Bank Capital Management

by

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Declaration

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Abstract

The work undertaken in this study empirically explores the determinants of regulatory bank capital buffers, and how they influence bank decisions. Focusing on bank capital management under the Basel I framework, this thesis serves to address some of the concerns that have been voiced regarding the implementation of the new regulation (Basel II) and the broader economic effects that could result.

In particular, the research chapters of this thesis examine the cyclical behavior of European bank capital buffers, the long run relationship between bank capital buffers and charter values, and the simultaneous adjustments of capital and risk. In each of the research chapters, we acknowledge the endogenous nature of the capital decision of a bank, and assume that banks will define an internally optimal probability of default (a function of risk and capital) to be managed over the long term. Adjustment costs, illiquid markets, together with the costs associated with a regulatory breach contribute as factors in a banks internal decision when setting a target capital ratio. Treating capital in this way, we note that it is the amount of capital held above the requirement that determines a banks attitude towards risk. Importantly, this work has shown that excessive risk taking is rarely a consequence of insufficient capital.

Chapter 1

Introduction

Broadly speaking, there are two distinct ways that a bank can finance its operations; either with borrowed money (debt) or with funds provided by its shareholders or owners (equity). On the one hand, borrowing money generates contractual liabilities, which if not paid when due can cause a bank to fail. On the other hand, investments made by its owners can gain or lose value without any risk of the bank defaulting on its obligations. Therefore, everything else equal, the greater the portion of capital contributed by its owners, the safer the bank is in that it is less likely to default on its obligations in periods of economic adversity. Bank regulators have therefore continuously placed a strong emphasis on capital adequacy as a key element in ensuring safety and soundness in banking institutions and in the financial system as a whole. For this reason, capital regulation has become a dominant instrument in modern day banking regulation.

Despite the safety and soundness benefits associated with requiring banks to hold larger portions of capital, capital adequacy regulation can impose important costs. Assuming away capital market frictions, the Modigliani-Miller theorem states that the cost of debt and the cost of equity are equal. However, as discussed in detail in Chapter 2, the Modigliani-Miller theorem is not applicable to banks and moreover, banks do find that holding equity capital is costly.

The costs and benefits of holding capital must be balanced by the bank. The banks assessment of the associated costs and benefits may not however, necessarily correspond directly to the social costs and benefits. In particular, banks may (i) anticipate support from the public sector in the event of a failure, encouraging them to operate with relatively little capital, or (ii) neglect entirely the social costs of failure, including the loss of output when financial institutions are distressed, thereby holding less capital. It is therefore not surprising that the unremitting question posed by bank regulators is *"how much capital is enough?"*

Chapter 2 of this thesis will provide a review both of relevant literature, and also of the institutional arrangements for bank capital regulation. This thesis is concerned with understanding bank capital management decisions under Basel I, the regulatory framework that has applied for all periods of observation studied. Traditionally, literature analyzing bank capital decisions has focused on assessing the effects of minimum capital requirements on bank risk. The usual assumption is that bank capital is exogenous and therefore determined by regulatory requirements. In this framework, banks will never have an incentive to hold capital in excess of the regulatory minimum. This study takes on a different view, a capital buffer view. That is, the endogenous role of bank capital is acknowledged, and it is assumed that a bank will identify an internally optimal amount of capital to target in the long run. The target amount of capital will be determined as a trade-off of both implicit and explicit costs associated with a breach of regulation. In this context, this thesis empirically tests several predictions of the capital buffer theory outlined in Section 2.2. From here on, a capital buffer is defined as an amount of capital held in excess of the regulatory required minimum.

Several studies that have provided evidence in favor of the capital buffer view show that in practice, banks hold far more capital than regulation requires.[1] Several reasons have been suggested as to why a bank may chose to hold excess capital (see for example Marcus, 1984; Berger et al., 1995; Jackson, 1999; Milne and Whalley, 2001; Milne, 2004; Berger et al. (2008)). First, if banks have something to lose (eg. a large enough charter value) then they may voluntarily hold a capital buffer as protection by reducing the probability of failure. A banks charter value is defined as the net present value of future cash flows that a bank earns when it stays in business. Since the charter value would be lost in the case of failure, the charter value can be thought of the banks internal cost of failure. Therefore, banks without a sufficiently valuable charter are no longer concerned with future earnings and therefore have no incentive to hold capital as a protection. Second, banks may hold excess capital to signal soundness to the market as a means to obtain funds quickly and at a lower rate of interest in the event of unexpected profitable investment opportunities. This is commonly referred to as the market discipline argument for holding capital. Third, under asymmetric information, raising equity capital could be interpreted as a negative signal about the banks value. Myers and Majluf (1984) contend that the need to issue external equity sends a negative signal to investors to the effect that the firm does not have sufficient cash or debt capacity to take up opportunities as they appear. While their argument is applied to non-financial institutions, the same argument should apply to banks, particularly due to the opaqueness of bank activities. A breach of regulation triggers costly supervisory actions, possibly even leading to bank closure. By holding excess capital, banks' essentially insure themselves against costs related to market discipline or supervisory intervention in the event of a breach of the requirements. This incentive to hold additional capital increases with the probability of breaching the regulatory minimum.

Despite the incentives that exist for banks to hold a buffer of capital, it is also very costly to raise capital particularly when compared to raising insured deposits. The trade-off between the cost of a breach of regulation and the cost of holding additional capital will determine the optimum capital buffer (Marcus, 1984; Milne and Whalley 2001).

To summarize, the capital buffer of a bank serves as a cushion with which banks are able to absorb costly unexpected shocks. This is particularly true if the financial distress

[1]See for example Flannery and Rangan (1997), Peura and Jokivuolle (2004) Barth et al. (2004), and Berger et al. (2008), Brewer III et al. (2008).

costs from low capital and the costs of accessing new capital are high. The incentive to hold a capital buffer is even stronger in a dynamic multiperiod setting. Here, if adjustment costs that prevent banks from altering either capital or risk exist, then a large enough buffer, capable of absorbing several successive negative shocks, is required (Marcus, 1984; Milne and Whalley, 2001).

Historically, two contending approaches to regulatory capital assessment have been adopted. The first, more traditional approach, that was adopted in the US prior to the introduction of Basel I in the 1990s, relies largely on banker and supervisor judgment, resisting the need for specific numerical definitions of capital adequacy. This line of thinking is based on the notion that each bank is unique in its risk structure. The second, more modern approach, places far more emphasis on legislation drawn out in part from lessons learnt during banking crises. This methodology imposes precise numerical minimum capital standards on internationally active banking institutions as per Basel I.

Basel II, the new bank capital regulation set to replace the existing accord (Basel I[2]), combines the traditional and modern approaches. Embedded within the structure of Basel II are the numerical minimum capital requirements imposed via Basel I. The fundamental difference between Basel I and Basel II is a structural change that emphasizes the range of capital that may be required given the specific risks faced by each bank. Several important rationales exist to explain the amendment of the regulatory framework. These include pressure from banks for lower, more efficient regulatory capital requirements that align better with their own assessments of risk. Moreover, quantitative risk modeling within banks has grown significantly, increasing the desire of banks to have one system for risk assessment. Basel I and its successor Basel II are reviewed in detail in Section 2.3.

European banks have already adopted the new rules while implementation in the United States (US) is slightly lagging. Large banks in the US started implementing the new regulation only in 2009.[3]

Concerns regarding the new regulation have however been voiced, in particular relating to the broader economic effects resulting from its implementation (see for example Benink et al., 2008). Since one of the primary aims of Basel II is to create a closer link between capital and risks, the requirements have the potential to become more dependent economic conditions.

In addition, it has been noted that a more risk sensitive capital adequacy regulation may reduce a banks willingness to take risk or engage in transactions with riskier counterparties particularly during adverse economic conditions. This in part is due to the increased involvement of rating agencies in regulation but also due to greater transparency through reporting and disclosure requirements. However, if banks already risk adjust their total capital, i.e. minimum capital plus buffer capital, more than implied by

[2]The first Basel Committee consultative document, *A New Capital Adequacy Framework*, was issued on June 3, 1999, and the second consultative document, The New Basel Capital accord, was issued in January 2001. The documents are available through the website for the Bank for International Settlements at www.bis.org.

[3]Small banks will not be required to comply with Basel II for several reasons. One view is that Basel II would interfere with the existing FIDICIA legislation and prompt corrective action. In addition, it is felt that compliance with Basel II would place them at a competitive disadvantage when compared with larger rivals.

Basel I, then replacing Basel I with Basel II may not affect the capital to asset ratio or risk profile of banks portfolio as much as feared.

The research chapters of this study assess several outstanding issues by empirically testing some of the main findings of the capital buffer theory introduced in Section 2.2. The first of these, Chapter 3, examines the cyclical behavior of European bank capital buffers. In particular, addressing the following question: *"Do bank capital buffers vary cyclically?"* Our findings indicate that capital buffers move counter cyclically. Under the Basel I regime, capital requirements remained constant over the cycle. Under Basel II however, risk weights, and thus the capital requirements will fluctuate, increasing during a cyclical downturn when bank exposures are downgraded by external agencies or internal rating systems. Our findings therefore suggest that capital management will be especially challenging under the new accord since it will lead to higher capital requirements precisely at the time (the trough of the business cycle) when it is costly and difficult to access capital.

The remaining research chapters of the thesis focus on United States (US) bank holding company (BHC) and commercial bank balance sheet data. There are several reasons for considering US data rather than European data as per Chapter 3. First, all insured commercial banks have been required to submit Consolidated Report of Condition and Income statements (Call reports) to the Fed since as far back as 1976 on a quarterly basis, providing a rich cross section as well as time series dimension. Such detailed information is not available as as far back for European banks. In addition, data on BHC Fed Funds Y-9 reports provide balance sheet and income statement information on bank holding companies, providing a tool for obtaining market data for our sample of publicly traded banks. We make use of both the commercial bank and the holding company data so as to extract as much information as possible for our estimations since commercial banks report with fewer missing observations for variables employed as controls. Identifying the high holder to which the commercial bank belongs allows us to merge these two data sets. Appendices 4&5B explain the construction of the panel sample used in Chapters 4 and 5 of this thesis.

Chapter 4 specifically explores the long run relationship between bank capital buffers and charter values. The aim of chapter 4 is to determine whether charter value plays a significant disciplining role in bank capital management. In particular we ask: *"At what point does the expected loss from charter value outweigh the potential gain from deposit insurance?"* Our findings suggest that a high charter in itself does have a significant disciplining effect on bank capital management. Banks appear to manage capital in such a way so as to protect their valuable charter. Only once their charter value has fallen below a certain threshold do banks change their behavior and become significantly more risk loving. This finding is in line with concerns highlighted with regard to the market disciplining effect that increased disclosure requirements will have. Since the finding indicates that banks have already identified a natural disciplining effect which dictates capital management and risk taking, it remains to be seen how the third pillar will affect this disciplining mechanism.

The final research chapter, Chapter 5, addresses the following question: *"How do short* *term adjustments in capital and risk affect each other?"* Our results identify a two way positive and significant relationship between the capital buffer and risk adjustments over the 20 year sample period. Moreover, we show that the management of such adjustments is dependent on the degree of bank capitalization. These findings have implications for the changing regulatory framework in the US. The positive relationship between capital and risk adjustments suggest that introducing a more risk sensitive capital regulation is likely to affect US bank holding companies to a smaller extent than if capital were exogenous as assumed in the more traditional literature. Essentially, what we see is that BHCs do account for their risk when making capital buffer decisions. Our findings are in line with the hypothesis that financial institutions throughout the world have been developing frameworks for 'economic capital management' in response to the diversification of banking businesses, rapid progress in financial engineering, and the implementation of Basel II. The objective has been to develop precise measures of the various risks that financial institutions are exposed to, and to actively utilize such assessments in determining capital adequacy and in formulating business strategies.

Finally, Chapter 6 discusses the findings of the research Chapters 3,4 and 5 and briefly concludes.

Chapter 2

Background Information

This chapter provides some of the background material necessary for reading the analytical chapters that follow. This chapter is organized as follows: Section 2.1 provides a review of the related literature. We start by briefly discussing the main differences that exist between financial and non-financial firms. Section 2.1.1 discusses moral hazard in banking and some of the associated literature in this field. Section 2.1.2 introduces bank capital regulation and outlines research undertaken in this regard. Section 2.2 provides a short discussion of the theory of bank capital buffers, which will subsequently be investigated empirically in the latter chapters of this thesis. Finally, Section 2.3 details the regulation of bank capital, explaining differences between the Basel I and Basel II Accords, together with varying implementations of the regulations at an individual country level.

2.1 Literature Review

The capital structure of a firm relates to the way in which a corporation finances its assets through some combination of equity, debt, or hybrid securities. A firm's capital structure can thus be thought of as the structure of its liabilities.

The Modigliani-Miller[1] theorem forms the basis for capital structure analysis, even if it is generally viewed as a purely theoretical result since it assumes away many important factors of capital structure decisions.[2] The theorem states that in the absence of market imperfections, the value of any firm is unaffected by how that firm is financed. This theorem provides the foundation with which to assess why a company's value is affected by the capital structure it employs. If capital structure is irrelevant in a perfect market, then imperfections which exist in the real world must be the cause of its relevance.

Subsequent research has dealt with understanding consequences of various deviations from the conditions on which the Modigliani-Miller theorem is based with a view to understanding the corporate structure decisions of firms. No single universal theory of capital structure however exists, and, according to Myers (2001), there is no reason to expect one. Rather, four contending conditional theories have been put forward to explain

[1]Modigliani and Miller (1958).

[2]These 'other reasons' include bankruptcy costs, agency costs and asymmetric information.

corporate structure choices: the *trade-off theory*; *agency theory*; *pecking order theory*; and the *theory of market timing*.[3]

With regard to the determinants of capital structures of financial firms, until recently, the standard view has been that no apparent need to investigate financing decisions exists. This is partly due to the fact that capital regulation constitutes the overriding departure from the Modigliani and Miller propositions:

"Banks also hold capital because they are required to do so by regulatory authorities. Because of the high costs of holding capital [...]*, bank managers often want to hold less bank capital than is required by the regulatory authorities. In this case, the amount of bank capital is determined by the bank capital requirements (Mishkin, 2000, p.227)."*

This viewpoint, that the capital decision of a bank is exogenous is however, inconsistent with the observation that almost all banks, all the time, hold a capital buffer. The question whether capital requirements really play such a key role, since they are rarely binding, therefore still remains. The research reported in this thesis helps to provide some answers regarding the determinants of regulatory bank capital buffers, and how they influence bank decisions.

2.1.1 Financial Firms

Financial vs. Non-Financial Firms

Financial firms have much in common with non-financial firms. They aim to maximize profitability through the varying internal and external constraints placed on them, they are faced with competition and hence the need to remain innovative to thrive in the market place, and ultimately, they look to expand their business rapidly over time. If they are publicly traded, they are judged by the total return they make for their stockholders, in the same way other non-financial firms are.

Despite these similarities, several key differences between financial and non-financial firms do exist. When we refer to capital for non-financial firms, we tend to refer to both debt and equity. A firm raises funds from both equity investors and bond holders (and banks) and uses these funds to make its investments. When we value a non-financial firm, we consider the value of the assets owned by the firm, rather than just the value of its equity. With a financial firm on the other hand, debt has a slightly different connotation. Rather than viewing debt as a source of capital, financial firms view it as a kind of raw material, something to be molded into other financial products which can then be sold at a higher price to yield a profit. Consequently, capital in financial firms is more narrowly defined, including only equity capital. This definition of capital is reinforced by the regulatory authorities who evaluate the equity capital ratios of banks and insurance firms.

Although banks have a slightly varied and unique capital structure whereby equity capital is levered with demandable debt that is part of the economy's payments system, financial firms differ from non-financial firms in that they are far more regulated than firms in any other industry. In general, these regulations take three forms. First, banks

[3]See Harris and Raviv, 1991 for a thorough analysis of these issues.

and insurance companies are required to maintain capital ratios to ensure that they do not expand beyond their means and consequently put their claim holders or depositors at risk. Second, financial firms are often constrained in terms of where they can invest their funds. For instance, the Glass-Steagall Act in the United States separated commercial banks from investment banking activities and restricted them from taking active equity positions in manufacturing firms. Third, the entry of new financial firms into the business is often restricted by regulatory authorities, as are mergers between existing financial firms.

If financial markets are assumed to be complete and depositors are perfectly informed about the failure risk of banks, then, similarly to non-financial firms, the Modigliani and Miller (1958) theory applies. This, however, requires that the possibility of shareholders to exploit depositors is removed. To illustrate this problem in a banking context, we assume that managers act in the interest of its shareholders, who seek to maximize share value. As banks are corporations, the owners' liability is limited to their investment, meaning that the shareholders' loss is limited, but a gain greater than the fixed amount owed to depositors fully falls to them. Due to the shareholders' convex payoff function, banks prefer risky to safe investments. This phenomenon is further highlighted within the option pricing framework. The payoff of equity can be interpreted as the payoff of a call option on the bank value with a strike price of the same value as the obligation towards depositors. However, if depositors are perfectly informed about the bank's investment strategies, they will demand deposit rates which fully reflect the bank's risk profile. Hence, shareholders cannot exploit their controlling position, and maximizing the share value is equivalent to the maximization of the bank's total value. Thus, the value maximizing portfolio is always chosen, and the market value of a bank is independent of its capital structure. In this framework, banks would always choose socially optimal risk levels and, hence, there would be no need for regulation.

Some authors have shown that the Modigliani-Miller theorem is however, not applicable to banks (Sealey, 1985). In a world with complete markets and in the absence of any frictions, there would not be a need for financial intermediaries. Information theories suggest that a primary rationale for the existence of banks is that they have an information advantage in monitoring firms (see Diamond, 1984). This information advantage of banks gives rise to moral hazard.

Moral Hazard in Banking

Despite being a highly regulated industry, banking sector institutions are subject to the same type of agency costs as firms in any other industry. Since banks play a crucial role in providing credit to non-financial firms, in transmitting the effects of monetary policy, and in providing stability to the economy as a whole, the agency problem has been repeatedly addressed in the banking literature (Allen and Cebenoyan, 1991; Dewatripont and Tirole, 1994; Gorton and Rosen, 1995). While many authors have assumed that the moral hazard problem affects banks in much the same way than non-financial firms, agency costs can in fact be particularly high for banks since they are informationally opaque. A core function of a bank is to hold information on their customers and other counterparties, as well as to monitor ongoing lending relationships. Without information asymmetries, households would invest their entire savings directly through mutual funds rendering banks unnecessary. It is therefore not possible to have banking with full transparency (see Goodhart, 1988). As a result, depositors lack necessary information to fully assess the riskiness of bank portfolios, and are unable to efficiently monitor and discipline banks.

Together with government deposit insurance and other safety net protections such as government bailout schemes, asymmetric information may increase incentives for risk shifting or lax risk management. This moral hazard problem, whereby banks view themselves as partly insulated from risk and will therefore not fully account for the negative consequences in its actions, has been well documented in the banking literature (Kane, 1989; Barth, 1991; Demirgüç-Kunt et al., 2004; Gropp et al., 2004; Erlend and Baumann, 2006). Here, depositors are unable to fully observe bank actions since interest rates do not adequately reflect the probability of failure, giving banks the incentive to increase leverage and risk. Similarly under deposit insurance where depositors are free from risk by depositing funds in a bank, their pay-off is independent of the riskiness of bank assets. The incentive to monitor the bank is therefore removed. Barth, Caprio and Levine (2005) explain how deposit insurance works to reduce the incentives of depositors to monitor banks since part of their capital is protected. An extensive body of empirical literature has confirmed the adverse incentive effects of deposit insurance (see for example Thies and Gerlowski, 1989; Wheelock, 1992; Demirgüç-Kunt and Detragiache, 2000; Ioannidou et al., 2008).

Moral hazard concerns are particularly high for larger banks, since to a greater extent than their smaller counterparts, they are covered by the various government safety net protections. In the event of difficulties, large, systemically important banks may expect a greater degree of support from the government than small banks since a failure of a large bank has the potential to create wide spread disruption in the economy. The moral hazard problem can however be mitigated in banks with high prospects for future gains. In banks with higher charter values, owners and managerial interests become most closely aligned since both have much to lose if a risky business strategy leads to insolvency. In this setting, high charter value banks act more prudently in order to protect the valuable charter (see Marcus 1984, Keeley 1990, Demsetz et al. 1997, Galloway et al., 1997; Boot and Greenbaum 1993; Hellman et al. 2000; Matutes and Vives 2000; Gonz'alez, 2005; Park and Peristiani, 2007).

Bank Capital Regulation

In order to offset risk increasing incentives, bank regulators directly affect capital structure by setting minimums for equity capital and other types of regulatory capital (Rochet, 1992; Dewatripont and Tirole, 1994). A growing body of theoretical work has focused on assessing the effects of capital requirements both on bank capital as well as on their risk appetite. Traditionally, a theory of moral hazard has dominated in which information asymmetries and deposit insurance shield banks from the disciplining control of depositors.

Studies assessing conditions, or regulatory set ups, that act to eliminate moral hazard in banking have considered the capital decision of a bank as being exogenous. Abstracting from dividend and recapitalization preferences, this strand of literature analyzes incentives in asset risk choice. Several studies have found that although capital adequacy regulation may reduce the total volume of risky assets, the composition may be distorted in the direction of more risky assets, and average risk may increase. Risk consistent weights here are not sufficient to correct for this moral hazard effect in the limited liability of banks (Koehn and Santomero, 1980; Kim and Santomero, 1988; Rochet, 1992; and Freixas and Rochet, 1997). While the literature in this field tends to agree on the fact that the probability of failure is excessively high due to adverse incentive effects of mispriced deposit insurance, or the safety net in general, what is less clear is whether capital regulation is effective in reducing the moral hazard problem. One set of authors question the need for capital regulation if the correct pricing of deposit insurance can eliminate moral hazard (Gennotte and Pyle, 1991 and Giammarino et al., 1993).

In a moral hazard framework, banks will never have an incentive to hold excess capital. In practice, however, banks may not be able to instantaneously adjust capital or risk due either to adjustment costs, or illiquid markets. They therefore hold substantially more capital than that required of them (Keeley, 1990). Furthermore, under asymmetric information, raising equity capital could be interpreted as a negative signal with regard to the bank's value (Myers and Majluf, 1984), rendering banks unable or reluctant to react to negative capital shocks instantaneously. However, a breach of the regulation triggers costly supervisory actions, possibly even leading to the bank's closure. Hence banks have an incentive to hold more excess capital as an insurance against a breach of regulation. This incentive increases with the probability of breaching the regulatory minimum and, with the volatility of the capital ratio. The trade-off between costs associated with recapitalization and consequences of a breach of regulation determines the optimum capital buffer (Marcus, 1984; Milne and Whalley, 2001; Brewer III et al., 2008).

The Contribution of this Study

The work undertaken in this study focuses on empirically testing various aspects of the capital buffer theory (for statements of this theory see among others Milne and Whalley, 2001; Peura and Keppo, 2006; VanHoose, 2007). Analyzing bank capital decisions under the Basel I regulatory framework, we contribute to the literature by providing empirical analysis and evidence on a number of varying issues. In particular, we assess how, under strict regulatory requirements, banks choose their internally optimal capital buffers. We start by analyzing how these buffers have varied with the cycle over time in order to contribute to the procyclicality debate of the Basel II rules. We additionally explore the long run relationship between the capital buffer and the charter value of the bank, focusing in particular on testing how capital buffers are managed as charter values change. Finally, we assess the relationship between short term adjustments to capital and risk to understand the interaction of capital and risk in bank capital management decisions. While we acknowledge that in light of the current financial crisis these relationships have the potential to become more complex in the future, the work undertaken here does provide some evidence as to how banks managed capital in the run up to the crisis and what relationships between important variables looked like at this time.

