Diamond, Douglas. 1991. Monitoring and regulation: The choice between bank loans and directly placed debt. *Journal of Political Economy* 99, 689-721.
- Diamond, Douglas. 1984. Financial intermediation and delegated monitoring. *Review of Economic Studies* 51, 393-414.
- Diamond, Douglas, and Phillip Dybvig. 1983. Bank runs, deposit insurance, and liquidity. *Journal of Political Economy* 91, 401-419.
- Diamond, Douglas, and Ragharam Rajan. 2001. Liquidity risk, liquidity creation, and financial fragility: A theory of banking. *Journal of Political Economy* 109, 287-327.
- Diamond, Douglas, and Raghuram Rajan. 2000. A theory of bank capital. *Journal of Finance* 55, 2431-2465.
- Dietrich, J. Kimball, and Christopher James. 1983. Regulation and determination of bank capital changes 38, 1651-1658.
- Dowd, Kevin. 2000. Bank capital adequacy versus deposit insurance. *Journal of Financial Services Research* 17, 7-15.
- Estrella, Arturo. 2004a. Bank capital and risk: Is voluntary disclosure enough? *Journal of Financial Services Research* 26, 145-160.
- Estrella, Arturo. 2004b. The cyclical behavior of optimal bank capital. *Journal of Banking and Finance* 28, 1469-1498.
- Flannery, Mark. 1989. Capital regulation and insured banks' choice of individual loan default risks. *Journal of Monetary Economics* 24, 235-258.
- Flannery, Mark, and Kasturi Rangan. 2004. What caused the bank capital build-up of the 1990s? FDIC Center for Financial Research Working Paper No. 2004-03, August.
- Furfine, Craig. 2001. Bank portfolio allocation: The impact of capital requirements, regulatory monitoring, and economic conditions. *Journal of Financial Services Research* 20, 33-56.

- Furlong, Frederick. 1992. Capital regulation and bank lending. *Federal Reserve Bank of San Francisco Economic Review*, 23-33.
- Furlong, Frederick. 1988. Changes in bank risk-taking. *Federal Reserve Bank of San Francisco Economics Review*, 45-56.
- Furlong, Frederick and Michael Keeley. 1989. Capital regulation and bank risk-taking: A note. *Journal of Banking and Finance* 13, 883-891.
- Gambacorta, Leonardo, and Paolo Emilio Mistrulli. 2004. Does bank capital affect lending behavior? *Journal of Financial Intermediation* 13, 436-457.
- Genotte, Gerard and David Pyle. 1991. Capital controls and bank risk. *Journal of Banking and Finance* 15, 805-824.
- Gjerde, Øystein, and Kristian Semmen. 1995. Risk-based capital requirements and bank portfolio risk. *Journal of Banking and Finance* 19, 1159-1173.
- Gonzalez, Francisco. 2005. Bank regulation and risk-taking incentives: An international comparison of bank risk. *Journal of Banking and Finance* 29, 1153-1184.
- Gordy, Michael. 2003. A risk-factor model foundation for ratings-based bank capital rules. *Journal of Financial Intermediation* 12, 199-232.
- Gordy, Michael, and Bradley Howells. 2004. Procyclicality in Basel II: Can we treat the disease without killing the patient? Manuscript, Board of Governors of the Federal Reserve System, May 12.
- Hancock, Diana, and James Wilcox. 1994. Bank capital and the credit crunch: The roles of risk-weighted and unweighted capital regulation. *Journal of the American Real Estate and Urban Economics Association* 22, 59-94.
- Haubrich, Joseph, and Paul Wachtel. 1993. Capital requirements and shifts in commercial bank portfolios. *Federal Reserve Bank of Cleveland Economic Review*, 29 (Quarter 1), 1-15.