2.2 The Theory

The empirical estimations in this study are based on the continuous time capital structure trade-off model of Milne and Robertson (1996) with the assumption that regulators engage in a Poisson audit, as in Merton (1977) and Marcus (1984). Moreover, if regulators discover a breach of capital regulations during an audit, they require undercapitalized banks either to issue new capital or to close down. The incentive based view of bank capital regulation, developed in Milne and Whalley (2001), views the capital decision as an endogenous response to the imposition of bank capital regulations.

The trade-off between costs of recapitalization and consequences of breaching the regulatory minimum is the driving force behind the target level of buffer capital chosen by the bank. The capital buffer therefore serves as a capital cushion, protecting against negative unexpected shocks to the system.

The amount of non-tradable assets a bank holds at time t is a fixed amount A. The capital of the bank is denoted by C and can be thought of as its book equity or net worth. The balance of financing the holding of A is achieved by raising zero cost short term deposits given by: $D = A - C$. Changes in bank capital can then be written as:

$$dC = (RA - \theta)dt + \sigma dz = -dD \tag{2.1}$$

where RA is the constant expected cash flow generated by A per unit time; θ is the dividend paid to the shareholder; $\sigma \in [\sigma_1, \sigma_2]$ is a choice the bank faces over the uncertainty of cash flows. The value of the bank to its shareholders, or the market value of the banks shares, is then given by:

$$V(C) = \max_{\theta,\sigma} E\left(\int_t^{\infty} \theta e^{-\rho\tau} d\tau\right) \tag{2.2}$$

here ρ denotes the discount factor, as well as the cost of equity relative to debt since depositors are unremunerated.

Regulation occurs at random intervals as per Merton (1978). Auditors are interested in the level of C compared to the required minimum $\hat{C}$. If $\hat{C} > C$, then the bank must decide whether to recapitalize at the cost of $x + \Delta C$ (where x denotes the fixed cost of recapitalization) or to liquidate. In the case of liquidation, debt holders are repaid in full from deposit insurance, and shareholders receive nothing.

This is a problem of dynamic stochastic optimization with analytical solutions. Application of standard techniques shows that the value function satisfies the Hamilton-Jacobi-Bellman differential equation, or equation of optimality:

if $C > \hat{C}$:

$$\rho V = \max_{\theta,\sigma \in [\sigma_1,\sigma_2]} [\theta + (RA - \theta)V_C + \frac{1}{2}\sigma^2 V_{CC}] \tag{2.3}$$

if $\hat{C} \geq C$:

$$\begin{aligned} \rho V = \max_{\theta,\sigma\in[\sigma_1,\sigma_2]}[\theta + (RA - \theta)V_C + \frac{1}{2}\sigma^2 V_{CC}]+ \\ q[\max(\max_{\Delta C > \hat{C} - C}\{V(DeltaC + C) - \Delta C - x\}, 0) - V(C)] \end{aligned} \tag{2.4}$$

As long as the bank's capital level C stays above the required minimum level, it continues to chose θ and σ so as to maximize current dividends to shareholders as well as the instantaneous capital gain $[(RA - \theta)V_C + \frac{1}{2}\sigma^2 V_{CC}]$. If the bank breaches regulatory requirements and the breach is noted during a random audit, the bank faces the choice of recapitalization or liquidation. Recapitalization ΔC is optimal if the gain in shareholder value, $V(\Delta C + C) - V(C)$, is greater than the cost of recapitalization $\Delta C + x$.

The most important findings of the model can be summarized as follows:

2.2.1 Cyclicality of Capital Buffers

The theoretical model outlined above predicts that risk taking will be positively related to the level of capital held. If banks have a greater level of asset risk, then they will hold a higher level of capital to insure themselves against breaching the minimum capital requirements. As loans are traditionally the most important bank asset category, so credit risk will be one of the key drivers of asset risk. Therefore, since credit risk is strongly related to the business cycle, the capital buffers of banks will fluctuate cyclically. Despite theory indicating a probable relationship between capital buffers and the business cycle, the direction remains ambiguous and therefore incomplete. In Chapter 3, we empirically test the following hypotheses in this regard:

H_0 : **Under the Basel I Accord, business cycle fluctuations *do not* have an impact on the capital buffers of European banks;**

against two alternatives:

H_{1a} : **Capital buffers move *positively* with the business cycle i.e. banks tend to increase capital in business cycle expansions and reduce capital in recessions;**

and

H_{2a} : **Capital buffers move *negatively* with the business cycle i.e. banks tend to reduce capital in business cycle expansions and increase capital in recessions.**

These descriptive hypotheses are consistent with a number of different underlying structural models of bank capital dynamics. Estrella (2004) examines the relationship between target forward looking capital buffers and deterministic cycles of loan losses. He finds that banks, subject to costs of capital adjustment, will build up capital buffers in anticipation of loan losses. Since loan losses themselves tend to lag the business cycle, this suggests that actual capital buffers will rise during cyclical downturns, i.e. negative cyclical comovement.

2.2.2 Capital Buffers and Charter Value

The capital buffer model highlights a central role for charter value in bank capital decisions. If charter value is sufficiently high, then the bank will always wish to retain a capital buffer to reduce the expected cost of infringing the regulatory capital requirement. If the charter value of the bank exceeds a certain threshold, then the bank will manage its capital in such a way as to reduce the probability of regulatory breach. The target amount of capital the bank will choose is thus a function of risk, charter value, audit frequency, costs associated with recapitalization together with the costs of holding equity in relation to debt. The bank will adjust towards the target buffer level C^* by retaining earnings as long as $C < C^*$, and paying out all earnings as dividends when $C = C^*$. The opposite effect is evident when the banks charter value falls below a certain threshold. In this case, the bank is no longer concerned with future earnings and has little incentive to maintain adequate capitalization. Such banks have low expected earnings that offer little protection against loss of earnings. As a result such banks have a very high probability of failure.

The relationship between charter value and desired capitalization is predicted to be highly non linear. As long as the charter value is a degree greater than the cost of recapitalization, a decline in expected earnings increases desired capital protection to protect the charter value.

For a set of publicly traded US BHCs, the hypotheses to be tested in Chapter 5 can be outlined as follows:

H_0 **No long run relationship between bank capital and charter value exists.**

against the alternatives:

H_{1A}: **The long run relationship between capital and charter value is significantly linear.** A positive linear relationship signifies that high charter value banks will hold larger buffers of capital so as to protect the valuable charter. Alternatively a negative linear relationship indicates that banks with valuable charters have better access to the capital markets and therefore have less need to hold a large amount of excess capital.

and

H_{1B}: **The long run relationship between capital and charter value is highly non linear and hump shaped.** For banks with high charter values, the optimum capital buffer increases as the charter value decreases. Only if the charter value falls close to the cost of recapitalization is the relationship reversed.

2.2.3 Capital Buffer and Risk Adjustments

The buffer theory of capital further predicts that a bank approaching the regulatory minimum may have an incentive to increase its capital and reduce risk to avoid the regulatory costs triggered by a breach of the capital requirements. Essentially, the model predicts that adjustments in capital buffers and asset risk are positively *(negatively)* related for banks with larger *(smaller)* than average capital buffers. Moreover, banks with small *(large)* capital buffers will adjust their capital faster *(slower)*. Similarly banks with small *(large)* capital buffers will adjust their risk levels faster *(slower)*.

Furthermore, with unremunerated deposits[4], the desired amount of excess capital is invariant to the capital requirement. It is rather the buffer of free capital over and above the regulatory minimum that determines bank attitude towards risk. Once capital has been built up towards the target level, changes in capital requirements will have no impact on bank behavior. Moreover, incentives for risk taking tend to be reduced, as leverage is increased. However, once the bank is close to insolvency there is a marked increase in incentive for risk taking (gambling for resurrection). The hypotheses tested in Chapter 4 are given as:

H_0: **Short term adjustments in both the capital buffer and bank risk have no impact on one another, and the speeds of adjustment are equal for banks with large and small capital buffers respectively.**

against two alternatives:

H_{1A} : **Short term adjustments in the capital buffer and risk are positively related for banks with large capital buffers. This hypothesis is in line with the theory that well capitalized banks will maintain healthy cushion of excess capital over time.**

and

H_{1B} :**Short term adjustments in the capital buffer varies systematically, but negatively, with adjustments in risk ie. riskier banks will hold less capital in their buffer stock. This hypothesis is in line with the notion that banks with capital near the regulatory minimum will try to build up their excess capital over time.**

2.3 Bank Regulation

The combination of the general instability of banking institutions, their complex web of interconnections; together with their important facilitating role in the economy, has led the banking sector to become a thoroughly regulated industry. Various different instruments have been adopted for the regulation of the banking sector, and can broadly be characterized by the following: the government safety net, restrictions on asset holdings, capital requirements, chartering and bank examination, disclosure requirements, consumer protection and restrictions on competition.

Capital regulation has become one of the key instruments of modern banking regulation with the aim of providing both a buffer during adverse economic conditions, as well as a mechanism aimed at preventing excessive risk taking ex ante (see Rochet, 1992; Dewatripont and Tirole, 1993). Broadly speaking, a bank has only two distinct means to finance its operations; either through the use of borrowed money or alternatively, it can make use of funds provided by its owners. Borrowings (including deposits) generate contractual liabilities, which, if not paid when due, can result in bank failure. On the contrary, the owners' investments can either gain or lose value without causing the bank to default on its obligations. Thus, all other things being equal, the greater the proportion of a bank's operations that are financed with capital funds contributed by its owners, the higher the chance that the bank will continue to be able to pay its obligations during

[4]Deposits that earn low returns.

periods of economic adversity. This simple reasoning is the basis for the longstanding emphasis that bank supervisors have placed on capital adequacy as a key element of bank safety and soundness.

With the intention of indirectly affecting capital structure by reducing the relative amount of debt, capital regulation requires that banks hold an amount of capital dependent on both the quantity and the quality of its assets. The ideology stems from a combination of the legal construction of limited liability together with an important incentive feature of debt finance. The concept of limited liability implies that cash flows can not become negative, as debt remaining after all assets have been liquidated and all outstanding debt repaid as far as possible, will be forgiven.[5] In a largely leveraged firm, owners are able to reap the gains of success while shifting losses to the lenders via limited liability. Consequently, incentives for risk taking beyond Pareto optimality are significantly increased.[6] Since banks often have capital structures with substantial amounts of debt, the possibility of such risk shifting behavior in this sector is particularly problematic.

2.3.1 Basel I

The regulation, as implemented by the Basel Accord of 1988, applies to all internationally active banks. The Basel Committee on Banking Supervision was established at the end of 1974 to provide a forum for banking supervisory matters.

Although the Basel Committee is not a formal regulatory authority in itself, it has great influence over the supervising authorities in many countries. The hope is that by agreeing basic goals, the Committee can achieve common approaches and standards across many member countries, without attempting detailed harmonization of each member country's supervisory techniques. In 1988, recognizing the emergence of larger more global financial services companies, the Committee introduced the Basel Capital Accord (Basel I). This sought to strengthen the soundness and stability of the international banking system by requiring higher capital ratios.

Since 1988, the Basel I framework has been progressively introduced not only in member countries but also in virtually all other countries with active international banks. In June 1999, the Committee issued a proposal for a new Capital Adequacy Framework to replace Basel I. Following extensive communication with banks and industry groups, the revised framework was issued on 26th June 2004 and is known as Basel II.

The Rules

Over 100 countries to date have adopted the rules, most of which additionally require locally active banks to adhere to them. Under Basel I, the capital adequacy ratio is equal to eight percent of the banks risk weighted assets, and acts as an indicator of the banks ability to absorb losses. The numerator of the ratio comprises total capital which is a combination of tier one and tier two capital. Tier one capital refers to the banks core capital, including equity and disclosed reserves and can absorb losses without a bank

[5] See Eichberger and Harper (1997).

[6] For a more detailed discussion of the risk shifting phenomenon in banking and the role of capital requirement regulation in mitigating this, see Greenbaum and Thakor (1995); and Keely (1990).

being required to cease trading. The ratio of the banks' tier one capital to risk weighted assets should be no less than four percent. Tier two capital on the other hand relates to secondary bank capital, and includes items such as undisclosed reserves, general loss reserves and subordinated term debt. Tier two capital can absorb losses in the event of a winding up and so provides a lesser degree of protection for depositors. The denominator of the ratio is obtained by multiplying assets by a predefined weighting coefficient.[7]

The capital regulation rules, as outlined above, are a minimum to be implemented by the individual supervisory authorities with the aim of creating a level playing field for market operatives, as well as for ensuring a sound and stable financial environment. Several of the supervisory authorities acting in the countries included in our study have, for various reasons, either set capital ratios above those recommended by the accord, or, alternatively, supplemented the rules with a range of additional requirements outlined below.

2.3.2 Europe

All European countries have chosen to implement the Basel I minimum of eight percent as the requirement for internationally active banks. However, in addition to this, as discussed below, several countries have supplemented these rules with alternative measures to ensure soundness and stability. All measures are outlined in Table 2.1.

Spain

In Spain, due to the concern of the Banco de España regarding the ability of Spanish banks to keep up with potential credit losses latent in the expansion of lending activity, capital requirement regulations were supplemented in June 2000 by a dynamic provisioning system. The idea of the provisioning was based on the notion that funds are set against loans outstanding in each accounting time period, in line with an estimate of expected long run losses. Essentially, banks will build up a provision during a cyclical upturn which is subsequently drawn from during a recession, or cyclical downturn. The provision will increase when actual losses for one year are lower than expected, and is used against specific provisions in years when losses are higher than expected. The provisioning system therefore acts to smooth out cyclicality impacts of specific provisions on the profit and loss account. The statistical provision is calculated using a bank's own internal method[8], or alternatively, via a standard method recommended by the Banco de España. The standard method classifies exposures into six different categories depending on their degree of riskiness. Each category is allocated a weight coefficient.[9] The total provision is then equal to the sum of the requirements for all six categories. It is therefore unsurprising, that the capital buffers of Spanish banks have remained relatively unchanged (around 3.6 percent) since the implementation of the dynamic provisioning in June 2000.

[7]Under the Basel I accord, four risk buckets are set: 0 percent for claims on central governments; 20 percent for claims on other banks; 50 percent for loans secured by residential property and 100 percent for claims on private sector.

[8]The regulator must verify that the model adopted characterizes a suitable means to measure and manage credit risk.

[9]The coefficients range from zero, for zero risk exposures, to 1.5, for high risk exposures.

United Kingdom

In addition to the basic requirements set out by the Basel Accord, the UK Financial Services Authority (FSA) has implemented various additional requirements to assure the safety and soundness of its banking sector. First, the FSA sets two separate requirements for each bank: a 'trigger ratio' and a 'higher target ratio'. The trigger ratio serves as a minimum ratio which will generate regulatory intervention if breached. The 'target ratio' serves as a warning signal and as a cushion of capital acting to prevent the accidental breach of the trigger ratio. The gap between the target and the trigger ratio acts as a buffer in that regulatory pressure is exerted when the capital ratio falls below the target but drastic regulatory action is only enforced in the event of a breach of the trigger ratio. These ratios are bank specific and are based on the supervisor's perception of the degree of riskiness of the banking institution. Banks deemed by the supervisor to be more *(less)* risky is required to hold higher *(lower)* levels of capital. Consequently, most UK banks are required to hold capital in excess of those specified by the Basel Accord. For the purpose of our estimations, we calculate the capital buffer for UK banks based on an assumed nine percent minimum, since we are unable to obtain individual bank specific requirement data.

Recently Acceded Member States (RAMS)[10]

Banking policy for developing or transition economies generally tends to differ from that adopted for more developed markets. Since a stable financial system is vital for economic growth, the key questions for policy makers in this context relate to the specific methods of bank regulation and supervision that can promote more efficient and robust financial systems. Considering the varying degrees of development as well as the distinct differences that exist between the RAM economies in terms of banking sector structures, it is unsurprising that the minimum capital adequacy ratio required of financial market operatives has varied across countries throughout our sample period.

Table 2.1 highlights the minimum ratios adopted in each of the RAM countries. In Estonia and Cyprus, regulatory capital ratios were tightened from eight to ten percent of risk weighted assets to account for changes in market structure. In 1997, the Estonian authorities cited rapid growth of banks assets and changes in their operational environment as the main reasons for Estonias higher regulatory ratio. In 2001, Cyprus raised its capital adequacy ratio to account for the increase in securities market activity. Latvia and Lithuania on the other hand both reduced their required ratios from ten to eight percent effective from January 2005.[11]

In Poland, while banks are required to hold no more than the eight percent regulatory minimum, 15 percent is the requisite ratio for banks in their first year of operation, and 12.5 percent in the second year.

[10] We define the RAM10 as the ten accession countries that joined the European Union (EU) in 2004. Countries included are Cyprus, the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Slovenia and Slovakia.

[11] The ten percent regulatory minimum continues to be effective for AB VB Mortgage Bank in Lithuania.

2.3.3 United States

Prior to the 1980s, US banks were not subject to specific numerical standards imposed by regulators. Rather, banker and supervisory judgment was exercised such that the circumstances of the individual institution were considered. To this effect, important factors such as managerial capability, loan portfolio quality and adherence to fixed ratios were considered as arbitrary rules that did not always account for the most important factors.

Only after the worldwide recession in 1981 did Federal banking agencies across the US impose explicit numerical regulatory requirements for banks. These measures were further amended shortly after the initial requirements were imposed. In 1985, the International Lending and Supervision Act (ILSA) required that all banks hold a primary capital (consisting mainly of equity and loan loss reserves) ratio of 5.5 percent of assets, while the total amount of primary plus secondary (primarily qualifying subordinated debentures) capital had to exceed six percent of assets. Moreover, any bank operating with less than three percent of primary capital to assets were deemed unsafe and were subject to comply with enforcement actions. For the first time, capital was viewed as a cushion for absorbing shocks, as a means to signal strength and soundness to investors as well as to support overall banking sector growth and stability.

In 1986, regulators however became concerned that the regulations imposed failed to distinguish between different types of risks. It was therefore felt that the rules did not provide an accurate measure of risk exposures associated with modern banking activities. Finally then, in 1988, regulators in the Group of Ten countries (G-10) agreed upon a new legislation that appeared to capture all risks associated with banking activity. The new Basel Capital Accord was adopted and implemented in the US in 1992. It affected both tier one as well as total capital and was able to capture both on and off balance sheet risks by weighting items based on their perceived riskiness.

In addition to the Basel capital requirement, the US imposed an additional leverage ratio requirement on banks. This is based on the unweighted sum of all balance sheet assets. Five categories of bank types exist: *well capitalized banks*, *adequately capitalized banks*; *under capitalized banks*; *significantly under capitalized banks* and *critically under capitalized banks*. In order to be *adequately capitalized*, a bank holding company must have a tier one capital ratio of at least four percent, a total capital ratio of at least eight percent, and a leverage ratio of at least four percent. To be considered *well capitalized*, a bank holding company must have a tier one capital ratio of at least six percent, a total capital ratio of at least ten percent, and a leverage ratio of at least five percent. The requirements for each category of bank is outlined in Table 2.2. These capital ratios are reported quarterly via the Call Reports or Thrift Financial Reports. These capital requirements are currently in force standing as the main tool in regulating the US banking system.

2.3.4 New Rules

Since its implementation in 1988, The Basel Accord has helped to strengthen the soundness and the stability of the international banking system as a result of the higher capital ratios that it required. However, since the Basel I capital adequacy requirements were defined and adopted in the early 1990s, banking has become far more complex. The initial Basel rules are therefore in the process of being reassessed and updated to better suit current banking operations and risks inherent in assets held by banks.

While the basic methodology of limiting a bank's risk weighted assets relative to its capital will be retained, the primary aim of Basel II is to create a closer link between capital requirements and risks. Basel II, combines the two historical approaches to bank capital adequacy regulation. The new accord provides legislation for banks to closely follow in the calculation of their capital. Numerical minimum requirements therefore remain however, much more emphasis will be placed on the wide range of risks that can be faced by each individual bank. The forms of banking capital were largely standardized in the initial accord and have been left untouched in the updated version. Basel II aims to bring the framework more in line with modern banking by becoming more risk sensitive and representative of current risk management practices. There are several components to the new framework. First, it is more sensitive to the risks that firms face: the new framework includes an explicit measure for operational risk and additionally updates the existing weightings that exist against credit risk. Second, under the standardized approach, banks will be permitted to make use of external ratings by acknowledged ratings agencies; introducing differing weight coefficients for counterparties distinct from the set risk buckets defined under Basel I. Risk coefficients for enterprizes under Basel II, will range between 20 and 150 percent depending on the risk involved.

The accord further reflects improvements in firms' risk management practices, for example by the introduction of the internal ratings based approach (IRB). The IRB approach will allow firms to rely, to a certain extent, on their own internal estimations of credit risk. Risk coefficients here will be even more risk sensitive than under the standardized approach, with coefficients ranging between three and 600 percent, depending on the perceived riskiness of the counterparty.

Main Differences: Basel I vs. Basel II

Basel II differs from its predecessor in several respects: first, the capital formula is substantially revised; second, guidelines on the supervisory review of banks' capital adequacy are included; and third, the concept of market discipline is implemented through updated disclosure rules. The Basel II framework consists of three pillars detailed below:

Pillar I

Pillar I sets out the minimum capital requirements firms will be required to meet to cover credit, market and operational risk. Pillar I of the new capital framework revises the 1988 guidelines by aligning the minimum capital requirements more closely to each bank's actual risk of economic loss. First, Basel II improves the capital framework's sensitivity to the risk of credit losses generally by requiring higher *(lower)* levels of capital for those borrowers thought to present higher *(lower)* levels of credit risk. Three options are available to banks and supervisors in choosing an approach most appropriate for the sophistication of a bank's activities and internal controls. Under the standardized approach, banks that engage in less complex forms of lending and credit underwriting and that have simpler control structures may use external measures of credit risk to assess the credit quality of their borrowers for regulatory capital purposes. Banks that engage in more sophisticated risk taking and that have developed advanced risk measurement systems may, with the approval of their supervisors, select from one of two internal ratings based (IRB) approaches. Under the IRB approach, banks rely partly on their own measures of a borrowers' credit risk to determine their capital requirements. This method is subject to strict data, validation, and operational requirements. Second, the new framework establishes an explicit capital charge for a bank's exposure to the risk of losses caused by failures in systems, in processes, or those that are caused by external events such as natural disasters. Similarly to the range of options provided for assessing exposures to credit risk, banks will choose one of three approaches for measuring their exposures to operational risk. The approach will be agreed together with the supervisor, such that it reflects the quality and sophistication of internal controls over this particular risk area. By aligning capital charges more closely to a bank's own measures of its exposures to credit and operational risk, the Basel II framework encourages banks to refine those measures. It also provides explicit incentives, in the form of lower capital requirements, for banks to adopt more comprehensive and accurate measures of risk as well as more effective processes for controlling their exposures to risk.

Pillar II

The rules under Pillar II create a new supervisory review process. This requires financial institutions to have their own internal processes to (i) assess their capital needs; (ii) appoint supervisors to evaluate their overall risk profile; and to (iii) ensure that adequate capital is held. Pillar II of the new capital framework recognizes the necessity of exercising an effective supervisory review of banks' internal systems. In particular, the supervisory review should assure that overall risks are adequately assessed, that bank management exercises sound judgment and has set aside adequate capital for these risks. Supervisors will evaluate the activities and risk profiles of individual banks to determine whether organizations should hold capital above the minimum requirements and whether there is any need for remedial actions. The Committee expects that, when supervisors discuss with banks about their internal processes for measuring and managing their risks, they will help to create implicit incentives for organizations to develop sound control structures and to improve those processes.