- Hellmann, Thomas, Kevin Murdock, and Joseph Stiglitz. 2000. Liberalization, moral hazard in banking, and prudential regulation: Are capital requirements enough? *American Economic Review* 90, 147-165.
- Hendricks, Darryll, and Beverly Hirtle. 1997. Bank capital requirements for market risk: The internal models approach. *Federal Reserve Bank of New York Economic Policy Review*, December.
- Holmström, Bengt, and Jean Tirole. 1997. Financial intermediation, loanable funds, and the real sector. *Quarterly Journal of Economics* 112, 663-691.
- Jackson, Patricia, Craig Furfine, Hans Groeneveld, Diana Hancock, David Jones, William Perraudin, Lawrence Radecki, and Masao Yoneyama. 1999. Capital requirements and bank behavior: The impact of the Basel accord. *Basel Committee on Banking Supervision, Working Paper No. 1*, April.
- Jacques, Kevin, and Peter Nigro. 1997. Risk-based capital, portfolio risk, and bank capital: A simultaneous equations approach. *Journal of Economics and Business* 49, 533-547.
- Jacques, Kevin, and David Shirm. 2004. Bank lending and the effectiveness of monetary policy under a revised Basel accord, in Benton Gup, ed., *The New Basel Capital Accord*, Thomson, pp. 217-238.
- Jeitschko, Thomas, and Shin Dong Jeung. 2005. Incentives for risk-taking in banking: A unified approach. *Journal of Banking and Finance* 29, 759-777.
- Kahane, Yehuda. 1977. Capital adequacy and the regulation of financial intermediaries. *Journal of Banking and Finance* 1, 207-218.
- Kashyap, Anil, and Jeremy Stein. 2004. Cyclical implications of the Basel II capital standards. *Federal Reserve Bank of Chicago Economic Perspectives*, 18-31.
- Keeley, Michael. 1988. Bank capital regulation in the 1980s: Effective or ineffective? *Federal Reserve Bank of San Francisco Economic Review*, Winter.

- Keeley, Michael, and Frederick Furlong. 1990. A reexamination of the mean-variance analysis of bank capital regulation. *Journal of Banking and Finance* 14, 69-84.
- Kim, Daesik, and Anthony Santomero. 1988. Risk in banking and capital regulation. *Journal of Finance* 43, 1219-1233.
- Kishan, Ruby, and Timothy Opiela. 2000. Bank size, bank capital, and the bank lending channel. *Journal of Money, Credit, and Banking* 32, 121-141.
- Kishan, Ruby, and Timothy Opiela. 2006. Bank capital and loan asymmetry in the transmission of monetary policy. *Journal of Banking and Finance*, 30, 259-285.
- Klein, Michael. 1971. A theory of the banking firm. *Journal of Money, Credit, and Banking* 3, 205-218.
- Koehn, Michael and Anthony Santomero. 1980. Regulation of bank capital and portfolio risk. *Journal of Finance* 35, 1235-1244.
- Kopecky, Kenneth, and David VanHoose. 2006a. Bank equity and monitoring with and without capital regulation. Working Paper, Temple University and Baylor University.
- Kopecky, Kenneth, and David VanHoose. 2006b. Capital regulation, heterogeneous monitoring costs, and aggregate loan quality. *Journal of Banking and Finance*, Forthcoming.
- Kopecky, Kenneth, and David VanHoose. 2004a. Bank capital requirements and the monetary transmission mechanism. *Journal of Macroeconomics* 26, 443-464.
- Kopecky, Kenneth, and David VanHoose. 2004b. A model of the monetary sector with and without binding capital requirements. *Journal of Banking and Finance* 28, 633-646.
- Lam, Chun, and Andrew Chen. 1985. Joint effects of interest rate deregulation and capital requirements on optimal bank portfolio adjustments. *Journal of Finance* 40, 563-575.