Pillar III

The aim of Pillar III is to improve market discipline by requiring firms to publish certain details of their risks, capital and management practices. Pillar III leverages the ability of market discipline to motivate prudent management by enhancing the degree of transparency in banks' public reporting. It sets out the public disclosures that banks must make that provide greater insight into the adequacy of their capitalization.

Basel II applies to internationally active banks. In the European Union, the new capital requirements framework has been implemented through the Capital Requirements Directive (CRD). The CRD directly affects certain types of investment firms and all deposit takers (including banks and building societies). Member States were required to apply, the CRD from January 1, 2007. Institutions could choose between the Basic indicator approach, that increases the minimum capital requirement in Basel I approach from 8% to 15%, and the Standardized Approach that evaluates the business lines as a medium sophistication approaches of the new framework. The most sophisticated approaches, Advanced IRB approach and AMA or advanced measurement approach for operational risk were available from the beginning of 2008. From this date, all EU have applied Basel II.

The framework under the CRD reflects the flexible structure and the major components of Basel II. It has been based on the three pillars, but has been tailored to the specific features of the EU market. Member States were required to apply the Directive from the start of 2007, but the more sophisticated risk measurement approaches only became available in 2008. The CRD is not a stand alone directive, rather it implements the new framework by making significant changes to two existing directives: the Banking Consolidation Directive and the Capital Adequacy Directive, both of which were based on Basel I.

In the UK, the Financial Services Authority (FSA) is working with the Basel Committee, the EU and the banking industry to develop its policies for implementing the new capital adequacy framework via the Capital Requirements Directive.

Several concerns regarding the new regulation have been raised. One effect of the new rules is to give credit rating agencies an explicit role, particularly for less sophisticated banks, in determining how much capital is enough. The risk associated with this methodology is highlighted by the current crisis whereby it seems that agencies have over estimated the creditworthiness of some asset backed securities. Moreover, Basel II encourages banks to use instruments such as credit derivatives to transfer risks. The complexity of such instruments however, lies behind the banks' difficulty in knowing who will ultimately bear the exposure to defaults. Its most prominent feature however is its risk sensitivity compared to its predecessor. Much debate therefore exists relating to potential cyclicality effects.

Moreover, Pillar III of the new framework introduces a market discipline component to bank regulation. Under Pillar III, banks will be required to disclose to the public the new risk based capital ratios and more extensive information about the credit quality of their portfolios and their practices in measuring and managing risk. Regulators expect such disclosures will make banks more transparent to financial markets, thereby improving market discipline. However, it has been questioned whether a meaningful distinction between disclosure and market discipline does in fact exist. It is therefore important to understand what motivates bank capital management under Basel I (in the absence of a Pillar III), whether it is possible to identify some internal disciplining force driving capital and risk taking.

In addition, it has been argued that a more risk sensitive capital adequacy regulation may impact a banks' risk appetite via additional requirements associated with riskier counterparties. It is therefore clearly of interest to understand the varying effect of risk on capital buffer formation since the introduction of Basel I in the US. These questions have important implications for competition policy, moral hazard in banking and the overall safety and soundness of banks.

2.A Tables

Table 2.1: Individual Country National Capital Requirements: Europe.

	Minimum required ratio	*Year of implementation*	*Reason for change*
All EU countries	8%		
Denmark	8%		
Sweden	8%		
UK	9%		
Cyprus	8%	1997	
Cyprus	8%	2001	Changes in market structure.
Czech Republic	8%	1992	
Estonia	10%	1997	Rapid growth of bank assets.
Hungary	8%	1991	
Latvia	10%	1997	
Latvia	8%	2004	
Lithuania	10%	1997	
Lithuania	8%	2005	
Malta	8%	1994	
Poland	8%	1992	
Slovakia	8%	1997	
Slovenia	8%	2004	

Notes:
As explained in Section 2.3.2, the FSA sets additional 'trigger' and 'higher target' ratios for UK banks resulting in higher levels of capital required by the regulators. For this reason in the study we apply a nine percent requirement to UK banks active in the sample and calculate the buffer as capital above this level.
EU countries include Austria, Belgium, Germany, Spain, Finland, France, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal.

Table 2.2: Capital Ratios for US Bank Categories

	Tier one capital requirement	*Total capital requirement*	*Tier one leverage requirement*
Well capitalized bank	≥ 6	≥ 10	≥ 5
Adequately capitalized bank	≥ 4	≥ 8	≥ 4
Under capitalized bank	< 4	< 8	< 4
Significantly under capitalized bank	< 3	< 6	< 3
Critically under capitalized bank		$2 \geq$ tangible equity	

Source: FDIC.

Chapter 3

The Cyclical Behavior of European Bank Capital Buffers

[1]

3.1 Introduction

As outlined in Section 3.3 of Chapter 2, much debate surrounding Basel II on bank capital requirements has centered on its potential procyclicality effect. Creating a closer link between capital requirements and risks means required capital will become largely determined by economic conditions. In a cyclical downturn capital requirements are likely to increase to account for increased counterparty risk. Similarly, during an economic upturn, the amount of capital required would be reduced. Since raising capital is costly, especially during a recession, banks might be forced to reduce their loan portfolio, so as to meet rising capital requirements. Thus many have argued that the new accord will make it much harder for policy makers to maintain macroeconomic stability.

The growing literature on the potential procyclicality of Basel II has largely focused on quantifying the likely range of variation in Pillar I capital requirements through the business cycle. In practice, well functioning banks hold capital in excess of the minimum requirements, which will reduce the impact of Pillar I regulatory capital requirements on loan portfolios. Moreover, the supervisory review powers granted to regulators under Pillar II, allowing them to demand a buffer of additional capital during a business cycle expansion, provide policy makers with a tool to counter the potential procyclicality effect of the new accord. All this implies that the management of bank capital buffers over the course of the business cycle will be as important, or even more important, than the Pillar I requirements as a determinant of the cyclical impact of the new accord. With this policy concern in mind, we investigate the cyclical behavior of bank capital buffers of European banks, under the old Basel 1988 Accord. By "capital buffer"we mean the amount of capital banks hold in excess of that required of them by national regulators. The main objective of this chapter is to establish the extent of comovement between this

[1] This chapter has been published as Jokipii and Milne (2008). 'The cyclical behavior of European bank capital buffers.' Journal of Banking and Finance, 32(8): pp. 1440-1451.

buffer and the cycle, and to determine whether such comovement is country, bank type or bank size specific. We also analyze the impact of various cost and revenue variables on the behavior of bank capital buffers.

Our estimation results reveal substantial differences in the cyclical behavior of capital buffers. We find that capital buffers of RAM (ten countries that joined the EU in May 2004) banks move together with the business cycle while those of banks in the Denmark, Sweden and the United Kingdom (DK,SE,UK) and Euro Area (EA) sub-samples exhibit negative comovement.[2] We also find additional distinctions by size and type of bank. Capital buffers of commercial and savings banks, as well as those of larger banks have a negative relationship with the cycle while those of co-operative banks and of smaller banks move together with the cycle. In almost all cases we find a fairly slow speed of adjustment towards desired capital buffers. These results provide a benchmark from which inferences relating to the introduction of Basel II and its effect on capital buffer management can be made. In particular, they shed some light on how capital management decisions may need to be adjusted through Pillar II and III of Basel II in order to offset the potential cyclical effects of the new accord.

The rest of this chapter is organized as follows. Section 3.2 discusses the motivation for holding excess capital, sets out the hypotheses we test, and describes our data including the various controls we introduce for bank specific determinants of bank capital. Section 3.3 presents our specification and empirical results and summarizes some robustness checks. Finally, Section 3.4 briefly discusses the findings and concludes.

3.2 Hypotheses and Data Description

Our data, for the years 1997-2004, indicates that banks hold far more prudential capital than that required by the regulators (see Tables 3.1 and 3.2).[3] Total capital buffers (tier one plus tier two) of banks within the EU15 vary from 1.87 percent of risk weighted assets in Portugal to 4.79 percent in Finland with an average across the EU15 of 2.93 percent. Buffers are also substantial in the Accession countries, ranging between 2.64 percent in Cyprus and 6.99 in Malta. The average buffer for the RAM10 is around 5.14 percent which is considerably larger than in the EU15.

Several reasons have been put forward to explain why banks hold excess capital (see amongst other studies Marcus, 1984; Berger et al., 1995; Jackson, 1999; Milne and Whalley, 2001; Estrella, 2004; Milne, 2004). Banks generally will tend to assess their risks differently than regulators, for instance using their own internal economic capital models. Appropriate bank specific capital levels will therefore be set according to their own assumptions and risk appetites.

Banks may also need to hold excess capital in order to signal soundness to the market and satisfy the expectations of rating agencies (Jackson, 1999). These market disciplines may lead banks to hold more capital than required by regulators. Banks may also hold

[2]The latter finding is broadly in line with most of the individual country studies that analyze the determinants of excess capital and their relationship to the cycle (see among others Ediz et al., 1998; Rime, 2001; Ayuso et al., 2004; Lindquist, 2004; Stoltz and Wedow, 2005; Francis and Osborne, 2009; Repullo and Suarez, 2009).

[3]Similarly large capital buffers are also held by US and Asian banks. See for example Peura and Jokivuolle (2004) for a tabulation of US capital buffers.

a buffer of capital as a protection against the breach of the regulatory minimum requirements (Marcus, 1984; Milne and Whalley, 2001; Milne, 2004). By holding capital as a buffer, banks insure themselves against costs arising from a supervisory intervention in response to a breach of the requirements.

A further reason for holding a capital buffer is to take advantage of future growth opportunities, putting banks in a position to obtain wholesale funds quickly and at a competitive rate of interest in the event of unexpected profitable investment opportunities. In the event of a substantial increase in loan demand, banks with relatively little capital may lose market share to those that are well capitalized. It is difficult to empirically distinguish these different underlying determinants of bank capital buffers: for example higher portfolio volatility can be expected to increase capital buffers, whether these are the result of market disciplines or of a desire to avoid supervisory interventions. It is important to note that cyclicality in the banking system is not a new phenomenon. Potential sources of volatility include the probability of default, the loss given default, exposure at default as well as the correlation factor (see Lowe, 2002 for a more detailed discussion). The issue we are concerned with is whether the new guidelines on bank capital management will create additional volatility in capital, and in turn on credit availability. This chapter has a more limited objective, to investigate how capital buffers of European banks behave over the business cycle, and in particular whether capital buffers are higher in business upturns and lower in business downturns (positive comovement) or the reverse (negative comovement), controlling as far as we can for various bank specific determinants of capital buffers. We thus test the following null hypothesis:

H_0 : **Under the Basel I Accord, business cycle fluctuations do not have an impact on the capital buffers of European banks;**

against two alternatives:

H_{1a} : **Capital buffers move positively with the business cycle i.e. banks tend to increase capital in business cycle expansions and reduce capital in recessions;**

and

H_{2a} :**Capital buffers move negatively with the business cycle i.e. banks tend to reduce capital in business cycle expansions and increase capital in recessions.**

These descriptive hypotheses are consistent with a number of different underlying structural models of bank capital dynamics. Estrella (2004) examines the relationship between internally optimal forward looking capital buffers and deterministic cycles of loan losses. He finds that banks, subject to costs of capital adjustment, will build up capital buffers in anticipation of loan losses. Since loan losses themselves tend to lag the business cycle, this suggests that actual capital buffers will rise during cyclical downturns, i.e. negative cyclical comovement.

It is also argued (see among others Rajan, 1994; Borio et al., 2001; Crockett, 2001) that portfolio risks actually increase during an economic upturn. During an economic boom, lenders provide large amounts of credit while imbalances that will become responsible for the following recession continue to build up, increasing the possibility of unusually large losses during a cyclical downturn. Under this interpretation rational forward looking banks may build up capital buffers during cyclical upturns, i.e. positive comovement.

Both positive and negative comovement may also arise as a consequence of myopic bank behavior. For example during an economic upturn, when risks are less likely to immediately materialize, banks may underestimate risks and as a result expand their loan portfolios and lower their capital ratios (negative comovement). On the other hand unanticipatedly high levels of loan loss provisions in an extended cyclical downturn may lead to lower capital ratios in a deep recession (positive comovement).

While we cannot distinguish these different structural models of bank capital buffers, or distinguish myopic from forward looking expectations, we can control for institution specific factors that influence the banks desired level of capital. A large body of literature examines variations in risk profile and portfolio and capital structure decisions between different types of banks (see among others, Saunders et al., 1990; Gorton and Rosen, 1995; Esty, 1997; Salas and Saurina, 2002). Differences in capital buffers can arise because of variations in portfolio risks, in ownership structures and in access to the capital market.

The clearest prediction of this literature is that larger banks will hold smaller average capital buffers. Most obviously, large geographically diversified banks will have a much smaller probability of experiencing a large decline in their capital ratios, a diversification effect increasing with size. This effect is reinforced by asymmetric information between lenders and borrowers and by government support for banks that are too big to fail. Banks help overcome information asymmetries by screening and monitoring borrowers, but these are costly activities and banks are likely to balance the cost of (and gain from) these activities against the cost of excess capital. In the presence of scale economies in screening and monitoring, one would expect large banks to substitute relatively less of these activities with excess capital. Large banks may expect a greater degree of support than small banks from the government in the event of difficulties, further reducing capital buffers.

3.2.1 Sample selection

We build an unbalanced panel data set with eight years of annual bank balance sheet data obtained from the Bureau Van Dyck Bankscope database. Our sample includes data for commercial, savings and co-operative banks. In total, 468 banks are included in the sample, made up of 364 EA banks, 427 EU15 banks and 41 banks for the RAM10 (the 10 accession countries that joined the European Union in 2005). All 25 European Union countries are represented in the sample. As is usual in panel studies using accounting data, we remove some extreme outlier observations of changes in capital buffers.[4] See Appendix 3.B for a description of the treatment of outliers in this sample.

We have to consider carefully the timing of accounting years. The majority of bank accounting years end in the December of the calendar year (this applies to around 80 percent of our observations. However some 20 percent of our observations are for accounting

[4]Data errors lead to occasional very large movements in reported capital buffers. Of the total 3736 observations available to us, we dropped 21 in the extreme tails of the cross sectional distribution of capital buffers, with a much larger number of standard deviations from the mean than the bulk of observations, on the assumption that these are reporting errors.

years ending between January and March). Since capital buffers in the first quarter of the calendar year are determined by economic conditions in the previous year, we have transferred all accounting years ending between January and March back one year, so for example an end-March 2004 year we classify as an 2003 observation.

The largest bank in the samples is BNP Paribas, with total assets of around €906 bln at the end of 2004. The smallest bank, Budapest Bank in Hungary, has total assets amounting to just around €1.5 million at the end of 2004. The largest number of banks are in France (103 banks) and Spain (70 banks) from the EU15 and in Poland (10 banks) for the RAM10.

Our sample is further broken down by bank type distinguishing between commercial, co-operative and savings banks. We additionally differentiate between small and large banks, defining large banks as those with total assets exceeding the 2004 median of €37 billion in 2004. The sample distribution across sub-samples, by type and size of bank, is presented in Table 3.3. The RAM10 sub-sample is made up of small commercial banks, with the exception of a small Polish savings bank, Powszechna Kasa Oszczednosci Bank. We divide the EU15 into two further sub-samples, the Euro area (EA) and Denmark, Sweden, and UK (DK-SE-UK). The two sub-samples and the total EU15 contain a similar breakdown of banks, with 19 percent of banks large and with 65 percent commercial banks, 15 percent co-operative banks and around 20 percent savings banks. Across the entire data set Sweden has the largest percentage of large banks (around 50 percent), followed by Ireland (around 35 percent).

Dependent and explanatory variables Table 3.1 tabulates average capital buffers for individual banks in the sample, by time and by country. Here the capital buffer is measured as the institutions' total tier one plus tier two capital ratio less its regulatory minimum requirements.[5] These requirements vary slightly from one country to another, sometimes exceeding the Basel minimum of eight percent. The individual country averages are averages weighted by the market share (total assets) of the individual banks. There are several differences in the buffer sizes between countries. Many of the smaller countries such as Finland, Belgium and Ireland have large buffers of around four percent when compared to banks in larger countries such as France and Italy and the UK, where the buffers are around two percent above the required minimum.

On average over our sample period RAM10 banks held far more capital than banks in the EU15 countries (see the averages of the composite countries in Table 3.2). However this gap has declined over time. Figure 3.5 plots the evolution of our individual sub-sample capital buffers. In the EU15 capital buffers rose slightly between 1998 and 1999, but then increased substantially between 2002 and 2003. In the RAM10 countries capital buffers have behaved very differently, rising steadily from 1997 to 1998 before falling sharply between 2000 and 2001. Thereafter, the RAM10 buffer level continues on a slight downward trend and by 2004 is at a similar level to the EU15.

[5] We study only the total capital buffer not the tier one buffer. There are two reasons for this. We need to take account of variations in the minimum level of required capital between jurisdictions (see Chapter 2). As summarized in Table 2.1 these differences are in total not tier one capital requirements. Also the main source of capital fluctuation e.g. equity and loan loss reserves, affect both tier one and total capital buffers.

Figure 3.5 also distinguishes between different bank types and bank sizes, for the EU25 and for our three sub-samples (EA, DK,SE,UK and RAM10), and compares these buffers with our principal explanatory variable, the output gap. The capital buffers of co-operative banks behave very differently than those of commercial and savings banks, possibly reflecting the differences in ownership structure and objectives of co-operative banks.[6] This figure also confirms that small banks hold much higher average capital buffers than large banks.

[6]Co-operative banks cannot easily issue new shares and members prefer cash payments over retained earnings because there is no market for their ownership claims.

Table 3.4 provides definitions of the variables used in our estimation. Our cyclical indicator is real GDP growth calculated from Eurostat data for each of the 25 countries and for the different sub-sample country groupings.[7] Our basic specification *(Model I)* includes three additional variables (*roe*, *risk* and *size*) as controls for various determinants of individual capital buffers as discussed by Estrella (2004). The first of these determinants is *the greater cost of equity capital funding*, relative to deposits or debt. Theoretical analysis (see Myers and Majluf, 1984; Campbell, 1979) suggests that in the context of information asymmetries, equity is a more costly alternative to other bank liabilities. Equity may also be disadvantaged because interest payments on debt are deducted from earnings before tax.

Direct measurement of this cost is difficult. Previous studies (see among others Ayuso et al., 2004; Bikker and Metzemakers, 2004; Stoltz and Wedow, 2005) have included the banks return on equity (*roe*), the ratio of post tax earnings to book equity, as a proxy for the direct costs of remunerating excess capital. However *roe* may well exceed the remuneration demanded by shareholders and to this extent is a measure of revenue rather than cost. For comparability with previous studies we include *roe* as a control variable, but we acknowledge that this reflects both revenue and cost. The buffer capital model of Milne (2004) suggests that for financially strong banks the revenue impact will generate a negative relationship between *roe* and capital buffers, because a high level of earnings substitutes for capital as a buffer against unexpected shocks i.e. under both cost and revenue interpretations we expect to observe a negative relationship between the capital buffer and the *roe* variable.

The second determinant identified by Estrella (2004) is the expected cost of failure equal to the dead weight cost carried by shareholders times the probability of failure.[8] Since a banks' probability of failure is dependent on its risk profile, we proxy the cost of failure by adopting various measures of risk. As a first measure, we consider the ratio of non-performing loans to total loans (*risk*) as in Ayuso et. al (2004). This is an ex post measure of the risks assumed by banks and is comparable to other measures adopted in the literature since banks with non-performing loans are obliged to make provisions for loan losses. If banks set their capital in line with the true riskiness of their portfolios, then we would expect the relationship here to be positive.[9] Furthermore, we include an alternative measure for risk as per Stoltz and Wedow (2005) and Lindqvist (2004) whereby we consider the ratio of new net provisions over total assets $risk2$.[10] As discussed above there are several reasons, most notably greater portfolio diversification, for expecting a negative relationship between bank size and the level of capital buffers. Furthermore, we include dummy variables denoted *big* and *small* to capture differences in buffer movements varying with the size of the institution. *big* equals one for banks in

[7] We also investigated the use of the output gap which we obtained by applying the Hodrick-Prescott filter to the real GDP series. Estimates substituting this gap differed to only a minor extent and are therefore not presented here.

[8] An alternative framework for modelling these costs is Milne, 2004 and Milne and Whalley, 2001.

[9] Banks may vary significantly in their willingness to take risk. This measure therefore can be assumed to uncover information on bank type. Any further idiosyncratic time invariant component in the banks risk profile would be captured by the component of the residual term of Equation 3.6

[10] As the results for *risk* are broadly in line with those obtained for $risk2$, we present only those for *risk* since more observations are available for this variable.

the highest decile of the size distribution of assets and zero otherwise. Similarly *small* equals one for banks in the lowest thirtieth percentile of the size distribution of assets. These dummy variables are recomputed for each time period and for each sub-sample.

In a further specification *(Model II)* we include three additional balance sheet variables to control for the determinants of bank capital. Our $profit$ variable capturing post tax profits over total assets has an ambiguous anticipated sign. Higher retained earnings can be expected to increase capital buffers, but also higher expected earnings can be expected to reduce desired capital buffers. The ratio of bank loans to total assets (*net loans*) suggests a riskier profile so the expected sign is therefore positive. Annual loan growth ($\Delta loans$) is a proxy for credit demand (this variable is also used by Ayuso et al., 2004) and should be expected to increase assets relative to capital and hence lower capital buffers.

3.3 Estimation Results

Following previous literature (Ayuso et al., 2004, Estrella, 2004) we use a partial adjustment framework with quadratic costs of adjusting capital.[11] Lower adjustment costs result in a faster speed of adjustment δ:

$$\Delta buf_{ijt} = \delta(buf^*_{ijt} - buf_{ijt-1}) + u_{ijt} \tag{3.1}$$

Here buf_{ijt} and buf^*_{ijt} are the actual and the optimum capital buffer respectively, of bank i in country j at time t. The proportionate adjustment towards the desired capital buffer in each period is δ. u_{ijt} is the error term that can be decomposed as the sum of two components, a random country specific component μ_i , plus a pure bank idiosyncratic component ε_{ijt} .

The desired capital stock buf^*_{ijt} however cannot be observed, and is therefore approximated by the various cost and revenue variables discussed in the previous section.[12] The estimated version (our *Model I*) including these variables is therefore:

$$buf_{it} = \alpha kk_{it} + \gamma kf_{it} + (1-\delta)buf_{it-1} + \beta cycle_t + u_{it} \tag{3.2}$$

All of the variables in equation (3.2.) are defined in levels and so as is common with panel data analysis, we proceed to transform equation (3.2.) into first differences in order to obtain unbiased estimates. Since the model includes the lagged endogenous variable among the regressors and, since some of our other explanatory variables are likely to be endogenous, we employ the two step generalized method of moments (GMM) procedure of Arellano and Bond (1991).[13] The instruments chosen include the full set of lags of the dependent variable (buf) together with two to four lags of both $risk$ and roe. In each case, the number of lags was chosen to avoid correlation with the error term (which now

[11] We do not investigate the possibility of asymmetries in these costs, since it may be easier to reduce capital, e.g. by paying dividends or buying back equity, than it is to increase capital.

[12] For a theoretical derivation and explanation of partial adjustment in models of bank capital see Ayuso et al. 2004 or Estrella, 2004.

[13] The GMM estimator is particularly useful in obtaining unbiased and efficient estimates in dynamic models with lagged endogenous variables as regressors.

appears in first differences) while simultaneously minimizing the number of observations lost.

3.3.1 Estimation results for country groups

The results for *Model I* are presented in Table 3.5 for the total EU25 sample and our four sub-sample country groups. Estimation results are presented with both the domestic and the broad (EU25) measures of the cycle (real GDP growth).

For the EU25 and the EU15, EA and DK,SE,UK sub-samples, we find a negative significant relationship between the capital buffer and each of the cycle variables, consistent with our hypothesis H_{2a}. In the Euro Area (EA) sub-samples, a one percentage rise in the growth rate of domestic GDP is associated with a 0.13 percent fall in the capital buffer. The positive 0.12 coefficient on the lagged dependent variable indicates that this cyclical impact increases after one year. A larger impact effect is seen for the DK,SE,UK sample, where the capital buffer decreases on average around 0.46 percentage points on a one percentage point rise in the domestic cyclical variable, however this is offset by a negative coefficient on the lagged dependent variable. These effects, a positive coefficient on the lagged dependent variable and a negative coefficient on the growth rate of domestic GDP, carry through to the EU15 and EU25 aggregated samples.

These findings are broadly in line with previous literature. Ayuso et al. (2004), Lindqvist (2004), Stoltz and Wedow (2005) and Francis and Osborne (2009) find a similar negative relationship between bank buffers and the cycle variables for German, Spanish, Norwegian and UK banks respectively. These findings can additionally be compared to those of Bikker and Metzemakers (2004) who conduct a cross country analysis of bank capital buffers for 29 OECD countries. Using the aggregate OECD database they find a negative relationship between capital buffers and the cycle. Their finding however is only marginally statistically significant. They consequently conclude that while the relationship appears to be negative, cyclical effects on buffer movements are fairly limited.

The RAM10 sample returns opposite results. Here we find a significant positive relationship between the buffer and the cycle variables, in line with our hypothesis H_{1a}. Here we see a significant increase in the capital buffer variable of 0.10 and 0.25 percentage points for a one percentage point rise in the rate of GDP growth.

Tables 3.5 also reports results using a broader cyclical measure (GDP growth for the EU15, or EU25, as a whole) instead of domestic GDP growth. This makes little difference to the results, aside from a slightly smaller coefficient on the lagged dependent variable for the DK,SE,UK sub-sample.

Turning to the bank specific variables, the coefficient on is significant with the expected negative coefficient in each of the sub-sample estimations, but the coefficient size is fairly small: -0.03 in the EA and RAM10 and slightly larger -0.09 in DK,SE,UK. The signs of the *big* coefficients are negative, consistent with the notion that big banks keep lower levels of capital in the expectation that in the event of difficulties, they will be bailed out. The sign of the *small* coefficient is positive, suggesting that these banks hold larger capital buffers. These size coefficient are however only significant in some sub-samples.

risk (non performing loans over total lending) is highly significant and positive for four of the five sub-samples. This suggests that banks with relatively risky portfolios generally do hold more capital. For the case of DK,SE,UK, the *risk* coefficients are negative and significant.

Finally, the cost of adjusting capital, captured by the lagged endogenous variable, is positive and significant in almost all cases. This finding is in line with the view that the costs of capital adjustment are an important explanation of the holding of large capital buffers. The coefficients are largely uniform across sub-samples, which would indicate that the costs of adjustment are largely consistent between countries, corresponding to a rate of adjustment towards desired capital of around 66 percent per annum. However we find that the coefficients are negative for the DK,SE, UK sub-sample, which is inconsistent with a costly adjustment model of bank capital management.

Table 3.6 presents further estimation results for a second model *(Model II)*, adding several further balance sheet variables to our baseline model *(Model II)*. The sign of the relationship between GDP growth and bank capital buffers is unchanged. In EA and DK,SE,UK sub-samples the magnitude remains negative but is smaller (the decline is more marked when using the domestic measure of the cycle). In the RAM10 the magnitude remains positive and is now larger. The additional variables in this second model are themselves cyclically varying, so some change in the estimated comovement is unsurprising. Overall we conclude from this second specification that considerable cyclical comovement exists and that this movement is very different in RAM10 than in the rest of the EU .

The coefficient on the proxy for the cost of holding capital (*roe*) and the speed of adjustment (the coefficient on the lagged dependent variable) are broadly unchanged from those reported for *Model I.* The coefficients for the *risk* proxies are now larger while the coefficients on the *big* and *small* variables are almost the same as in the previous model specification.

The new $profit$ variable for all sub-samples is positive and highly significant; indicating that retained earnings seem to be used to increase the capital cushion. The effect is noticeably larger for the EA sample when compared to the other sub-samples. The expected negative sign for the *net loans* variable is found for the EU15, EA and RAM10 sub-samples, however the coefficients are broadly insignificant. The DK,SE,UK sample returns a highly significant positive coefficient. Considering the $\Delta loans$ variable, for all sub-samples, we find the parameter to be highly significant, with a negative sign as expected. This finding suggests that a contemporaneous increase in loan demand substantially reduces the capital buffer.

Estimation results for sub-groups of types and sizes of banks. Table 3.7 reports further versions of these estimation results, for sub-groups of banks, distinguishing between commercial, savings and co-operative banks and also large and small banks. We report estimates using data only for the EA15. Here we wish to determine the effect that special bank specific features can have on capital buffer movements. We find this particularly useful for our estimations since the RAM10 sub-sample consists only of small commercial banks and RAM10 banks appear to behave so differently from those in the EA15. Considering commercial and savings banks, we find that the comovement with the cycle remains negative. The results for savings banks are more significant than for commercial banks, suggesting that the negative relationship reported in Table 3.7 is largely driven by savings banks. For co-operative banks however, the relationship is very different, a positive relationship evident between the cycle and capital buffers.

This finding can help explain the relationship between our results and those of other researchers. Stoltz and Wedow (2005) present evidence for German banks showing that the relationship between the buffer and the cycle variable is stronger for savings banks than it is for co-operatives. The cross country study of Bikker and Metzemakers (2004) finds that the cyclical effects appear to be limited. This finding is in line with our results since they focus their estimations on commercial banks only. Ayuso et al. (2004) consider only savings and commercial banks in their study and find a robustly significant negative relationship. Their study does not however analyze bank type effects separately.

The *roe* variable coefficients are very similar to those reported in Table 3.5. The coefficient is noticeably more significant amongst savings banks than it is for co-operative or commercial banks. This finding tends to indicate that the cost of holding excess capital appears to be most significant for co-operative banks when compared to savings and commercial banks.

The *risk* coefficient remains positive and significant for both commercial and co-operative banks in all three sub samples, while it is negative for savings banks. The impact of bank size (the *big* and *small* variables) is similar to that reported in Tables 3.5 and 3.6, but only statistically significant for small savings banks.

For all three sub-samples, the buf_{ijt-1} variable is positive and highly significant for commercial banks, while it is much smaller (and significant) for savings banks and insignificant for co-operative banks. This suggests that adjustment costs are more important for commercial banks.

Table 3.7 additionally reports a comparison by bank size. Here small banks are those with total assets less than €37bn in 2004. The dummy variables *big* and *small* are dropped from these estimates. We find a positive and significant relationship between the capital buffers of small banks and the cyclical variables, while the relationship is negative and significant for large banks. The coefficients on the *roe* variable are little changed from those obtained for the initial total sample estimations, negative and significant for both small and large banks. The *risk* coefficients remain positive and significant for both small and large banks. The estimated cost of adjusting capital (the coefficient on buf_{ijt-1}) is significant for both large and small banks. The coefficient is somewhat lower for small banks suggesting that adjustment costs play a larger role in the case of large banks.

To summarize, our estimations by both size and type of bank provide evidence that the capital buffers of both small and co-operative banks have a positive relationship with the output gap variables. On the other hand we find negative comovement with the cycle for commercial banks, savings banks, and large banks. These differential results might be due to different access to capital markets or due to the fact that both smaller banks as well as cooperative banks are more reliant on retained earnings than other banks in the sample hence building up capital during the economic upturn.

3.3.2 Robustness tests.

We investigated a large variety of alternative specifications as a check on the robustness of our main findings, including subsets of the explanatory variables reported in Tables 3.5 and 3.6. In all cases the relationship between the capital buffer and the output gap is very similar to that which we report here.

A major concern is endogeneity, leading us to investigate whether the relationships that we report between capital buffers and the business cycle is robust to alternative dynamic specifications. We estimate a static version of the model where we omit the lagged dependent variable buf_{ijt-1}. We also experimented with varying lag lengths for the explanatory variables, and by dropping the *roe* variable from the estimations (since this is itself a cyclically varying variable). Finally we estimated a fixed effects version of the model, in which all the bank specific variables ($risk, roe, big$ and $small$) were omitted but in which we introduce a dummy (fixed effect) for each bank in the sample. In all these cases the coefficients on the business cycle variables remain fairly close to our reported results, indicating that these estimates are reasonably robust to dynamic re-specification.

There are potentially individual national effects that could arise from various country specific characteristics relating to the legal, regulatory, structural, or tax and accounting framework. A simple way to test, and control for these conditions, is to create a country specific dummy variable (D_i) for each country. As it turns out, there are no significant fixed country dummy coefficients in our regressions, indicating that all the national effects are already captured by our chosen specifications.

We also re-estimated *Model II*, including both the broad cycle and the difference between the broad EU25 cycle and the domestic cycle as explanatory variables. In the case of the DK,SE,UK and the RAM10 country grouping, we find that both the domestic cycle and the additional impact of the broad cycle are significant at the five or ten percent level. In the other sub-samples and the EU25 there is no significant additional effect. Very similar results emerged when re-estimating *Model I*. This indicates that, while there is collinearity between the broad and domestic cycle, the domestic cycle is the slightly better measure. It does better than the broad cycle for DK,SE,UK and the RAM10, while the choice of cycle measure is immaterial for the other groupings.

Checking for downward bias in the standard errors on aggregate variables We are concerned with a further econometric problem affecting all studies, such as our own, that combine macro level and micro data, whether in panel or cross section. This problem, originally highlighted by Moulton (1990), is the downward bias on standard errors for macroeconomic variables, when there is clustering of unobserved random error components. This possibility cannot be ignored since any omission of macroeconomic variables, affecting the dependent variable, will lead to such clustering. Correcting for clustering of unobserved variables can have a dramatic impact on reported significance levels. In the cross sectional example reported by Moulton, standard errors on aggregate variables are biased upwards by a factor of around three. A change of this size would imply a fall for example in t-statistics from an apparently highly significance level, to a statistically insignificant level of less than 1.5. Failure to investigate this bias invalidates the results of very many published papers.

Several methods have been proposed to deal with this problem, the most common being robust cluster adjustment of standard errors available in *stata*. Unfortunately we have been unable to carry out this adjustment, since the adjustment is only available for the estimation of a static panel regression with random effects. The option to adjust our preferred dynamic fixed effects regression models is not available. We instead conduct two alternative calculations in order to assess the magnitude of the resulting bias in the standard errors on our aggregate cyclical variables (reported in Table 3.8). First, we estimate a static random effects version of our model, allowing us to then apply the robust cluster adjustment to the standard errors. For purposes of comparison we compare these estimates with those from a static fixed effects version of our model as well as our preferred dynamic fixed effects model. We find that for each variable, without the robust cluster adjustment, the standard error in the static regression using either fixed or random effects are very similar. We find that using the robust cluster adjustment, the standard error changes increase by on average by around 20 percent for each variable within each sub sample. This suggests that, while clustering of errors reduces but does not totally overturn the significance of our results. We therefore conclude that our sample is affected to only a small extent by the problem of residual clustering identified by Moulton (1990).

3.4 Discussion

This chapter has examined the relationship between European bank capital buffers and the business cycle. Much of the empirical literature in this field has focused on analyzing the determinants of bank capitalization within a single country framework. Our research is cross country, allowing for the comparison of behavior in different sub-sample groups of countries and for different groups of banks.

We build an unbalanced panel of 486 banks, using annual balance sheet data between 1997 and 2004. Controlling for various determinants of capital buffers, we estimate the remaining impact of the business cycle. We find a significant *negative* relationship between the capital buffers of banks and the cycle variable adopted, for EU25, EU15, EA and DK,SE,UK sub-samples. This finding is in line with the existing literature in this field. For the RAM10 banks i.e. those in the ten accession countries that joined the EU in 2004, our results indicate that capital buffers move *positively* with the cycle. However, as indicated in Figure 3.5, RAM10 capital buffers have been converging on those in the rest of the EU, and it is possible that negative comovement may be observed once this convergence is complete.

We further break the sample down, distinguishing between both type and size of bank. Our findings indicate that capital buffers of large banks, and of commercial and savings banks, appear to behave in a similar fashion to the sample as a whole, comoving *negatively* with the cycle i.e. rising in recession. On the other hand the capital buffers of small banks and of co-operative banks move *positively* with the cycle, declining in recession. These differential results might be due to different access to capital markets, so that these banks are more reliant on retained earnings than other banks in the sample hence building up capital during the economic upturn.

Our results complement and extend the findings of previous researchers. Negative comovement of capital buffers with the cycle has been reported before for banks in individual countries (Ayuso et al., 2004; Lindqvist, 2004; Stoltz and Wedow, 2005; Francis and Osborne, 2009; Repullo and Suarez, 2009). The only previous cross country study, that of Bikker and Metzemakers (2004) finds a rather smaller degree of negative comovement than we do, using a longer time period of aggregated OECD bank data. However their data covers only commercial banks. Our investigation of different bank types reveals a more pronounced negative comovement for savings banks than commercial banks, which may help to explain the difference in our finding.

Negative comovement suggests a further cause of concern relating to the potential procyclical impact of the introduction of Basel II on bank capital adequacy. Larger banks, notably the commercial and savings banks, have in our sample period increased capital buffers in the economic downturn. Under the new accord, Pillar I capital requirements will increase as bank exposures are downgraded, whether by external rating agencies or in internal rating systems. Repullo and Suarez (2009) provide further confirmation of these findings. They show that capital buffers are countercyclical under risk-insensitive capital requirements (e.g. Basel I) and procyclical under risk-sensitive capital requirements (e.g. Basel II). Yet, under risk-sensitive capital requirements, the higher buffers maintained in expansions are insufficient to prevent a significant contraction in the supply of credit at the arrival of a recession. This suggests that capital management will be especially challenging since it will lead to higher capital requirements precisely at the time (the trough of the business cycle) when most banks are seeking to reduce their capital levels.

3.A Tables and Figures

Table 3.1: Bank Capital Buffers by Country (weighted by market share).

	1997	1998	1999	2000	2001	2002	2003	2004	Avg
Austria	2.8	2.5	1.8	3.4	5.2	12.5	10.1	6.4	5.6
Belgium	3.8	4.7	3.8	4.9	5.2	5.1	6.3	5.5	4.9
Germany	2.1	2.3	2.8	3.1	2.7	3.4	4.8	5.4	3.3
Spain	5.6	5.3	4.7	3.7	3.9	3.6	3.6	3.6	4.2
Finland	6.6	4.4	3.7	3.5	3.7	3.4	5.7	5.3	4.5
France	5.1	4.6	3.8	3.8	4.0	4.2	3.4	2.9	4.0
Greece	2.3	2.1	9.5	7.2	3.8	2.8	5.9	5.3	4.9
Ireland	4.3	3.7	3.2	2.9	4.6	4.3	4.4	3.9	3.9
Italy	4.3	5.8	4.4	4.5	2.5	2.9	2.9	3.7	3.9
Luxembourg	6.1	4.8	4.8	4.6	4.5	4.9	6.6	4.8	5.2
Netherlands	7.1	8.0	5.6	5.5	6.1	6.7	7.6	7.6	6.8
Portugal	9.3	8.2	7.9	6.3	5.1	4.4	5.2	5.8	6.5
Denmark	4.4	3.4	3.3	2.7	3.0	3.6	4.9	4.2	3.7
Sweden	2.6	6.7	16.5	5.4	4.6	4.8	5.3	5.o	6.4
UK	12.1	9.7	11.4	9.7	8.4	8.9	9.8	7.2	9.8
Cyprus	2.1	1.7	2.5	4.5	5.7	6.0	5.4	5.3	4.2
Czech Republic	2.9	10.2	12.2	6.2	7.3	6.9	6.7	4.8	7.2
Estonia	3.1	7.7	9.1	6.2	6.3	6.2	5.3	4.3	6.0
Hungary	5.0	6.5	6.7	5.9	4.2	4.8	3.3	3.2	5.0
Latvia	10.1	3.6	8.4	5.5	4.6	4.5	4.3	4.4	5.7
Lithuania	6.3	14.4	5.5	4.8	6.7	6.7	4.1	3.1	6.5
Malta	6.5	8.4	8.0	8.1	6.5	7.1	7.6	6.9	7.4
Poland	1.9	3.7	5.2	4.9	5.8	4.9	4.8	7.4	4.8
Slovakia						5.4	9.2	9.5	8.0
Slovenia	6.3	4.6	6.7	8.1	7.5	7.6	5.7	6.3	6.6

Table 3.2: Bank Capital Buffers by Sub-Samples.

	1997	1998	1999	2000	2001	2002	2003	2004	Avg
EU15	5.2	5.1	5.8	4.8	4.5	5.1	5.9	5.1	5.2
EA	4.9	4.6	4.6	4.4	4.2	4.8	5.5	5.0	4.8
DK,SE,UK	6.3	6.6	10.3	5.9	5.3	5.8	6.9	5.4	6.6
RAM	4.9	6.7	7.1	6.0	6.0	6.0	5.6	5.5	6.0

Table 3.3: Sample Distribution.

	Commercial	Cooperative	Savings	Big	Small	Total
Austria	12	8	6	4	22	26
Belgium	10		2	2	10	12
Germany	24	8	2	7	27	34
Spain	23	3	44	8	62	70
Finland	4		1	1	4	5
France	55	42	6	13	90	103
Greece	12			1	11	12
Ireland	11			4	7	11
Italy	30	13	11	10	44	54
Luxembourg	7			1	6	7
Netherlands	18	1		5	14	19
Portugal	8	1	2	3	8	11
Denmark	13		2		15	15
Sweden	3	1	2	3	3	6
UK	41		1	9	33	42
Cyprus	5				5	5
Czech Republic	3				3	3
Estonia	2				2	2
Hungary	6				6	6
Latvia	4				4	4
Lithuania	2				2	2
Malta	2				2	2
Poland	9		1		10	10
Slovakia	2				2	2
Slovenia	5				5	5
EU25	306	77	85	71	397	468
EU15	5271	77	79	71	356	427
EA	214	76	74	59	305	364
DK, SE, UK	57	1	5	12	51	63
RAM	35	0	6	0	41	41

Figure 3.1: *EU25.*

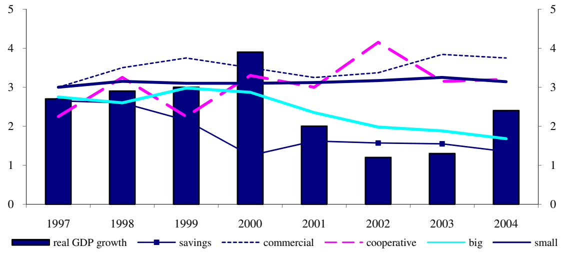


Figure 3.2: *EU15.*

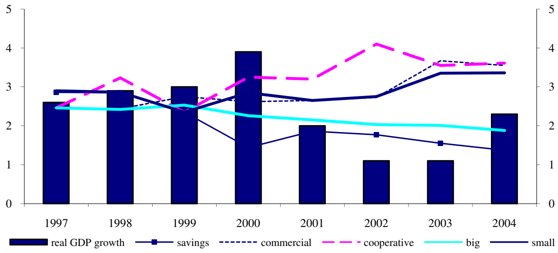


Figure 3.3: *Euro Area.*

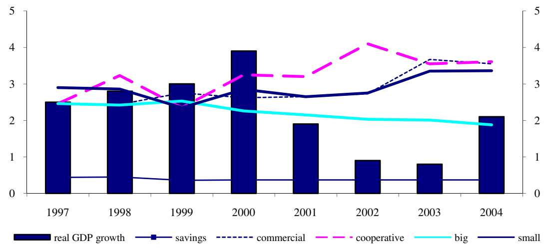


Figure 3.4: *DK, SE and UK.*

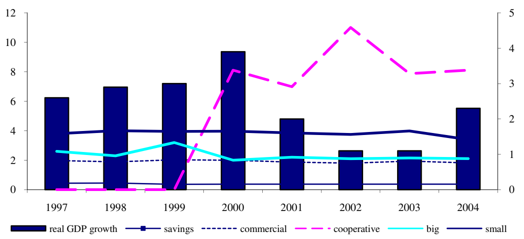


Figure 3.5: *RAM.*

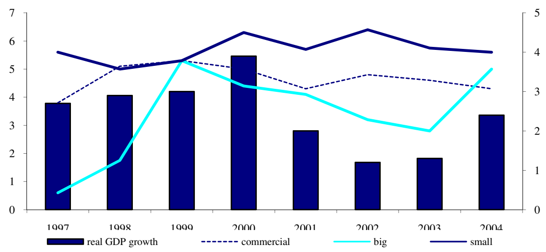


Table 3.4: Variable Descriptions.

Variable	Description
Balance sheet variables	
buf	Capital ratio minus national regulatory minimum as per Table 3.1.
roe_{ijt}	Return on equity.
$risk_{ijt}$	Ratio of non-performing loans to total loans.
$risk2_{ijt}$	Loan loss provisions over total assets.
$size_{ijt}$	Log of total assets.
$profit_{ijt}$	Post tax profit over total assets.
$\Delta loans_{ijt}$	Annual loan growth.
$totalloans_{ijt}$	Loans over total assets.
Business cycle variables	
gdp_{jt}	Domestic and sub-sample GDP growth.
$outputgap_{jt}$	HP filtered real GDP series.

Table 3.5: Two Step GMM Estimates (Model I).

	EU25 *Model I*		EU15 *Model I*		EA *Model I*		DK-SE-UK *Model I*		RAM *Model I*	
Cycle variable:	domestic cycle	EU25 cycle	domestic cycle	EU15 cycle	domestic cycle	EU15 cycle	domestic cycle	EU15 cycle	domestic cycle	EU15 cycle
buf_{ijt-1}	0.36 (4.22)***	0.45 (4.62)***	0.20 (2.91)***	0.19(3.02)***	0.12 (3.12)***	0.18 (3.62)***	-0.40 (3.02)***	-0.35 (3.12)***	0.22 (9.66)***	0.27 (6.88)***
roe_{ijt}	-0.03(1.85)*	-0.04 (1.66)*	-0.04(5.41)***	-0.05(3.43)***	-0.03 (1.75)**	-0.05(1.23)	-0.09 (1.66)**	-0.10 (0.98)	-0.03(1.27)*	-0.03 (4.01)***
$risk_{ijt}$	64.55(4.33)***	62.75(3.55)***	44.66 (3.16)***	43.72 (2.18)**	42.11 (3.12)***	37.62 (2.42)**	-31.69 (4.02)***	-68.75 (4.66)***	22.66 (1.45)	26.78 (1.75)*
big_{ijt}	-14.87 (2.13)**	-24.33 (1.65)*	-17.25 (0.08)	-16.74 (1.81)*	-19.32 (2.01)**	-18.33 (1.85)*	-23.67 (0.08)	-19.54 (0.21)	-11.76 (0.06)	-22.34 (0.04)
$small_{ijt}$	21.77(1.92)*	18.33(1.99)**	22.33(0.17)	16.33(0.33)	19.01(1.90)*	23.04(1.66)*	13.22(0.08)	12.76(0.66)	23.54(1.94)**	20.87(1.46)
$cycle_{jt}$	-0.10(3.77)***	-0.09(3.22)***	-0.12 (4.99)***	-0.12 (4.65)***	-0.13(3.66)***	-0.15(5.02)***	-0.46(4.55)***	-0.40 (6.33)***	0.10 (2.02)**	0.25 (3.97)***
Sargan	21.34 (0.74)	20.58 (0.67)	20.97 (0.69)	24.79 (0.78)	25.78 (0.76)	21.69 (0.59)	32.58 (0.99)	29.87 (0.55)	25.67 (0.85)	21.46 (0.92)
a(1)	-2.16 (0.00)	-2.78 (0.00)	-2.02 (0.00)	-2.76(0.00)	-2.45 (0.00)	-2.62 (0.00)	-1.44 (0.00)	-1.68 (0.00)	-1.76 (0.00)	-1.67 (0.00)
a(2)	-1.56 (0.72)	-1.69 (0.44)	-1.04 (0.52)	-1.33 (0.96)	-1.65 (0.44)	-0.95 (0.52)	-1.62 (0.26)	-1.79 (0.71)	-1.21 (0.75)	-0.99 (0.55)

Note: Dependent variable is $bufijt$. Other variables as defined in Table 3.4. T-values presented in parentheses. a(1) and a(2) represent first and second order residual tests. *, **, *** denote significance at the ten, five and one percent levels of significance respectively. Cycle variable corresponds to real GDP growth. Models including the broad and the sub-group cycle are estimated separately.