- Lown, Cara and Stavros Peristiani. 1996. The behavior of consumer loan rates during the 1990 credit slowdown. *Journal of Banking and Finance* 20, 1673-1694.
- Marini, François. 2003. Bank insolvency, deposit insurance, and capital adequacy. *Journal of Financial Services Research* 24, 67-78.
- Milne, Alistair. 2002. Bank capital regulation as an incentive mechanism: Implications for portfolio choice. *Journal of Banking and Finance* 26, 1-23.
- Mingo, John. 1975. Regulatory influence on bank capital investment. *Journal of Finance* 30, 1111-1121.
- Mingo, John and Benjamin Wolkowitz. 1977. The effects of regulation on bank balance sheet decisions. *Journal of Finance* 32, 1605-1616.
- Miyake, Atsushi, and Tamotsu Nakamura. 2006. A dynamic analysis of an economy with banking optimization and capital adequacy regulations. *Journal of Economics and Business*, Forthcoming.
- Morrison, Alan, and Lucy White. 2005. Crises and capital requirements in banking, *American Economic Review* 95, 1548-1572.
- Pattison, John. 2006. International financial cooperation and the number of adherents: The Basel committee and capital regulation. Presented at Perspectives on Monetary, Financial, and Economic Integration, Conference in Honor of Michele Fratianni, Indiana University, April 8.
- Pederzoli, Chirara, and Constanza Torricelli. 2005. Capital requirements and business cycle regimes: Forward-looking modeling of default probabilities. *Journal of Banking and Finance* 29, 3121-3140.
- Peek, Joe and Eric Rosengren. 1995a. The capital crunch: Neither a borrower nor a lender be. *Journal of Money, Credit, and Banking* 27, 625-638.
- Peek, Joe and Eric Rosengren. 1995b. Bank regulation and the credit crunch. *Journal of Banking and Finance* 19, 679-692.

- Peltzman, Sam. 1970. Capital regulation in commercial banking and its relation to portfolio regulation. *Journal of Political Economy* 78, 1-26.
- Pennacchi, George. 2005. Risk-based capital standards, deposit insurance, and procyclicality. *Journal of Financial Intermediation* 14, 432-465.
- Repullo, Rafael. 2004. Capital requirements, market power, and risk-taking in banking. *Journal of Financial Intermediation* 13, 156-182.
- Repullo, Rafael, and Javier Suarez. 2004. Loan pricing under Basel capital requirements. *Journal of Financial Intermediation* 13, 496-521.
- Rime, Bertrand. 2001. Capital requirements and bank behavior: Empirical evidence for Switzerland. *Journal of Banking and Finance* 25, 789-805.
- Rochet, Jean-Charles. 1992. Capital requirements and the behavior of commercial banks. *European Economic Review* 36, 1137-1178.
- Santos, João. 2001. Bank capital regulation in contemporary banking theory: A review of the literature. *Financial Markets, Institutions, and Instruments* 10, 41-84.
- Santos, João. 1999. Bank capital and equity investment regulations. *Journal of Banking and Finance* 23, 1095-1120.
- Seater, John. "Optimal Bank Regulation and Monetary Policy." North Carolina State University (January 2001).
- Sheldon, George. 1996. Capital adequacy rules and the risk-seeking behavior of banks: A firm-level analysis. *Swiss Journal of Economics and Statistics* 132, 709-734.
- Shrieves, Ronald, and Drew Dahl. 1992. The relationship between risk and capital at commercial banks. *Journal of Banking and Finance* 16, 439-457.
- Tanaka, Misa. 2002. How do bank capital and capital adequacy regulation affect the Monetary transmission mechanism? CESIFO Working Paper No. 799.
- Thakor, Anjan. 1996. Capital requirements, monetary policy, and aggregate bank lending: Theory and empirical evidence. *Journal of Finance* 51, 279-324.

- Van den Heuvel, Skander. 2002. Does bank capital matter for monetary transmission?
Federal Reserve Bank of New York Economic Policy Review 8, 259-65.
- Van den Heuvel, Skander. 2003. The bank capital channel of monetary policy.
Working Paper, University of Pennsylvania, September.
- Wagster, John. 1999. The Basel accord of 1988 and the international credit crunch of
1989-1992. Journal of Financial Services Research 15, 123-143.
- Wall, Larry, and David Peterson. 1987. The effect of capital adequacy guidelines on
large bank holding companies. Journal of Banking and Finance 11, 581-600.
- Zicchino, Lea. 2005. A model of bank capital, lending, and the macroeconomy: Basel
I versus Basel II. Bank of England Working Paper No. 27