Table 3.6: Two Step GMM Estimates (Model II).

	EU25 *Model II*		**EU15** *Model II*		**EA** *Model II*		**DK-SE-UK** *Model II*		**RAM** *Model II*	
Cycle variable:	domestic cycle	EU25 cycle	domestic cycle	EU15 cycle	domestic cycle	EU15 cycle	domestic cycle	EU15 cycle	domestic cycle	EU15 cycle
buf_{ijt-1}	0.28(3.66)***	0.24(5.82)***	0.33 (3.51)***	0.25(3.24)***	0.19 (4.62)***	0.21 (3.76)***	-0.39(4.01)***	-0.39 (3.97)***	0.12 (3.02)***	0.18 (4.63)***
roe_{ijt}	-0.03 (1.81)*	-0.03(1.31)	-0.05(1.97)**	-0.04 (2.35)**	-0.04(1.05)	-0.05 (1.16)	-0.09 (0.23)	-0.08(3.20)***	-0.03(0.45)	-0.03 (0.66)
$risk_{ijt}$	76.44 (3.54)***	72.33 (3.17)***	35.86 (5.02)***	66.97 (4.87)***	55.24 (4.22)***	23.67 (3.96)***	-30.06(2.99)***	-28.74(3.15)***	86.35 (3.05)***	77.84 (4.66)***
big_{ijt}	-24.44(1.44)	-18.76 (1.96)**	-11.99(0.13)	-21.77(1.66)*	-12.65(1.45)	-12.22(1.69)*	-23.65 (0.11)	-18.77 (0.31)	-23.44 (0.15)	-19.87 (0.66)
$small_{ijt}$	19.66(1.47)	22.34(1.52)	12.77(0.99)	13.66(0.77)	18.86(1.84)*	15.87(1.92)*	20.11(0.16)	13.66 (0.22)	12.12(2.01)**	15.66 (1.99)**
$peofit_{ijt}$	180.10 (3.56)***	175.22 (3.02)***	165.21(3.99)***	135.21(3.42)***	152.55(3.11)***	164.75(3.75)***	66.32 (4.02)***	78.56 (4.51)***	82.47 (4.66)***	90.57 (4.06)***
$cycle_{ijt}$	-0.06(3.98)***	-0.02(3.01)***	-0.08(4.01)***	-0.41 (3.33)***	-0.04(3.11)***	-0.10(2.98)***	-0.06(4.55)***	-0.38 (5.78)***	0.19 (2.55)**	0.16(3.11)***
$\Delta loans_{ijt}$	-0.01 (3.06)***	-0.01(3.77)***	-0.01 (3.05)***	-0.00 (2.52)**	-0.02(2.06)**	-0.02(1.97)**	-0.02 (3.13)***	-0.01 (4.12)***	-0.06 (3.11)***	-0.08(3.25)***
$totalloans_{ijt}$	-0.06(0.98)	-0.06(0.76)	-0.11(1.02)	-0.01 (0.63)	-0.00(0.72)	-0.01(0.99)	0.01 (2.99)***	0.00 (2.87)***	-0.01 (0.11)	-0.02(0.55)
Sargan	24.68 (0.88)	27.69 (0.76)	27.69 (0.99)	29.78 (0.92)	27.63(0.79)	22.46(0.83)	26.89 (0.63)	27.96 (0.79)	22.97 (0.46)	23.69 (0.76)
a(1)	-2.34 (0.00)	-2.65 (0.00)	-2.42 (0.00)	-2.36 (0.00)	-2.09 (0.00)	-2.11 (0.00)	-0.96 (0.00)	-1.02 (0.00)	-1.55 (0.00)	-1.67 (0.00)
a(2)	-1.11 (0.46)	-0.84 (0.36)	-1.42 (0.45)	-1.29 (0.65)	-1.08 (0.46)	-1.12 (0.76)	-1.24 (0.82)	-1.34 (0.23)	-0.92 (0.65)	0.76 (0.98)

Note: Dependent variable is $bufijt$. Other variables as defined in Table 3.4. T-values presented in parentheses. a(1) and a(2) represent first and second order residual tests. *, **, *** denote significance at the ten, five and one percent levels of significance respectively. Cycle variable corresponds to real GDP growth. Models including the broad and the sub-group cycle are estimated separately.

Table 3.7: Two Step GMM Estimates (by bank size).

	Commercial Banks		Cooperative Banks		Savings Banks		Big Banks		Small Banks	
Cycle variable:	domestic cycle	EU25 cycle	domestic cycle	EU15 cycle	domestic cycle	EU15 cycle	domestic cycle	EU15 cycle	domestic cycle	EU15 cycle
Δbuf_{ijt-1}	0.33(4.00)***	0.21(4.11)***	-0.15 (0.60)	0.19(0.77)	-0.17(1.46)	-0.16(3.04)***	0.44(6.00)***	0.30(4.66)***	0.25(3.33)***	0.15(3.21)***
roe_{ijt}	-0.03(1.52)*	-0.04(1.33)	-0.01(0.70)	-0.02 (1.32)	-0.04(4.01)***	-0.06(4.66)***	-0.10(3.99)***	-0.7(3.12)***	-0.04(1.86)*	-0.03(1.97)**
$risk_{ijt}$	26.55(2.11)**	22.46(2.12)**	40.55(3.62)***	70.44(3.17)***	-31.22(4.11)***	-22.54(3.66)***	40.25(2.25)**	69.68(2.52)***	29.66 (2.23)**	55.78(2.09)**
big_{ijt}	-16.57(0.44)	-16.33(0.96)	-21.43(0.66)	-20.66(0.68)	-18.99(0.65)	-21.34(0.11)				
$small_{ijt}$	11.22(0.56)	18.76(0.45)	15.66(0.34)	21.23(0.26)	17.43 (1.52)	18.75(1.43)				
$profit_{ijt}$	146.89(4.00)***	137.66(4.11)***	130.22(3.00)***	120.66(1.85)*	170.22(4.06)***	140.66(4.98)***	201.46(3.88)***	160.35(2.93)***	130.22 (2.99)***	88.66(4.01)***
$cycle_{jt}$	-0.16(1.25)	-0.45(2.77)**	0.15(2.18)**	0.22(0.84)	-0.10(3.00)***	-0.37(4.61)***	-0.12(2.53)**	-0.55(1.63)	0.06 (2.99)***	0.20(2.97)***
$\Delta loans_{ijt}$	-0.03(4.62)***	-0.02(3.85)***	0.00(3.66)***	0.03(4.96)***	0.01(0.75)	-0.01(0.66)	-0.01(6.33)***	-0.02(7.44)***	0.00(0.12)	-0.00(0.32)
$totalloans_{ijt}$	0.10(1.05)	0.00(0.12)	-0.25(8.53)***	-0.01(0.63)	-0.03(4.00)***	-0.09(1.88)*	0.01(3.01)***	0.01(3.00)***	-0.12(1.97)***	-0.01(1.86)*
Sargan	42.44 (0.78)	34.66 (0.63)	27.89 (0.93)	25.67 (0.86)	22.97 (0.79)	33.79 (0.67)	31.75 (0.92)	22.97 (0.78)	23.67 (0.81)	22.75 (0.84)
a(1)	-1.66 (0.00)	-2.11 (0.00)	-1.75 (0.00)	-1.65 (0.00)	-1.88 (0.00)	1.35 (0.00)	-2.44 (0.00)	-3.13 (0.00)	-1.78 (0.00)	-1.44 (0.00)
a(2)	-1.21 (0.74)	-1.34 (0.90)	-1.66 (0.96)	-1.53 (0.76)	-1.57 (0.83)	-1.45 (0.98)	-1.76 (0.80)	1.45 (0.76)	-1.55 (0.86)	-1.63 (0.76)

Note: Dependent variable is bufijt. Other variables as defined in Table 3.4. T-values presented in parentheses. a(1) and a(2) represent first and second order residual tests. *, **, *** denote significance at the ten, five and one percent levels of significance respectively. Cycle variable corresponds to real GDP growth. Models including the broad and the sub-group cycle are estimated separately.

Table 3.8: Robustness Check: Within Group Correlations Summary.

		Dynamic	**Static**					**Moulton formulae**	
	avg no of banks per country	within group avg	within group avg (fe)	fe	re	robust cluster adj.	s.e percentage δ	coeff. var d.b*	s.e d.b*
EU25	19	0.03	0.04	0.09	0.09	0.06	27.59	1.72	1.31
EU15	28	0.02	0.03	0.09	0.09	0.07	25.27	1.81	1.35
EA	30	0.02	0.03	0.09	0.09	0.08	17.39	1.87	1.37
DK SE UK	21	0.03	0.04	0.16	0.16	0.13	23.17	1.80	1.34
RAM	4	0.04	0.06	0.21	0.21	0.19	11.43	1.18	1.09

Note: The static case refers to results obtained by running the regression excluding the LDV. The dynamic case refers to our equation (3.7.). fe and re denote fixed and random effects respectively. Within-group correlations are obtained by calculating an average correlation coefficient of individual bank correlations within each country. *d.b stands for downward bias..

3.B Data Manipulations

In order to deal with various incidents of large fluctuations in the level of the buffers over time, we clean the data and get rid of any eccentric jumps that are not representative of the sample. Such jumps were generally due to individual bank effects rather than due to entry or exit from the sample and were identified via graphical representation of the sample. In 1999, together strange buffer figures for Austrian Raiffeisenlandesbank Oberösterreich AG, Greek Emporiki Bank, and Swedish Kommuninvest Bank resulted in a significant outlier that would drive overall results. In Austria, Raiffeisenlandesbank Oberösterreich AG reports its capital buffer figures for the first time in 2003, reporting a ratio of 13.2 percent. In the case of Emporiki bank the capital buffer jumps from -0.8 percent in 1998 to 16.6 percent in 1999. In Sweden on the other hand, a similar jump is apparent in 1999. This jump is attributable to a single bank Kommuninvest Bank who reports its capital ratio for the first time this year. The capital ratio reported is equal to 59.4 percent. These banks are removed from the sample in order gain a more accurate representation of capital buffer movements and its relationship with the cycle over our sample period. While other erratic movements are visible in Table 3.1, these are kept in the sample since they appear representative of buffer movements in the sub-sample to which they belong.

Chapter 4

Bank Capital and Charter Values

4.1 Introduction

Traditionally, banking literature has centered on the notion that banks commit moral hazard. Due to various government deposit insurance schemes as well as other safety net protections, banks view themselves as partly insulated from risk and therefore do not fully account for the negative consequences of their actions (see Gorton and Rosen, 1995). Merton (1977) shows that the existence of deposit insurance derives the put option of the bank.[1] Since the deposit insurance premium depends on the perceived riskiness of the insured institution, the value of the put option can increase with risk, particularly when the premium does not correctly capture bank risk. In moral hazard models, bank shareholders have incentives to transfer wealth from the insuring agency (to maximize the value of the put option) by adopting riskier strategies and reducing invested capital relative to assets (see Keeley, 1990). As a means to offset these risk increasing incentives, bank regulators directly target capital structures by setting minimum requirements for bank capital.

Following the Myers and Majluf (1984) pecking order hypothesis, the higher cost of capital (relative to deposits or debt) would dictate a capital minimization policy on the part of banks. This however contrasts observed bank behavior. Banks typically hold a significant amount of capital in excess of the required minimum (a buffer of capital) as an insurance against risks that need to be managed, indicating that capital standards are rarely binding.[2]

These stylized facts have motivated the literature to search for incentives that act to mitigate the moral hazard behavior of banks. Theoretical analysis of bank capital decisions has highlighted a central role for the charter value, also referred to as the franchise value (see Keeley 1990; Demsetz et al., 1997; Hellman et al., 2000; Matutes and Vives, 2000; Repullo 2004). The charter value, is the value that would be foregone if the

[1] The right to sell the banks' assets at the face value of its liabilities.

[2] See for example Allen and Rai (1996), Peura and Jokivuolle (2004) Barth et al. (2005) and Berger et al. (2008).

bank closes, hence, capturing the banks' private cost of failure. Traditional charter value models have formally shown how a valuable charter can help reduce excessive risk taking, since banks with a valuable charter have much to lose if a risky business strategy leads to insolvency (see among others Marcus, 1984; Keeley, 1990; and Ancharya, 1996). The incentive to preserve the charter value should therefore outweigh the desire of shareholders to maximize the put option value when risk is low, while the opposite is true at higher probabilities of default. A large body of empirical literature has found evidence in favor of the charter value hypothesis (CVH), that high charter value banks are less risky (see Keeley 1990; Demsetz et al., 1997; Galloway et al., 1997; Saunders and Wilson, 2001; Park and Peristiani, 2007).

In contrast to the traditional charter value models focusing on the amount of capital held against market risk, the more recent capital buffer theory introduces a dynamic aspect whereby a bank is faced with implicit and explicit costs of maintaining an internally defined target level of capital above the required minimum (see among others Milne and Whalley, 2001; Peura and Keppo, 2006; VanHoose, 2007a). The target level of capital can be thought of as being a banks' long run desired probability of default and is therefore a function of both risk and capital. In this framework, the relationship between charter values and the capital buffer is determined by two opposing forces: (i) a charter value effect, and (ii) a moral hazard effect. The charter value effect dominates when the expected loss of the charter value outweighs the increase in the option value. Banks with a sufficient charter will be encouraged to build up enough capital to reduce the risk of failure. The moral hazard effect dominates when the charter value is insufficient and all incentives to protect the charter value are removed. The bank is no longer concerned with future earnings and has little incentive to maintain a capital buffer. The long run relationship between capitalization and charter values are therefore predicted to be highly non linear, and dependent on the size of the charter.

Several papers have tried to shed some light on the relationship between bank capital and charter values (see Keeley, 1990; Allen and Rai, 1996). These studies have however, assumed the relationship to be linear. In this chapter, we contribute to the literature by exploring non linearity between capital buffers and charter values. Adopting both quadratic, and semi parametric spline estimation techniques, we wish to determine the functional form of these relationships, and in particular, identify the size of the charter which constitutes a reversal in the dominating effect. Our findings indicate that between 1986 and 2008 the relationship between bank capital and charter values is non linear and concave. Moreover, for banks with charter values above the median threshold, the capital buffer is held relatively constant. This finding is in contrast to predictions that banks with higher charters necessarily hold larger capital buffers.

The remainder of the chapter is organized as follows: Section 4.2 outlines the theoretical predictions of the relationships studied. Section 4.3 describes the data and defines the key variables. Section 4.4 presents our empirical methodology and results. Section 4.5 briefly discusses our findings and concludes.

4.2 Theoretical Predictions

Marcus (1984) shows that incorporating intertemporal considerations into pure static moral hazard models has potential moderating effects on the behavior of banks. Moral hazard models based on static assumptions neglect the notion that banks can generate rents. Such rents can arise from monitoring costs or imperfect competition. In a dynamic framework, the present value of future rents constitute the banks charter value.

In charter value models[3], today's value of a banks equity, C, is given by:

$$V_0(C) = [AN(d_1) - e^{-rT}DN(d_2)] + e^{-rT}CVN(d_2) \tag{4.1}$$

where $d_1 = \frac{[log(A_0/D)]+(r\sigma^2/2)/T}{\sigma\sqrt(T)}$, $d_2 = d_1 - \sqrt(T)$, and $N(\cdot)$ is the cumulative standard normal distribution, CV denotes charter value and T is the maturity date.

Additions to capital now increase shareholder wealth at the following rate:

$$\frac{\partial V_0(C)}{\partial A} - 1 = \frac{N(d_1) + e^{-rT}CVn(d_2)}{(A\sigma\sqrt(T))} - 1 \tag{4.2}$$

In contrast to a pure moral hazard model, the sign of the expression is undetermined. An increase in equity reduces the probability of default and the associated loss of charter value, while it also reduces the value of deposit insurance. For a high enough CV, the first effect dominates. Hence a larger CV gives the bank an incentive to hold capital.

Moral hazard models introducing a charter value as a mitigating effect have largely been restricted to the part of capital which is held against market risk, failing to recognize the endogenous nature of bank capital decisions. Milne and Whalley (2001) develop a continuous time dynamic option pricing model introducing endogenous capital into a model with charter value. The concept of endogenous capital is based on a trade-off banks face when violating the capital requirement. This trade-off is between incurring costs related to recapitalization, or, the loss of charter value consequent of failure.

In the model, regulation occurs at random intervals as per Merton (1978). Auditors are interested in the level of capital, c, compared to the required minimum, $\hat{c}$. If $\hat{c} > c$, then the bank must decide whether to recapitalize at the cost of $x + \Delta c$ (where x denotes the fixed cost of recapitalization) or to liquidate. In the case of liquidation, debt holders are repaid in full from deposit insurance, and shareholders receive nothing.

As long as capital is in excess of the requirement, banks act to maximize shareholder wealth. If however, the capital buffer is depleted and the supervisor notices, then a bank can either recapitalize or fail. Recapitalization is optimal if the gain in shareholder value outweighs cost of recapitalization. Non linearity between bank capital and charter values in the model therefore represents a trade-off between two varying effects. The first, a charter value effect where charter value is sufficiently high such that the shareholder value lost in liquidation is relatively high. In this case the bank will be encouraged to build up the buffer of capital to reduce the expected cost of violating capital requirements

[3] Assuming the following diffusion process: $dA = RAdt + \sigma Adz$ with R as the instantaneous expected growth rate of assets, A, and σ, the instantaneous standard deviation of the rate of return. dz is a Wiener process.

as well as to reduce the probability of failure. Earnings are either retained in full, or if the long run target level of capital, $\hat{c}$, is reached, then all earnings are paid out as dividends. When no costs are associated with regulatory breach, the charter value becomes the value of the bank. Shareholders of well capitalized banks, those with capital at the long run optimum, are fully insured against costs associated with a regulatory breach.

If on the other hand, the charter value is too low, a moral hazard effect dominates[4]. The bank is no longer concerned with future earnings and the model reverts back to a simple pure static moral hazard case. Gambling for resurrection, if successful results in excess returns, on the other hand, if unsuccessful, a bail out by deposit insurance is guaranteed. The existence of state guarantees create additional incentives for capital transfer to shareholders[5]. The threshold between the dominance of these effects is dependent on either a greater ability to increase the uncertainty of cash flows which increases the potential gains of exploiting moral hazard[6], or a higher frequency of audit which lowers potential gains.

4.3 Data

To test the predicted long run relationship between bank capital and charter values, we construct an unbalanced panel of quarterly US bank holding company (BHC)[7] and commercial bank balance sheet data between 1986Q2 and 2008Q2. All bank level data is obtained from the Consolidated Report of Condition and Income (referred to as the Call Reports) published by the Federal Reserve Bank of Chicago.[8] In addition, we obtain information for the Fed Funds Y-9 form, filed by BHCs. By identifying the high holder to which the individual commercial banks belong, we are able to merge the two datasets.[9] We merge the two datasets since the BHC capital data is required for matching with market data. Including the commercial balance sheet data allows us to keep a richer data sample, as more observations used as control variables are available for the commercial banks than for BHCs. Only publicly traded BHCs are kept in the sample. All market data is obtained from the Center for Research on Securities Prices (CRSP). The final panel contains bank balance sheet and income data for over 600 BHCs. See Appendix 4.B for more information on the construction of the data set.

4.3.1 Principal Variables of Interest

Bank Capital Buffers: Buffer capital, buf_{it}, is defined as the amount of capital bank i holds in excess of that required by regulation at time t. In the US, bank capital

[4] Such banks have a very high probability of failure since they have very low expected earnings offering little/no protection.

[5] Milking the property whereby extra dividends are paid during times of financial stress. This mechanism gives shareholders funds that should otherwise go to bondholders or towards bankruptcy costs.

[6] Since the put option value is always increased by a widening of the distribution of returns.

[7] A bank holding company, under the laws of the United States, is any entity that directly or indirectly owns, controls, or has the power to vote 25% or more of a class of securities of a U.S. bank. Holding companies do not however, administer, oversee, or manage other establishments of the company or enterprize whose securities they hold. They are primarily engaged in holding the securities of (or other equity interests in) companies and enterprizes for the purpose of owning a controlling interest or influencing the management decisions.

[8] This data is publicly available at www.chicagofed.org.

[9] Once the initial dataset is obtained, we further clean the data by keeping only those bank holding companies for which we have three consecutive quarters of data.

is currently regulated via the Basel I Accord, requiring banks to hold a tier one capital ratio of at least four percent, a total capital ratio (tier one + tier two) of at least eight percent and a leverage ratio (tier one capital over total assets) of at least four percent.

Two components together constitute the capital ratio. The numerator, measures the absolute amount of capital held which is inversely related to the probability of failure. The denominator captures the riskiness of the bank. Together, the ratio provides an indication about the adequacy of capital in relation to some indicator of absolute risk.

Under both the total capital and tier one ratio requirements of Basel I, the calculated risk is captured via risk weighted assets. This measure includes off balance sheet exposures and additionally adjusts for differentials in credit risk according to the type of instrument and counterparty. The denominator of the leverage ratio however, is the total assets of the bank, assuming that the capital needs of a bank are determined by the level of assets. The inaccuracy of the leverage ratio as a sole measure of capital adequacy is highlighted through the existence of risky off balance sheet activities which are not captured by this measure.

There is however no reason to expect that the capital measures defined by regulators necessarily reflect the internally defined measure that banks target in the management of their operations. Economic capital is the amount of risk capital, assessed on a realistic basis, which a firm requires to cover the risks that it is running or collecting as a going concern, such as market risk, credit risk, and operational risk. It is the amount of money which is needed to secure survival in a worst case scenario. Typically, economic capital is calculated by determining the amount of capital that the firm needs to ensure that its realistic balance sheet stays solvent over a certain time period with a pre-specified probability. However, obtaining a proxy measure of economic capital that is accurate as well as comparable across institutions is extremely difficult. Therefore, in this chapter, we assume that banks manage their capital in such as way as to reduce both likelihood of a breach of regulation as well as the implicit and explicit costs associated. We therefore adopt the total capital ratio as the basis on which we calculate the buffer of capital. The measure of risk weighted assets (rwa) in the denominator requires banks to charge more capital for riskier assets, discouraging them from holding risky assets. If the risk weights accurately measure the riskiness of assets, then the risk weighted capital ratio should successfully distinguish between risky and safe banks, and effectively predict bank failure. Data on rwa are not, however, available as far back as 1986. Therefore, in order to order to analyze capital management decisions dating back prior to the implementation of Basel I, we create a proxy series as per the methodology put forward by Beatty and Gron (2001). Our estimated rwa variable, defined as $erwa$ is calculated as $total\ loans + (0.2 * agency\ securities) + (0.5 * municipal\ securities) + (1 * corporate\ securities)$.

Moreover, we proxy missing values of tier one capital with the series for total equity. Comparing pre- and post- Basel periods we find that the correlations for both series are good. Between 1990 and 2006, the correlation between the $erwa$ to total assets series and the true risk weighted assets to total assets is around 83 percent. The correlation between the ratio of common equity to total assets and the tier one capital to total assets ratio is around 97 percent.

Prior to the introduction of Basel I in 1992, US regulators employed a simple leverage ratio to assess capital adequacy: primary capital[10] had to exceed 5.5 percent of assets, while the total amount of primary plus secondary[11] capital had to exceed six percent of assets. According to the Federal Reserve Boards definition of zones for classifying banks with respect to supervisory action, we consider a ratio of total capital to risk weighted assets equal to seven percent to be the regulatory minimum. This requirement was effective until December 31, 1990, when banks were required to hold a minimum of 3.25 percent of their risk weighted assets as tier one capital and a minimum of 7.25 percent of their risk weighted assets in the form of total capital. From the end of 1992, the minimum tier one and total capital ratios were raised to four and eight percent respectively under Basel I. Capital requirements throughout the sample period are detailed in Table 4.1.

Charter value: The charter value of a bank is defined as the net present value of its future rents. Charter value can hence be thought of as being the market value of assets, minus the replacement cost of the bank (Keeley, 1990; Demsetz et. al., 1997 and Gropp and Vesala, 2001). As is common in the literature, we proxy the charter value of the bank by calculating Tobins q[12] as follows:

$$q = \frac{bvl + mve}{bva} \tag{4.3}$$

Where bva, bvl and mve depict the book value of assets, the book value of liabilities and the market value of equity respectively. The benefit of using Tobins q to capture charter value is that it is a market based measure meaning greater market power in both asset and deposit markets are reflected in a higher q value. Moreover, it allows for comparability among banks of varying sizes in our analysis.

Descriptive statistics of the main variables of interest are presented in Table 4.2. The sample is split by both capitalization, as well as by q, using an average value at the end of the sample. Banks can therefore either be above or below average. In addition to the sub-samples by capitalization and charter value, we further split the sample by asset size. BHCs in the top tenth percentile by maximum total assets are classified as *big.* Those in the tenth to fiftieth percentile are *medium*, and finally, BHCs in the bottom fiftieth percentile are considered *small.* Figures 4.1, and 4.2 plot the total capital ratios and q values of banks in each size sub-sample over the entire period respectively.

From Figures 4.1, and 4.2 we note substantial variations over time. In the late eighties, interest rates were rising, regulatory pressure was generally lax, and the banking industry was plagued with portfolio problems. Charter values at this time remain relatively low and consistent across the three size classes. Bank capital rose slightly. During the early 1990s, corresponding with a period of economic recovery and falling interest rates, we note slow rising charters, particularly among the larger BHCs. It is quite possible that the too-big-to-fail provision in the FDICIA provided an implicit subsidy to large banking

[10] The sum of equity plus loan loss reserves.

[11] Primarily qualifying subordinated debentures.

[12] Tobins q is a measure of firm performance that compares the market value of a company's stock with the value of a company's equity book value. If Tobin's q (the ratio of the market valuation of assets to the replacement cost of assets) is above 1, the firm is earning a rate of return higher than that justified by the cost of its assets.

firms, contributing to their higher charters evident at this time. Moreover, capital started to build up, corresponding with a sharp rise in portfolio risks. These observations might be explained through the introduction of the risk based capital requirements in the US at this time.

Smaller BHCs held considerably larger capital buffers than their larger counterparts, an observation that remains evident throughout the sample period. This finding is consistently predicted by the literature (see among others Gorton and Rosen, 1995; Esty, 1997; Salas and Saurina, 2002). Most obviously, large geographically diversified banks will have a much smaller probability of experiencing a large decline in their capital ratios, and a significantly greater ease with which to raise equity capital at short notice. This diversification effect increases with size and can perhaps explain the desire of smaller institutions to retain earnings as a precaution against unknown future needs. This effect is reinforced by asymmetric information between lenders and borrowers and by government support for banks that are at risk (too big to fail). Banks help overcome information asymmetries by screening and monitoring borrowers, but these are costly activities and banks are likely to balance the cost of (and gain from) these activities against the cost of excess capital. In the presence of scale economies in screening and monitoring, one would expect large banks to substitute relatively less of these activities with excess capital. Despite taking less risks, the larger capital buffers of smaller banks may reflect their difficulty in raising equity capital at short notice, thereby retaining earnings as a precaution against unknowns future needs. In all cases however, we note a significant jump in capital buffers between 1992 and 1995.

The mid- to late 1990s were plagued with massive consolidation in the banking industry. Rising concentration and hence market power appears to have raised the charter values of all BHCs significantly. Perhaps also because of scale economies, large BHCs saw their charter values rising much faster than medium and small BHCs. The anticipation and the eventual passage of the Gramm-Leach-Bliley Financial Modernization Act (GLB)[13] apparently further widened large banks' charter values relative to their smaller counterparts. Large BHCs were in a much better position to take advantage of the expansion of banking powers, and hence scope economies, than medium and small BHCs. The fact that very large BHCs continued to get even larger may have further substantiated their implicit too-big-to-fail subsidies. The capital buildup congruently continued its upward trend before stabilizing towards the late 1990s. Bank risks additionally continued to fall until this time, perhaps indicating a relationship between risk and capital borne from Basel I.

Towards the end of the sample period, there is some convergence in the average charters across the three size classes. Possible explanations for this variation include the over estimation of scope economies offered by GLB Act at the time of its implementation. Alternatively, technological advances in banking may have gradually filtering down to smaller institutions resulting in a removal of differences in this respect. Despite the slight convergence, the average charter values of large BHCs remained significantly above those

[13]The GBLA legalized the integration of commercial banking, securities brokerage and dealing and insurance activities, greatly expanding banking power and thus allowing banks to realize potential scope economies by engaging in a mix of financial services.

of medium BHCs which was in turn remained higher than the average charters of small BHCs.

4.4 Estimation: Methodology and Results

Despite the benefits of adopting Tobins q to capture bank charter value, we acknowledge some of the drawbacks associated. For example, due to the inclusion of bva in its calculation, Tobins q measures only historical costs rather than the current costs of assets. Deviations from one may therefore arise due to differences in expected and actual asset returns. Moreover, endogeneity between q and bank capital may exist, since banks will try to maintain a target probability of default depending on risk and capital, which is primarily driven by the value of q. To account for these factors, our analysis consists of two parts. In the first step, we regress our dependent variable q_{it} on a set of control variables that capture a banks' revenue mix, loan portfolio and deposit composition assumed to determine a banks' charter. We are then able to extract predicted values for q_{it} ($\hat{q}_{it}$) as inputs into our second step equation, allowing us to address the aforementioned estimation issues. The first step equation to be estimated can be formalized as follows:

$$q_{it} = \zeta_0 + \zeta_1 X_{0it} + \kappa_{0it} \tag{4.4}$$

where κ_{0it} is the error term consisting of a bank specific component (μ_{0i}) and white noise ($\varkappa_{0it}$). X_{0it} represents a vector of variables that determine the banks charter value including net interest margin (nim), capturing bank profitability; the ratio of loans to total assets ($loans$), measuring risk; the lagged debt to asset ratio ($debt_{t-1}$), to control for financial leverage; the ratio of bank deposits to total liabilities (td), to capture the cost of funds, *and* deposit growth rates ($gdep$), as a measure of bank growth possibilities. The definitions of control variables and their expected signs are detailed in Table 4.3.

In the second step, we focus on the relationship between q_{it} and buffer. As explained above, we include the predicted values $\hat{q}_{it}$ from the first stage as inputs into the second step regression. The hypothesis to be tested is that the long run relationship between the capital buffer and q_{it} is highly non linear such that high charter value banks will hold higher capital buffers. While banks with capital approaching the requirement will have little incentive to hold much capital as protection. The second step equation to be estimated can be presented as:

$$buf_{it} = f(\hat{q}_{it-1}) + \alpha_1 X_{1it} + \kappa_{1it} \tag{4.5}$$

The key variable in our non linear regression model is the lagged explanatory variable measuring bank charter value $\hat{q}_{it-1}$. We assume that the non linear relationship between $\hat{q}_{it-1}$ and the capital buffer is determine by the unknown function $f(\cdot)$.

In addition to capturing the relationship between $\hat{q}_{it-1}$ and capital, the model includes several other control variables that may influence the target capital buffer of bank i at time t. Different corporate finance theories produce a long list of factors that drive non-financial firms' capital structures (see Harris and Raviv, 1991; Frank and Goyal, 2003; Frank and Goyal, 2007). The empirical corporate finance literature has converged towards a set of variables that reliably predict leverage of non-financial firms in the cross section.[14] Recently, a set of authors developing models of target bank capital have confirmed the validity of these variables for a set of firms in a slightly different legal and institutional environment (Diamond and Rajan, 2000; Allen et al., 2006; and Gropp and Heider, 2008). Hence, variables included in the X_1 vector above are drawn from the corporate finance literature and can be defined as follows:

Risk From a regulators point of view, banks with a relatively risky portfolio, ie. with a high credit risk, should hold a larger capital buffer. Otherwise, these banks will be more likely to fall below the minimum capital ratio, increasing the probability of bankruptcy and likelihood of facing costs associated with failure.[15] Measuring bank risk is not a simple task since each alternate proxy has its own characteristics and limitations. Consequently no single proxy provides a perfect measure of bank risk. Several varying measures of risk have been adopted in the literature however, no consensus on which is most suitable exists.

Here, we capture risk by creatin an index as per Chessen (1987), Keeton (1989) and Shrieves and Dahl (1992). The index, constructed from accounting data, is calculated as follows:

$$(0.25 * interest\ bearing\ balances) + (0.10 * shortterm\ US\ treasury\ and\ government\ agency\ debt\ securities) + (0.50 * state\ and\ local\ government\ securities) + (0.25 * bank\ acceptances) + (0.25 * fed\ funds\ sold\ and\ securities\ purchased\ under\ agreements\ to\ resell) + (0.75 * standby\ letters\ of\ credit\ and\ foreign\ office\ guarantees) + (0.25 * loan\ and\ lease\ financing\ commitments) + (0.50 * commercial\ letters\ of\ credit) + (all\ other\ assets)$$

The weighted sum of these asset amounts is then divided by total assets.

Bank size: It is usually argued that larger firms are safer, better known in the market, and more exposed to agency problems (Jensen and Meckling, 1976) explaining why larger firms generally have lower degrees of capitalization. The size of a bank may additionally play a role in determining risk appetite through its impact on investment opportunities and diversification possibilities as well as access to equity capital. Large banks might be covered by the too-big-to-fail phenomenon whereby any distress will be bailed out by government assistance. Therefore, to capture size effects on both buffer and risk adjustments, we include the log of total assets (*size*) with an ambiguous expected sign in both cases.

Return on assets: Bank profitability may have a positive effect on bank capital if the bank prefers to increase capital through retained earnings rather than through equity issues. This might be the case since equity issues may convey negative information to the market about the banks value in the presence of asymmetric information. Return on assets (*roa*) is included as a measure of bank profits. The expected sign on the coefficient

[14]See Titman and Wessels, 1988; Rajan and Zingales, 1995; and more recently Frank and Goyal, 2007.
[15]See Ancharya (1996).

is positive since the level of buffer capital would, in this case, be expected to move in line with the level of bank profitability.

Liquidity: Banks with more liquid assets need less insurance against a possible breach of the minimum capital requirements. Moreover, the non zero risk weight associated with liquid assets means that banks can increase their capital buffers by liquidating assets. Therefore banks with more liquid assets generally have smaller target capital buffers and may also be willing to increase their levels of risk. We therefore expect a negative relationship between *liquidity*, calculated as the ratio of bond holdings, share holdings, and interbank assets to total assets, and the bank's capital buffer.

Each is described in detail in Table 4.3. In addition to the banks specific controls, we interact bank risk with the lagged charter value. By doing this, we will capture any relationship between bank charter and the capital buffer that works through risk. The error term, κ_{1it}, is assumed to consist of a bank specific component (μ_{1i}) and white noise ($\varkappa_{1it}$).

Equations (4.4.) and (4.5.) are estimated using pooled time series cross section observations, including a full set of time dummies to allow for the intercept to shift over time. These dummies capture unobserved bank invariant time effects not included in the regression, but their coefficients are not reported here for brevity. In addition to estimating equations (4.4.) and (4.5.) as presented above, we re-run the equations including the lagged dependent variable in each case. Here, we adopt the one and two step Blundell-Bond system GMM estimators (Blundell and Bond, 1998). However, since they produce quite similar estimates, we present only the (asymptotically) more efficient two step estimates. The results are presented with Huber/White/sandwich corrected standard errors.

4.4.1 Methodology

Since the functional form $f(\cdot)$ is assumed to be unknown, we adopt three varying approaches to estimate the relationships between charter value and the capital buffer in equation (4.5.). The first, $Model\ I$, assumes $f(\cdot)$ to be a simple linear function. The second, $Model\ II$, models $f(\cdot)$ as a quadratic function. These two approaches provide a baseline against which we can compare the more efficient spline estimator. In our final approach, $Model\ III$, we adopt a semi parametric methodology, whereby we estimate a standard regression that includes spline variables for each of the charter value splines. For equation (4.5.), the semi parametric spline approach allows the relationship between the capital buffer and charter value to vary depending on the size of the charter.[16]

The idea is that any continuous function can be approximated arbitrarily well by a piecewise linear function that is a continuous function composed of straight lines. One linear segment represents the function for $\hat{q}_{it-1}$ below s_1. Another linear segment represents the function for values between s_1 and s_2, and so on. The linear segments are arranged so that they join at s_1, s_2,..., which are called knots. The knots, in our case placed the 25th percentile, the median and the 75th percentiles, are used as threshold

[16] For a brief examination of the linear spline, see Greene (1993, pp. 235-238). A more detailed treatment is found in Seber and Wild (1989, pp. 481-489).

values from which the spline variables are created.[17]

Under *Model III*, spline variables are substituted for $\hat{q}_{it-1}$ in equation (4.5). The benefit of estimating a GMM equation with spline variables rather than a non parametric equation to capture non linearity, is that it allows the inclusion of all relevant variables already included in the previous estimations as control variables.

4.4.2 Results

The results from estimating equations (4.4.) and (4.5.) are presented in panels 1 and 2 of Table 4.4 respectively. Equation (4.4.) is presented in columns one and two. For equation (4.5) , columns three and four correspond to *Model I*, while columns five and six correspond to *Model II*. These are the simple parametric versions of our model. Columns seven and eight relate to the semi parametric case, *Model III*.

Equation (4.5.) For the linear case (*Model I*), the effect of charter value on the capital buffer is positive and highly significant as expected, such that banks with higher $\hat{q}_{it-1}$ values hold larger capital buffers. In addition, $risk$ is positive and significant in line with previous findings in the literature (see Shrieves and Dahl, 1992; Jacques and Nigro, 1997; Rime, 2001). The interaction term $\hat{q}_{it-1}risk_{it}$ is positive and significant. This indicates that the impact of charter value on capital buffers is dependent on the level of bank risk. The positive coefficient shows that as risk increases the impact of charter value on capital is enhanced.

The inadequacy of the linear model however, is highlighted by the improvement in the fit of the quadratic model. Since the variables $\hat{q}_{it-1}$ and its square $\hat{q}^2_{it-1}$ exhibit some evidence of collinearity, we center $\hat{q}_{it-1}$ at its mean. Hence, in *Model II* $\hat{q}_{it-1}$ is replaced by $\hat{q}CEN_{it-1}$. The coefficients on the quadratic estimates hint at a concave relationship between the two variables. In particular, we find a significant negative coefficient on the squared term ($\hat{q}^2_{it-1}$). For both the linear and the quadratic estimations, the coefficients attached to the variables of interest remain largely unchanged regardless of the estimation methodology imposed. The only difference is that the significance of the control variables; $size, roa$ and $liquid$ and is reduced under the GMM approach. The coefficients on the lagged dependent variables are positive as expected, and statistically significant in each case.

While the quadratic estimate provides a fairly good fit, one major limitation is that it imposes an arbitrary functional specification. For the estimations in column seven and eight, we therefore substitute our spline variables for $\hat{q}_{it-1}$ and additionally include all control variables as in the previous models. The coefficient on each spline variable corresponds to the slope of the piecewise linear function in the relevant interval.

Despite the clear improvement in the fit of the model, we additionally find that most spline variables are significant. The spline coefficients show a clear hump shaped relationship between charter value and buffer capital, in line with the concave form noted in the quadratic estimation. These results indicate that banks with charter values above the

[17] See Poirier (1974) and Garber and Poirier (1974) for a detailed discussion.To create the spline variables, we start by constructing a set of dummy variables which are set equal to one if the $\hat{q}_{it}$ value falls in the desired range, and zero otherwise. The dummy variables are then multiplied by $\hat{q}_{it}$ to obtain the $\hat{q}_{it}spline$ variables for equation (4.5.)

median level maintain a constant capital buffer. However, as the charter value decreases, banks build up their capital buffers since with lower expected earnings they are less able to cushion negative capital shocks out of current earnings. The larger capital buffer serves as an insurance against negative capital shocks. As the charter value continues to fall, the relationship is reversed. The incentive for the bank to protect its charter value is lost and the capital buffer falls rapidly towards zero. This is partially consistent with the predictions of the theoretical literature whereby it is assumed that as long as charter value is a degree greater than the cost of recapitalization, then a decline in expected earnings increases desired capital protection against poor earnings and more capital is needed to protect the charter value. However, we see that high charter value banks are not necessarily holding larger buffers of capital as predicted (see Marcus, 1984; Keeley, 1990; Demsetz et. al, 1997; Hellman et. al, 2000), but rather that the capital buffers remain relatively constant after a certain charter threshold. Banks with charter values slightly below the median range are holding the largest capital buffers. One possible explanation for the finding might be that for higher charter banks, it is generally easier to raise new equity in the future, reducing the need for holding large levels of precautionary capital. Alternatively, this finding indicates that banks with charter values above a certain threshold view themselves as too-big-to fail. The existence of government insurance schemes erodes the need for them to protect further against failure.

A positive and significant relationship continues to exist between capital and risk; as bank risk increases the capital buffer rises. The other control variables, $roa, size$ and $liquid$ generally have the correct sign, but are barely significant.

4.4.3 Cross Sectional Estimations

To assess the sensitivity of the results to pooling over the sample period, we additionally estimate cross section regressions for each time period. Since the results are broadly unchanged from those obtained under the pooled estimations we do not report them here. Instead, we graph the evolution of coefficients for $\hat{q}_{it-1}$ on buf_{it} for $Model\ I$ $Model\ II$ and $Model\ III$ in Figures 4.3, 4.4 and 4.5 respectively.

In Figure 4.3, we observe that the positive relationship documented in Table 4.4 has remained relatively constant over time. We do however note a slight increase in the linear impact of charter value on bank capital around the time of the capital buildup (between 1990 and 1994). The coefficients however always remain between 0.10 and 0.25 indicating that the variation has not been substantial.

Figure 4.4, corresponding to the quadratic estimation ($Model\ II$) again shows that the form of the relationship has not varied significantly over time. The negative coefficient on the squared term corresponding to the shape of the curve, documented here, indicates a consistently concave form. We do however note a slight change in the shape of the curve after 1995 when the slope becomes even steeper and remains that way until the end of the sample. This would tend to indicate that the non linear relationship between charters and capital buffers found in these estimations is particularly reinforced after 1994. Since this change in the relationship comes after the introduction of the Basel capital requirements, the finding is in line with that of Demsetz et. Al (1996). They show that after the introduction of Basel I, high charter value banks held more capital and took less risk. Moreover, they find that high franchise value banks reduce the probability of default by increasing capital.

The coefficients reported in Figure 4.5 correspond to the spline estimation (*Model III*) giving further insight into what drove the change in the relationship observed above. We can see that prior to 1994, banks with higher charters held higher buffers in line with the traditional charter value models. The non linear effect, captured by the coefficients on splines 1-3 indicate that the greatest change exists for low charter banks. In particular, coefficients for spline 3 and spline 2 appear to drive the fluctuation noted in Figure 4.4. These finding confirm the fact that a non linear relationship between capital and charter values only becomes substantial after 1994.

Our cross sectional estimations show that coefficients on the variables of interest have not varied substantially over time and therefore our previous estimations do not appear to suffer significantly from pooling over the sample period. We do however find that the non linear relationship between capital and charter values is enhanced substantially since 1995. This is in line with the panel estimation findings.

4.4.4 Robustness Check

As an additional robustness check, we vary the placement on the knots for the creation of our spline coefficients. In our initial estimation, the knots for creating spline variables were placed at the 25th percentile, the median and the 75th percentile. To further assess the validity of the finding that past a certain charter threshold, banks will hold a stable amount of capital (rather than the predicted increase in capital corresponding to larger charters), we create new spline variables as per Section 4.4.1, varying the location of the knots. Three further specifications are estimated: In *Specification I*, knots are placed at the 20th, 40th, 60th and 80th percentiles. In *Specification II* we place the knots at each decile until the median (10th, 20th, 30th, 40th and median) and then at the 75th percentile. Finally, in *Specification III*, the knots are placed at the 25th percentile, the median and then at each remaining decile (60th, 70th, 80th and 90th). These breakdowns allow a detailed assessment of how the relationship between bank capital and charter value varies depending on the size of the charter, and allows us to further assess the robustness of our estimation results obtained in the previous section. Table 4.5 defines the splines utilized in each of the specifications. The results from the robustness estimations are presented in Table 4.6.

Again, the results are broadly in line with the panel estimations and cross sectional findings. The detailed analysis confirms the finding that large charter banks maintain a constant capital buffer. For each specification, spline coefficients above the median range are very near to zero. Moreover, the signs on the slope coefficients below the median range additionally confirm the shape of the curve depicted by the panel estimations. That is, as charter values start to fall, capital is built up. The relationship is only reversed after charters fall below the 20th percentile range. After this time, the capital buffer falls rapidly towards zero. *Specification II* however indicates that the capital buffer never actually equals zero, rather once charter values fall below the 10th percentile, capital buffers remain consistently small but above zero nevertheless.

4.5 Discussion

This chapter analyzes the long run relationship between bank capital and charter values for a set of US BHCs between 1986 and 2008. Much of the literature examining the relationship between capital, risk and charter values have assumed the relationship to be linear. Our study explores the non linearity between bank capital and charter values by adopting both quadratic and semi parametric spline techniques.

Our results show that the relationship between capital and charter values is highly non linear as predicted by theory. Contrary to predictions however, we show that higher charter value banks do not necessarily hold more capital. One possible explanation is that beyond a certain charter level, it is easier for banks to raise new equity thereby reducing the need for them to manage large capital buffers. Alternatively, higher charter value banks may view themselves as partially insulated from failure due to the existence of government safety nets and the too-big-to-fail paradigm. Our results further indicate that when charters start to fall, banks build up capital in an attempt to protect their charter. Falling charters reflects the notion that expected earnings are falling and hence banks are less able to cushion negative capital shocks out of current earnings. A buildup of capital at this time insures against negative capital shocks. The relationship between capital and charter values is however reversed when charter values continue to fall. The capital buffer then very quickly falls towards zero as a means perhaps to "gambling for resurrection".

Our results indicate that the charter value in itself *does* act as a disciplining mechanism for bank capital management. Banks with a valuable enough charter will manage capital so as to maintain a cushion for protection against negative shocks. Our analysis has however, been limited to assessing capital ratios as defined by the 1988 accord. Current turmoil suggests that securitization and financial market innovation may have resulted in these capital buffers not reflecting the true capitalization of the banks, particulary in the US. The rise in unknown risks, rather than the measurable risks that financial institutions are specialized in managing, may therefore not have been adequately captured by the existing regulatory requirements.

While our results indicate that charter values appear to have encouraged prudent capital management policies in the run up to the current crisis, it is unclear how this relationship will change when supervisors and regulators account for the off-balance sheet risks. Our results therefore have important policy implications. Since bank capital management is evidently endogenous by nature, it is essential that amendments to bank capital requirements are able to capture the true nature of risks and exposures inherent.

4.A Tables and Figures

Table 4.1: US Bank Capital Requirements.

	Tier one ratio	Total capital ratio
1986 to end 1990		7%
1991 to end 1992	3.25%	7.25%
end 1992 to 2008	4%	8%

Table 4.2: Sample Distribution.

Observations		*Mean*	*Std. Dev*
Big Banks	buffer capital	1.80	0.09
	risk	0.74	0.10
	charter value	1.20	0.11
Medium Banks	buffer capital	2.89	0.06
	risk	0.56	0.05
	charter value	1.11	0.09
Small Banks	buffer capital	4.11	0.04
	risk	0.42	0.01
	charter value	0.91	0.04
Highly Capitalized Banks	buffer capital	5.10	0.07
	risk	0.48	0.16
	charter value	1.19	0.08
Low Capitalized Banks	buffer capital	1.32	0.10
	risk	0.82	0.10
	charter value	1.04	0.06
High Risk Banks	buffer capital	3.92	0.08
	risk	0.54	0.13
	charter value	1.01	0.08
Low Risk Banks	buffer capital	4.01	0.03
	risk	0.21	0.03
	charter value	1.21	0.04
High Charter Value Banks	buffer capital	4.01	0.08
	risk	0.59	0.10
	charter value	1.55	0.04
Low Charter Value Banks	buffer capital	2.94	0.09
	risk	0.70	0.21
	charter value	0.85	0.10
Total Sample	buffer capital	5.31	0.10
	risk	0.68	0.21
	charter value	1.08	0.05

Figure 4.1: *US BHC Total capital (by bank size).*

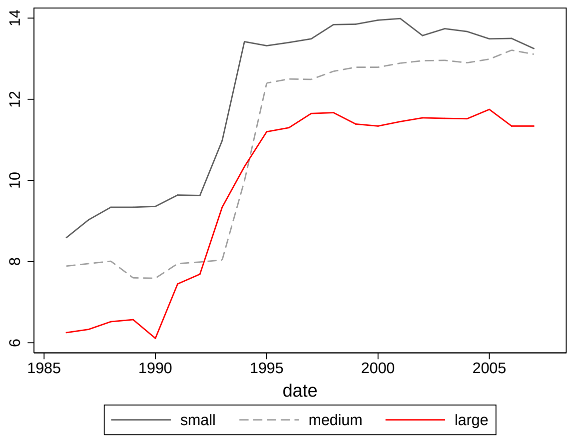


Figure 4.2: *US BHC q Values (by bank size).*

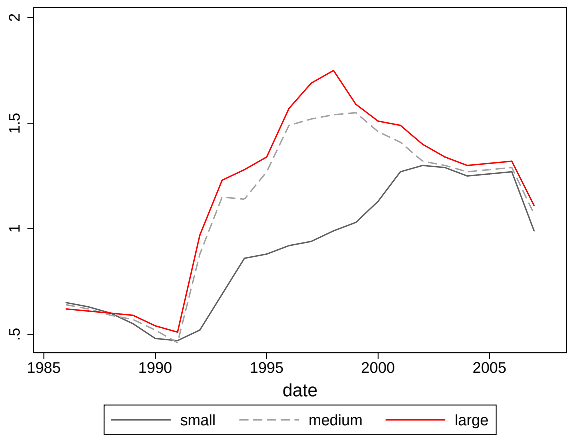


Table 4.3: Control Variables.

Variable	*Description*
Equation (4.4.)	
nim	ratio of net interest income to total assets.
$loans$	ratio of total loans to total assets.
$debt_{t-1}$	lagged ratio of total liabilities over total assets.
td	ratio of bank deposits to total liabilities.
$gdep$	deposit growth rate.
Equation (4.5.)	
$risk$	risk weighted assets as per Section 4.3.1.
$size$	log of total assets.
roa	the of ratio return on assets to total assets.
$liquid$	ratio of cash plus securities to total assets.

Table 4.4: Total Sample Panel Regressions

	First-step equation		**Second-step equation**					
			Model I: Linear		**Model II: Quadratic**		**Model III: Spline**	
	fixed effects	*GMM*	*fixed effects*	*GMM*	*fixed effects*	*GMM*	*fixed effects*	*GMM*
Panel I: Equation (4.4.): $q_{it} = \varsigma_0 + \varsigma_1 X_{0it} + \kappa_{0it}$								
nim	0.40 (1.97)**	0.49 (2.04)**						
loans	0.07 (0.98)	0.10 (2.87)***						
$debt_{t-1}$	-0.04 (3.12)***	-0.06 (1.88)*						
td	0.06 (1.85)*	0.08 (1.99)**						
gdep	0.13 (0.11)	0.17 (2.92)***						
R^2	0.37							
Sargan		78.95 (3.12)						
a(1)		0.74 (0.00)						
a(2)		2.02 (1.19)						
Panel II: Equation (4.5.):$buf_{it} = f(\hat{q}_{it}) + \alpha_1 X_{1it} + \kappa_{1it}$								
buf_{t-1}				0.09 (4.33)***		0.08 (3.29)***		0.05 (7.67)***
$\hat{q}_{it-1}$			0.69 (5.45)***	0.74 (3.40)***				
$\hat{q}CEN_{it-1}$					0.82 (5.00)***	0.76 (3.99)***		
$\hat{q}^2_{it-1}$					-0.59(4.39)***	-0.63(6.40)***		
spline1							0.57(2.04)**	0.69(1.98)**
spline2							-0.36(3.79)***	-0.41(4.19)***
spline3							0.00(1.67)*	0.02(0.96)**
spline4							0.01(2.26)**	0.03(2.18)**
risk			0.77 (7.02)***	0.64 (4.39)***	0.89 (8.92)***	0.44 (12.17)***	0.73 (9.29)***	0.86 (14.35)***
$\hat{q}_{it-1} risk_{it}$			0.38 (2.05)**	0.29 (2.00)**	0.41 (0.99)	0.39 (0.71)	0.47 (1.01)	0.38 (0.99)
size			-0.21 (1.84)*	-0.12 (1.54)	-0.22 (1.07)	-0.15 (1.83)*	-0.19 (0.99)	-0.24 (0.56)
roa			0.21 (1.98)**	0.18 (1.23)	0.28 (1.14)	0.18 (1.34)	0.25 (1.86)*	0.33 (2.11)**
liquid			0.02 (2.95)***	0.05 (0.99)	0.03 (1.99)**	0.07 (1.22)	0.06 (2.12)**	0.03 (2.69)***
R^2			0.29		0.38		0.47	
Sargan				64.34 (3.20)		34.23 (5.30)		28.40 (3.01)
a(1)				2.01 (0.00)		1.39 (0.00)		-2.30 (0.00)
a(2)				1.03 (0.33)		2.01 (0.21)		1.38 (0.88)

Note: *, ** and *** denote significance at the ten, five and one percent levels respectively. Each regression includes time dummies as a control that are not reported here. Coefficients depicted are estimates of equation (4.5.): $buf_{it} = f(\hat{q}_{it}) + \alpha_1 X_{1it} + \kappa_{1it}$. Spline1 refers to: $\hat{q}_{it} < 25^{th}$percentile; spline2, to: 25^{th} percentile $<\hat{q}_{it} <$ median; spline 3, to: median $<\hat{q}_{it} < 75^{th}$percentile; and spline4 to: $\hat{q}_{it} > 25^{th}$percentile.

Table 4.5: Robustness Check: Spline Definitions

spline name	*definition*
Specification I	
$spec1_1$	$\hat{q}_{it} < 20^{th}$ percentile
$spec1_2$	20^{th} percentile $<\hat{q}_{it} < 40^{th}$ percentile
$spec1_3$	40^{th} percentile $<\hat{q}_{it} < 60^{th}$ percentile
$spec1_4$	60^{th} percentile $<\hat{q}_{it} < 80^{th}$ percentile
$spec1_5$	$\hat{q}_{it} > 80^{th}$ percentile
Specification II	
$spec2_1$	$\hat{q}_{it} < 10^{th}$ percentile
$spec2_2$	10^{th} percentile $<\hat{q}_{it} < 20^{th}$ percentile
$spec2_3$	20^{th} percentile $<\hat{q}_{it} < 30^{th}$ percentile
$spec2_4$	30^{th} percentile $<\hat{q}_{it} < 40^{th}$ percentile
$spec2_5$	40^{th} percentile $<\hat{q}_{it} <$ median
$spec2_6$	median $<\hat{q}_{it} < 75^{th}$ percentile
$spec2_7$	$\hat{q}_{it} > 75^{th}$ percentile
Specification III	
$spec3_1$	$\hat{q}_{it} < 25^{th}$ percentile
$spec3_2$	25^{th} percentile $<\hat{q}_{it} <$ median
$spec3_3$	median $<\hat{q}_{it} < 60^{th}$ percentile
$spec3_4$	60^{th} percentile $<\hat{q}_{it} < 70^{th}$ percentile
$spec3_5$	70^{th} percentile $<\hat{q}_{it} < 80^{th}$ percentile
$spec3_6$	80^{th} percentile $<\hat{q}_{it} < 90^{th}$ percentile
$spec3_7$	$\hat{q}_{it} > 90^{th}$ percentile

Figure 4.3: *Model I: Linear coefficients.*

Figure 4.4: *Model II: Quadratic coefficients.*

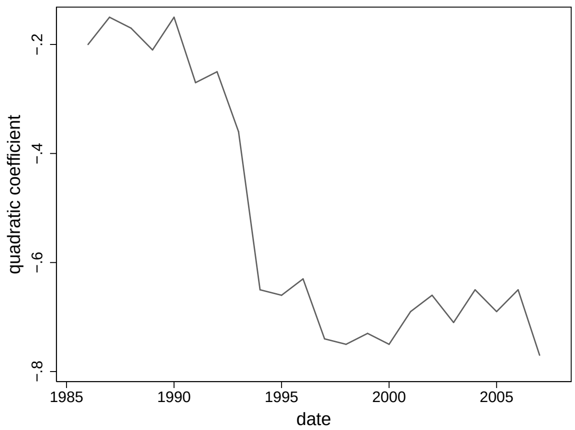
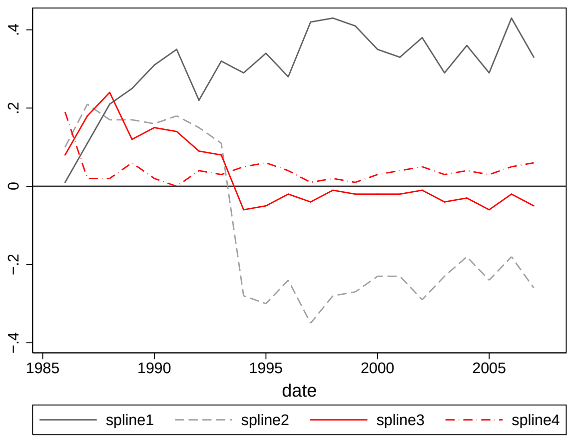


Figure 4.5: *Model III: Spline coefficients.*



Note: Coefficients depicted are estimates of equation (4.5.): $buf_{it} = f(\hat{q}_{it}) + \alpha_1 X_{1it} + \kappa_{1it}$. Spline1 refers to: $\hat{q}_{it} < 25^{th}$percentile; spline2, to: 25^{th} percentile $<\hat{q}_{it} <$ median; spline 3, to: median $<\hat{q}_{it} < 75^{th}$percentile; and spline4 to: $\hat{q}_{it} > 25^{th}$percentile.

Table 4.6: Robustness Check.

	Second-step equation					
	Specification I		**Specification II**		**Specification III**	
	basic fixed effects	*GMM*	*basic fixed effects*	*GMM*	*basic fixed effects*	*GMM*
Equation (4.5.):$buf_{it} = f(\hat{q}_{it}) + \alpha_1 risk_{it} + \alpha_2 \hat{q}_{it} risk_{it} + \alpha_3 X_{1it} + \kappa_{1it}$						
buf_{it-1}		0.04 (2.67)***		0.06 (3.65)***		0.07 (4.45)***
$spec1_1$	0.35 (1.97)**	0.39 (2.05)**				
$spec1_2$	-0.33 (3.98)***	-0.27 (3.15)***				
$spec1_3$	-0.12 (1.78)*	-0.12 (1.77)*				
$spec1_4$	0.02 (1.13)	0.01 (1.09)				
$spec1_5$	0.00 (1.69)*	0.01 (1.57)*				
$spec2_1$			0.04 (1.58)*	0.06 (1.67)*		
$spec2_2$			0.57 (2.89)***	0.46 (3.69)***		
$spec2_3$			-0.04 (2.37)**	-0.03 (5.56)***		
$spec2_4$			-0.10 (2.53)**	-0.07 (1.90)**		
$spec2_5$			-0.12 (1.16)	-0.12 (1.78)*		
$spec2_6$			0.00 (1.69)*	-0.01 (1.74)*		
$spec2_7$			0.01 (1.98)**	0.00 (2.17)**		
$spec3_1$					0.32 (1.87)**	0.29 (2.23)**
$spec3_2$					-0.22 (8.75)***	0.17 (7.30)***
$spec3_3$					-0.05 (1.70)*	-0.04 (1.10)
$spec3_4$					-0.02 (1.09)	-0.01 (1.10)
$spec3_5$					0.04 (1.93)*	0.03 (1.99)**
$spec3_6$					0.00 (2.23)**	0.05 (2.13)**
$spec3_7$					0.01 (1.93)*	0.00 (1.99)**
risk	0.76 (11.89)***	0.98 (12.22)***	0.87 (14.97)***	0.92 (12.35)***	0.89 (11.69)***	0.68 (12.19)***
$\hat{q}_{it-1} risk_{it}$	0.27 (1.15)	0.15 (0.75)	0.12 (0.96)	0.23 (1.33)	0.33 (0.89)	0.41 (1.26)
size	-0.10 (1.72)*	-0.08 (1.11)	-0.14 (3.02)***	-0.31 (1.96)**	-0.16 (1.75)*	-0.23 (2.72)***
roa	0.02 (1.94)*	0.08 (0.92)	0.04 (1.74)*	0.03 (1.68)*	0.06 (2.00)**	0.03 (1.55)
liquid	-0.16 (2.71)***	-0.10 (1.71)*	-0.22 (1.77)*	-0.21 (0.72)	-0.14(2.28)**	-0.11(1.98)*
R^2	0.21		0.33		0.35	
Sargan		32.34 (5.40)		43.10 (3.29)		29.20 (2.93)
a(1)		-2.30 (0.00)		2.10 (0.00)		-1.93 (0.00)
a(2)		1.29 (0.93)		-1.02 (0.36)		2.10 (0.73)

Note: *, ** and *** denote significance at the ten, five and one percent levels respectively. Each regression includes time dummies as a control that are not reported here. Coefficients depicted are estimates of equation (4.5.): $buf_{it} = f(\hat{q}_{it}) + \alpha_1 X_{1it} + \kappa_{1it}$. Spline variables are as defined in Table 4.5.

4.B Data Manipulations

4.B.1 Commercial bank dataset

All bank level data is obtained from the Consolidated Report of Condition and Income (referred to as the Call Reports) published by the Federal Reserve Bank of Chicago. Since all insured banks are required to submit Call Report data to the Federal Reserve each quarter we are able to extract income statement and balance sheet data for around 14,000 commercial banks. The dataset spans from $1976Q1 - 2006Q2$.

This particular dataset poses several problems for us to deal with in terms of cleaning the data and obtaining a consistent set of data series. There are several reasons for this. First, through time, definitions change for some of the variables of interest, therefore, looking merely at the Report documentation that that banks are required to fill in is not always sufficient. Therefore it is necessary, on some occasions, to join series together in order to yield sensible series through time. Moreover, most of the large banks only provide data on a consolidated foreign and domestic basis requiring the exploration of which series to use.

RCON vs. RCFD series In general, larger banks only provide data on a consolidated foreign and domestic basis. Therefore, it is necessary to use the $RCFD$ series rather than the $RCON$ series for each variable. For banks that do not have foreign operations however, it is possible to assume that the two series ($RCON$ and $RCFD$) will be identical, although it is necessary to bear in mind that foreign deposits in this case are not available.

The definition for total securities changes several times through our sample. It is therefore necessary for us to combine various individual series through time to create a consistent variable to work with. Prior to 1984, it is not possible to combine all of the items that are now considered as investment securities. We therefore need to approximate the securities variable. Pre-1984 we combine $RCFD0400$ (US Treasury securities), $RCFD0600$ (US Government agency and corporation obligations), $RCFD0900$ (obligations of states & political subdivisions) and $RCFD0380$ (other bonds, stocks and securities). In 1984q1 however, we are able to separately add up the items making up investment securities because a) trading account securities for sale at book value ($RCFD1000$) is replaced by *securities for sale at market value* ($RCFD2146$) and b) there is no guarantee that the securities are held to maturity match across the break in 1984. i.e. there is no guarantee that $RCFD0402$ (securities issued by states and political subdivisions in the US) + $RCFD0421$ (other domestic securities) + $RCFD0413$(foreign securities) = $RCFD0900$ (obligations of states and political subdivisions) + $RCFD0950$(other securities). For the pre and post 1984 series to be consistent, these two summations must be equal. We therefore combine the series $RCFD0390$ (book value of securities) and $RCFD2146$ (assets held in the trading account) for the period 19841 to 1993q4. After this time, $RCFD0390$ (book value of securities) is no longer available. From 1994q1 we therefore proceed by summing up $RCFD1754$ (total securities held to maturity), and $RCFD1773$ (total securities available for sale). Moreover, $RCFD1754$ (total securities held to maturity), and $RCFD1773$ (total securities available for sale) excludes securities held in the trading account, which is part of $RCFD3545$ (total trading assets). We therefore create an additional securities variable (securties2) which is the summation of $RCFD1754$ (total securities held to maturity), $RCFD1773$ (total securities available for sale) and $RCFD2146$ (assets held in trading accounts). We generally make use of the securities2 variable since this eliminates a break in the series in 1993.

For total loans, we again see that there is a break in the series in March 1984. In the third quarter of 1984, the series includes the variable $RCFD2165$ (lease financing receivables). From March 1984 we adopt $RCFD1400$ (total loans & leases, gross) as our total loans variable. Prior to this however, we replace the series with a sum of $RCFD1400$ (total loans & leases) and $RCFD2165$ (lease financing receivables). Similarly for net loans we have $RCFD2122$ (total loans, net of unearned income) for the period between 1984q1 and 2006q2. Prior to this, we again combine $RCFD2122$ (total loans, net of unearned income) with $RCFD2165$ (lease financing receivables).

Commercial and Industrial loans has a change in definition as well. From 1976 until 1984q3, we make use of the $RCFD1600$ (commercial and industrial loans). Here, each bank's own acceptances are included. From 1984q3 however, the series starts to include holdings of bankers' acceptances which are accepted by other banks. We therefore replace this series with a combination of the $RCFD1755$ (acceptances of other banks) and $RCFD1766$ (commercial and industrial loans, other). It remains impossible to create a consistent series here that would exclude banker's acceptances.

A further change in definition occurs with the Fed Funds series. Considering first the Fed Funds Sold series. From 1976 until 2002q1 we are able to make use of $RCFD1350$ (Fed Funds Sold). However, the series discontinues thereafter. We subsequently form a continuation by summing $RCONb987$ (Fed Funds sold in domestic offices) and RCFDb989 (securities purchased under agreement to sell).

Similarly, for Fed Funds Purchased, the series $RCFD2800$ (Fed Funds Purchased) discontinues at the end of 2001. We are then able to replace the series in 2002q2 with $RCFDb993$ (Fed Funds purchased in domestic offices) summed with RCFDb995 (securities sold under agreement to repurchase).

Other issues in the commercial bank dataset In most of the graphical analysis we find a kink in the series in 1997q1. Looking closer at the cause of this disturbance in the data, we find that the number of institutions falls in 1997q1 to 8,648 from 9,772 in 1996q4. The number subsequently rises again in 1997q2 when the number of reporting institutions jumps again to 9,248. Investigating the issue further, we find that there appears to be a fault in the dataset for this period. It seems that information reported for around 800 banks are all returned with 0 values. We therefore correct the data by setting values equal to those of the previous period where data is missing.

Dealing with mergers With respect to the treatment of bank mergers in the data, several possible alternative approaches are considered: *Option 0*: All observations affected by a merger are simply dropped from the sample. Note however,if using any lagged growth rates or differences in the model, this means dropping future observations as well as the observation when the merger takes place. This option is applied by many existing studies in the banking literature (see for example Kashyap and Stein, 2000). *Option 1*: This option is preferable when a large bank acquires a very much smaller bank. Here, all past balance sheet and income observations are rescaled, using a constant ratio, from the beginning of the sample up to the quarter preceding the merger. This ratio is equal to the increase in total assets triggered by the merger. *Option 2*: This option is preferable to Option 1 when two merging banks are of similar size. Here, the merged entities are reconstructed backwards as the sum of the merging banks. In this case a new new bank id, different from any existing id, is created and applied to all subsequent observations.

In this chapter, we adopt a mixture of Options 1 and 2; When merging banks are of different sizes we adopt Option 1 while for a small number of mergers where the merging banks are of similar size, we create a new bank id as per Option 2.

Merging the Commercial and BHC datasets The following steps were undertaken to merge the holding company data with with commercial bank data from the Federal Reserve Bank of Chicago. We start with the commercial bank data set and start by identifying those banks that belong to foreign call family:

1. We start by generating a foreign call identity as follows:

gen fgncall_ind = 0

replace fgncall_ind = 1 if fgncallfamily > 0 & fgncallfamily ˜ = .

We then created a variable called *identifier* which tells us the name of the financial high holder. (this is equal to the rssd9348 variable in the dataset:

gen identifier = high holder $/* = rssd9348 */$

If however, the high holder is a foreign call family, the variable gives the number of it instead:

replace identifier = $fgncallfamily$ if $fgncall\_ind == 1$

2. We then make use of the *identifier* variable to collect holding company data from the BHC data.

By changing the name of $rssd9001$ to identifier in BHC data. Moreover, we drop all observations equal to 0.

3. Finally we merge this dataset back to the commercial bank data. First we copy the commercial bank dataset and the BHC data into the same directory. Opening the commercial bank data, we type the following:

merge $rssd9001$ dateq using BHCpanel, unique sort $update\_merge(\_mergeBHC)$

Chapter 5

Bank Capital Buffer and Risk Adjustments

5.1 Introduction

Capital requirements have become one of the key instruments of modern day banking regulation providing both a cushion during adverse economic conditions and a mechanism for preventing excessive risk taking ex ante (see Rochet, 1992a; Dewatripont and Tirole, 1994). Theoretical work focusing on the effects of capital requirements on bank risk appetite is dominated by a theory of moral hazard, in which information asymmetries and deposit insurance shield banks from the disciplining control of depositors. Taking capital as exogenous, this strand of literature analyzes incentives in asset risk choice. These studies show that capital adequacy regulation may reduce the total volume of risky assets (see Merton, 1977; Sharpe, 1978; Furlong and Keeley, 1989). This literature however, has also shown that with the further assumption of a risk averse bank utility function [1], bank portfolio composition may be distorted in the direction of more risky assets. As a consequence, average risk may increase and risk consistent weights are required to correct for moral hazard.[2] The theoretical literature is thus ambiguous about the relationship between bank capital and bank risk.

A broader view, moving beyond the theory of moral hazard, is provided by the charter value theory.[3] This theory argues that banks have something to lose since bankruptcy leads to a loss of future profits. Two further possible characterizations of the relationship between bank capital and risk thus exist (see Calomiris and Kahn, 1991; Diamond and Rajan, 2000). In contrast to the predictions of the moral hazard theory, banks therefore no longer hold the minimum allowable amount of capital, rather, they have their own preferred (target) level of capitalization. If this level is exceeded by regulatory requirements, then there is no longer a relationship between capital and risk taking. To our

[1] A risk averse utility function is usually justified as reflecting the divergence of interest between managers and shareholders inducing risk averse behavior.

[2] Koehn and Santomero, 1980; Kim and Santomero, 1988; Rochet, 1992; and Freixas and Rochet 1997.

[3] Also referred to as the franchise value (see Marcus, 1984; Boot and Greenbaum, 1993; Demsetz et. al, 1997; Hellman, Murdoch, and Stiglitz 2000, Matutes and Vives 2000), charter value is the value that would be foregone if the bank closes.

knowledge, there is no theoretical analysis exploring the resulting relationship between capital and risk, which appears to be ambiguous. The following possible outcomes exist: (i) higher risk can increase the probability of default and encourage banks to increase capital, and (ii) higher systematic risk can reduce charter value and lower capital holdings. If however, regulatory capital requirements exceed the banks target level of capital, then a higher degree of capitalization will lead to a reduction in risk appetite whereby the charter effects become less important. The quantitative magnitude of this effect however, may be relatively small.

Within the charter value literature, attention has more recently shifted towards the capital buffer theory[4], a dynamic version of the charter value models in which there are costs both of altering the level of capital and allowing capital to fall below the minimum required levels. The buffer theory predicts that banks will maintain a level of capital above the required minimum (a buffer of capital). The costs of falling below the minimum required level of capital are both explicit and implicit. Buser et al. (1981) argue that implicit costs of regulation may arise from regulatory interference designed to control excess demand for insurance (eg. expanding risk taking). Explicit costs relate to penalties and/or restrictions imposed by the supervisor triggered by a breach of the regulation, possibly even leading to bank closure. The novel contributions of the capital buffer theory are to distinguish the long from the short run relationships between capital and risk taking and the impact of regulatory capital from observed bank capital. Here, regulatory capital will have a limited long run impact on bank risk choice, regardless of risk weighting. The long run relationship between the capital buffer and risk is similar to that predicted by the charter value theory, and can therefore be either positive or negative. The short run relationship between capital buffer and risk on the other hand, will depend on the degree of bank capitalization. For banks near their desired level (highly capitalized banks), we would expect a positive relationship. However, for banks approaching the regulatory required level, the relationship should be negative. An increase in regulatory capital requirements, in the short run, will reduce the buffer of capital and so has the same impact as a direct reduction in the capital buffer.

Several empirical papers have focused on understanding the relationship between risk and capital, testing whether increases in capital requirements force banks to increase or decrease their risk (see Shrieves and Dahl, 1992; Jacques and Nigro, 1997; Aggarwal and Jacques, 2001; Rime, 2001). Most of these studies have confirmed the positive relationship between capital and risk adjustments predicted by theory, indicating that banks that have increased their capital levels over time, have also increased their risk appetite. Shrieves and Dahl (1992) argue that a positive relationship between the key variables is in line with several hypotheses which include the unintended effect of minimum capital requirements, regulatory costs, bankruptcy cost avoidance as well as managerial risk aversion. Jacques and Nigro (1997) on the other hand find a negative relationship between changes in capital and risk levels. They note that such a finding may be attributable to methodological flaws in the risk based guidelines.[5] Alternatively, as suggested by Shrieves and Dahl (1992),

[4]See among others Milne and Whalley, 2001; Peura and Keppo, 2006; VanHoose, 2007a&b.

[5]Avery and Berger (1991) suggest that while the risk weights constitute a significant improvement

a negative relationship may exist between capital and risk adjustments if banks seek to exploit the deposit insurance subsidy.

Evidence on the capital buffer theory is however more limited. For a set of German savings banks, Heid et. al (2004) suggest that the coordination of capital and risk adjustments depends on the amount of capital the bank holds in excess of the regulation. Banks with low capital buffers try to rebuild an appropriate buffer by raising capital while simultaneously lowering risk. In contrast, banks with large buffers maintain their capital buffer by increasing risk when capital increases. These findings are in line with the predictions of the capital buffer theory.

The relationship between risk and capital has several important policy implications. The recent modification in the capital requirement regulation (Basel II) is a structural change that places far more emphasis on the range of capital that may be required given the specific risks faced by each bank. It has been argued that a more risk sensitive capital adequacy regulation may reduce banks' willingness to take risk. However, if banks already risk adjust their total capital, ie. minimum capital plus buffer capital, more than implied by Basel I, then replacing Basel I with Basel II may not affect the capital to asset ratio or risk profile of banks' portfolio as much as feared. It is therefore clearly of interest to understand the relationship between risk and capital buffer formation.

For a sample of publicly traded US bank holding companies (BHCs) we investigate the relationship between short run capital and risk adjustments. Our estimations show that the management of short term adjustments in capital and risk are dependent on the size of the buffer. For banks with capital buffers approaching the minimum requirement, the relationship between adjustments in capital and risk are negative. That is that low capital banks either (i) increase their buffers by reducing their risk, or (ii) gamble for resurrection by taking more risk as a means to rebuild the buffer. In contrast, the relationship between capital and risk adjustments for well capitalized banks is positive, indicating that they maintain their target level of capital by increasing *(decreasing)* risk when capital increases *(decreases)*. Allowing for the speed at which banks adjust towards their target capital and risk levels to be bank specific, we show that small buffer banks adjust to their target capital level significantly faster than their better capitalized counterparts. We are however, unable to find significant evidence of a similar trend for adjustments in risk. We additionally investigate the time varying nature of the relationship between capital and risk adjustments, which appears to exhibit a cyclical pattern: *negative* after the 1991/1992 crisis, and *positive* before 1991 and after 1997.

The rest of the chapter is organized as follows: Section 5.2 outlines the empirical framework adopted. Section 5.3 describes the data and defines the hypotheses to be tested. Section 5.4 presents our empirical estimations and results. Section 5.5 briefly discusses our findings and concludes.

over the old capital standards, several instances in which the weights assigned to specific categories are too crude to reflect true risk.

5.2 Empirical Framework

In order to investigate the short run relationship between capital buffer and risk adjustments, we acknowledge that banks will manage their capital buffer by accounting primarily for the risk of default. Similarly, risk taking will depend on how close the capital buffer is to the minimum requirement. Moreover, in this framework, observed changes in a banks' capital buffer and its portfolio risk can be thought of as a function of two components; one part which is managed internally by the bank plus an exogenous random shock. Building on previous work[6], our model, with simultaneously determined variables, can be written as follows:

$$\Delta buf_{it} = \Delta buf_{it}^{bank} + \varepsilon_{it} \tag{5.1}$$

$$\Delta risk_{it} = \Delta risk_{it}^{bank} + \mu_{it} \tag{5.2}$$

where Δbuf_{it} and $\Delta risk_{it}$ are the observed changes in the capital buffer and risk respectively. Δbuf_{it}^{bank} and $\Delta risk_{it}^{bank}$ are the changes in the capital buffer and risk that are managed internally by the bank. ε_{it} and μ_i and are the exogenously determined random shocks for bank i at time t.

The framework outlined above further assumes that banks will establish an internally optimal capital buffer and risk level that they will target over time. The long run level of target capital and risk are given by:

$$buf_{it}^{*} = \xi z_{it} + \eta_{it} \tag{5.3}$$

$$risk_{it}^{*} = \varphi u_{it} + \omega_{it} \tag{5.4}$$

Here z_{it} and u_{it} capture all variables (including Δbuf_{it} in the risk equation and $\Delta risk_{it}$ in the buffer capital equation) that determine the banks' target level of capital buffer and risk. ξ and φ are the vectors of coefficients to be estimated. Δbuf_{it} is assumed to impact the target level of risk since any short term change in the capital of the bank will affect the banks' probability of default. Similarly a shift in the banks' risk profile will alter the banks distance from the regulatory minimum.

Over time, exogenous shocks will drive actual levels away from or toward, target levels. Banks will therefore need to adjust both the capital buffer and risk taking to revert back to their internally optimal level. This adjustment is depicted by Δbuf_{it}^{bank} and $\Delta risk_{it}^{bank}$. Full adjustment to the target level however, may be too costly or infeasible. Our model therefore assumes partial, rather than complete, adjustment in each period.

We can then think of the bank managed adjustment as:

$$\Delta buf_{it}^{bank} = \xi_0(buf_{it}^{*} - buf_{it-1}) \tag{5.5}$$

$$\Delta risk_{it}^{bank} = \varphi_0(risk_{it}^{*} - risk_{it-1}) \tag{5.6}$$

[6] See Shrieves and Dahl, 1992; Jacques and Nigro, 1997; Aggarwal and Jacques, 2001.

Here ξ_0 and φ_0 are the speeds of adjustment of the capital buffer and risk respectively; buf_{it}^* and $risk_{it}^*$ are the target levels of capital buffer and risk; and buf_{it-1} and $risk_{it-1}$ capture the actual levels of buffer capital and risk in the previous period. $buf_{it} - buf_{it-1}$ and $risk_{it} - risk_{it-1}$ then represent the actual change in capital and risk between two periods, while $buf_{it}^* - buf_{it-1}$ and $risk_{it}^* - risk_{it-1}$ denote the desired long run change. These equations highlight the fact that observed changes in the buffer and risk levels in period t are a function of the differences between the target level of capital and risk in period t and previous period's actual capital and risk, and any exogenous shock.

Substituting equations (5.5.) and (5.6.) into equations (5.1.) and (5.2.) we then have:

$$\Delta buf_{it} = \xi_0(buf_{it}^* - buf_{it-1}) + \kappa_{it} \tag{5.7}$$

$$\Delta risk_{it} = \varphi_0(risk_{it}^* - risk_{it-1}) + \phi_{it} \tag{5.8}$$

We note that the observed changes in capital and risk in any given time period t is some fraction ξ_0 or φ_0 of the desired change for that period. If ξ_0 (φ_0)= 1, then the actual buffer (risk) level will be equal to the desired buffer (risk) level. That is, adjustment to the target level is instantaneous. If on the other hand, ξ_0 (φ_0)= 0, nothing changes, since the actual level of buffer (risk) at time t is the same as that observed in the previous period. Typically then, ξ_0 and φ_0 will lie between these extremes since adjustment to the desired stock of capital is likely to be incomplete for several reasons.

5.3 Hypotheses and Data

To determine how observed short run fluctuations of the capital buffer (Δbuf_{it}) impact on short run changes in bank risk ($\Delta risk_{it}$), we estimate our model derived in the previous section. It is important to note that the target levels of capital (buf_{it}^*) and risk ($risk_{it}^*$) cannot be observed and hence are approximated by various cost and revenue variables discussed in detail in Section 5.3.1 below.

$$\Delta buf_{it} = \alpha_1 - \xi_0 buf_{it-1} + \xi_1 Y_{it} + \xi_2 \Delta risk_{it} + \kappa_{it} \tag{5.9}$$

$$\Delta risk_{it} = \alpha_2 - \varphi_0 risk_{it-1} + \varphi_1 Z_{it} + \varphi_2 \Delta buf_{it} + \phi_{it} \tag{5.10}$$

where Δbuf_{it} and $\Delta risk_{it}$ are the observed changes in capital buffers and risk respectively, i = 1,2...N is an index of banks and t = 1,2,...T, is the index of time observation for bank i at time t. The Y_{it} and Z_{it} vectors capture the bank specific variables that determine the target buffer and risk levels respectively. κ_{it} and ϕ_{it} are assumed to consist of a bank specific component and white noise.

Our null hypothesis can be presented as:

H_0 : *Short term adjustments in the capital buffer and bank risk have no impact on one another.* The alternative hypotheses to be tested are then as follows:

H_{1A}: *The coefficients ξ_2, and φ_2, are positive and significant. Adjustments in capital buffer and risk are positively related for banks with large capital buffers. This hypothesis is in line with the theory that well capitalized banks will manage their desired probability* *of default, by maintaining an target capital buffer through positive adjustments in risk.*

and

H_{1B}: *The coefficients* ξ_2*, and* φ_2*, are negative and significant. The adjustments of buffer capital varies systematically, but negatively, with adjustments in risk taking. ie. Riskier banks will hold less capital in their buffer stock. This hypothesis is in line with the notion that banks with buffers near the regulatory minimum will build up their buffers of capital by reducing risk taking.*

5.3.1 Sample Selection

As per chapter 4, we create an unbalanced panel of US commercial bank and bank holding company (BHCs) balance sheet data covering the period between 1986q2 and 2008q2. All commercial bank data is obtained from the Consolidated Report of Condition and Income (referred to as the Call Reports) published by the Federal Reserve Bank of Chicago.[7] Since all insured banks are required to submit Call Report data to the Federal Reserve each quarter we are able to extract income statement and balance sheet data for a large number of commercial banks.[8] In addition, we obtain balance sheet data for BHCs from the Fed Funds Y-9 form. By identifying the high holder to which the individual commercial banks belong, we merge the two datasets to obtain balance sheet, income as well as risk based variables for publicly traded bank holding companies.[9] See Appendix 5.B for further information on data manipulations.

In general the BHCs in the sample have been well capitalized throughout the sample. The average bank has exceeded the minimum required capital ratio by a comfortable margin. The average[10] tier one (total) capital stood at 7.55(9.55) percent of risk weighted assets[11] in 1986 but reached 9.88(13.44) percent by 1994 and has remained relatively stable since.

Figure 5.1 documents the evolution of both tier one and total capital ratios over time. In 1992 both tier one and total capital ratios rose substantially. Several reasons can be put forward as possible explanations of this. First, this may simply reflect an unusual period of inflated bank profitability and share price appreciation during the 1990s. BHC capital ratios might thus have risen passively, simply because bank managers failed to raise dividends or repurchase shares. Second, this was around the time that the Basel I rules were introduced in the US. The Federal Deposit Insurance Committee Improvement Act (FDICIA) subsequently sought to impose greater credit risk on uninsured bank liability holders and consequently introduced a mandatory set of prompt corrective actions (PCA) that increased the cost of violating the capital standard. Hence, direct supervisory pressure may have contributed to the capital buildup. Although PCA does not directly apply to BHCs, it is relevant, because it applies to their bank subsidiaries and therefore

[7] This data is publicly available at www.chicagofed.org.

[8] In 1976 we have data for 14,000 banks which diminishes to around 8,000 banks by the end of the sample.

[9] Once the initial dataset is obtained, we further clean the data by keeping only those bank holding companies for which we have three consecutive quarters of data.

[10] Weighted by market capitalization.

[11] Risk weighted assets are defined as the total of all assets held by the bank, weighted for credit risk according to a formula determined by the countries regulator.

may affect the amount of excess capital held at the holding company level.

Dependent and Explanatory Variables

Bank Capital Buffers In this chapter, as per Chapter 4, we acknowledge that the capital to asset ratio that regulators define and monitor is the ratio of regulatory capital to risk weighted assets. There is however, no reason to expect that this is the same ratio that banks target internally when making risk decisions. Banks for example might consider the market value of capital, targeting a market value of equity below which the bond market starts charging a risk premium. Alternatively, banks may actively manage capital so as to remain within a desired range of economic capital[12] hence targeting the level of either book or market equity needed to carry our future acquisition strategies.

We define dependent variable Δbuf_{it}, as the observed change in the amount of capital the bank holds in excess of that required by the regulator. We adopt this measure of capital since we assume that banks will manage their capital in such a way as to avoid, or minimize, costs associated with a breach of regulatory requirements. Since individual subsidiary banks seldom issue independent equity and are rather wholly owned by a holding company, equity financing generally occurs at the BHC level. To capture changes in the buffer of capital, we focus solely on the BHCs.

Regulatory requirements placed on banks have undergone several changes throughout the sample period. At the beginning of our sample, US regulators employed a simple leverage ratio to assess capital adequacy: primary capital had to exceed 5.5 percent of assets, while the total amount of primary plus secondary capital had to exceed six percent of assets. Consequently, in the period between 1986 and the end of 1990, we consider a ratio of total capital equal to seven percent as the regulatory minimum with which we calculate the capital buffer. This criterion is based on the Federal Reserve Boards definition of zones for classifying banks with respect to supervisory action.

Effective December 31, 1990, banks were required to hold at least 3.25 percent of their risk weighted assets as tier one capital and a minimum of 7.25 percent of their risk weighted assets in the form of total capital (tier one + tier two). Finally, Basel I was introduced at the end of 1992. The minimum tier one and total capital ratios were subsequently raised to four and eight percent respectively. In addition to the Basel regulations, US banks are restricted by an additional leverage ratio of primary capital to total capital requirement imposed by the FDICIA. Current regulations therefore state that in order to be *adequately capitalized*, a BHC must have a tier one capital ratio of at least four percent, a total capital ratio of at least eight percent and a leverage ratio of at least four percent.

The tier one ratio of a bank is defined as tier one capital over the banks total assets, where tier one capital gives the ratio of a banks' core equity capital to its total risk weighted assets. Due to reporting changes, data on risk weighted assets are not available as far back as 1986. We therefore create proxy series for these variables prior to this time.

We adopt the methodology put forward by Beatty and Gron (2001) to estimate risk

[12] Economic capital is the amount of risk capital, assessed on a realistic basis, which a firm requires to cover the risks that it is running or collecting as a going concern, such as market risk, credit risk, and operational risk. It is the amount of money which is needed to secure survival in a worst case scenario.

weighted assets prior to 1990. Our estimated risk weighted assets variable, (*erwa*) is calculated as follows:

$total\ loans + (0.2 * agency\ securities) + (0.5 * municipal\ securities) + (corporate\ securities)$

Moreover, we proxy missing values of tier one capital with the series for total equity. We can then compare pre- and post- Basel periods. The correlations for both series are good. We find that between 1990 and 2006, the correlation between the *erwa* to total assets series and the true risk weighted assets to total assets is around 83 percent. The correlation between the ratio of common equity to total assets and the tier one capital to total assets ratio is around 97 percent.

Risk From a regulators point of view, banks with a relatively risky portfolio, ie. with a high credit risk, should hold a larger capital buffer. Otherwise, these banks will be more likely to fall below the minimum capital ratio, increasing the probability of bankruptcy and likelihood of facing costs associated with failure.[13] Measuring bank risk is not a simple task since each alternate proxy has its own characteristics and limitations. Consequently no single proxy provides a perfect measure of bank risk. Several varying measures of risk have been adopted in the literature however, no consensus on which is most suitable exists.

In this study we are concerned with portfolio risk, the proportion of risky assets in the bank's portfolio. This is the measure of risk on which bank regulators base their capital guidelines. Even though the proportion of certain risky assets in a bank's portfolio may not exactly reflect the overall asset risk of a bank, it may reflect project choice by bank managers and, thus, to some degree the overall asset risk. Several authors have therefore used the composition of a bank's portfolio to capture asset risk (See Godlewski, 2004; Berger, 1995; McManus and Rosen, 1991; Gorton and Rosen, 1995). Recent literature has shown that banks are steadily moving towards reliance on non traditional business activities that generate fee income, trading income and other types of non interest income and that consequently, bank risk is now largely found off balance sheet (DeYoung and Roland, 2001; Stiroh, 2004). Given the objective of this study, our aim is to correctly estimate risk in a manner that captures changes in management policy with regard to the risk profile of the bank over a twenty year history. Therefore, several asset based measures centered on existing literature are adopted, all of which come from the commercial bank side of the balance sheet of the unbalanced panel created in Section 5.3.1.

Our first measure of risk (*risk*) corresponds to the measure of risk adopted in Chapter 4. Here, we create an index as per Chessen (1987), Keeton (1989) and Shrieves and Dahl (1992). The index, constructed from accounting data, is calculated as follows:

$$(0.25 * interest\ bearing\ balances) + (0.10 * shortterm\ US\ treasury\ and\ government\ agency\ debt\ securities) + (0.50 * state\ and\ local\ government\ securities) + (0.25 * bank\ acceptances) + (0.25 * fed\ funds\ sold\ and\ securities\ purchased\ under\ agreements\ to\ resell) + (0.75 * standby\ letters\ of\ credit\ and\ foreign\ office\ guarantees) +$$

[13] See Ancharya (1996).

$$(0.25 * loan\ and\ lease\ financing\ commitments) + (0.50 * commercial\ letters\ of\ credit) + (all\ other\ assets)$$

The weighted sum of these asset amounts is then divided by total assets.

In addition to the *risk* measure described above, we consider the risk weighted assets to total assets ratio rwa/ta. The risk weighted assets are calculated in accordance with the Basel I rules. The rationale for this proxy is that the allocation of bank assets among risk categories is the major determinant of a bank's risk.[14] This measure of risk however does not account for market risk and therefore serves to capture credit risk only. As a consequence, it captures only one part of the true asset risk. Moreover, the relative weights assigned to each portfolio category may not correspond to the actual risk involved. Since there are only four kinds of relative weights (0, 20, 50 and 100 percent), each category within the portfolio may consist of assets with varying levels of risk.[15] Therefore, it is likely that two banks with the same rwa/ta ratio in fact have different levels of risk exposure.

An additional proxy for risk adopted is the ratio of non-performing loans[16] to total loans and credits, *npl*. This measure of loan portfolio quality is an ex-post measure of risk since banks with non-performing loans are obliged to make provisions for loan losses. In order to affectively capture risk through this methodology, we need to acknowledge that the risk of loans originated in a given year will not be reflected in past due and non accrual classifications until the subsequent period. Therefore the quality of loans must be measured as those past due or non accruals recorded the following year. Finally, we calculate the ratio of commercial and industrial loans to total assets (*c&iratio*). This measure is adopted since commercial and industrial loans are generally riskier than the other categories of loans.[17] Empirical studies (Gorton and Rosen, 1995; Samolyk, 1994) find evidence that banks with a *c&iratio* also have higher levels of non performing assets.

The rwa/ta ratio is generally considered to be a better ex-ante indicator of overall risk than the *c&iatio*, since it is a more comprehensive measure. Thus, while the *c&iratio* focuses only on a specific portfolio item, the Basel Accord guidelines group all assets into different portfolio categories and assign different risk weights according to the perceived riskiness of all of the portfolio categories. In contrast to the other two measures (the *c&iratio* and the rwa/ta), the *npl* ratio is an ex-post measure of risk. Thus, the *npl* ratio inherently depends on luck or chance in addition to other factors, in addition to ex-ante risk. The *npl* ratio may contain information on risk differences between banks not caught by the rwa/ta ratio, and thus is used as a complementary risk measure to the rwa/ta ratio.

[14]See Chessen (1987) and Keeton (1989). Jacques and Nigro (1997) argue that the rwa/ta captures the allocation as well as the quality aspect of portfolio risk. Avery and Berger (1991) and Berger (1995) show that this ratio is positively correlated with risk.

[15]For instance, all commercial loans have the same weight (100 percent) regardless of the creditworthiness of the borrower.

[16]Non-performing loans are those that are 90 days or more past due or not accruing interest.

[17]The major loans made by U.S. commercial bank lending activities can be segregated into four broad categories. These are real estate, commercial and industrial, individual, and others. Commercial and industrial loans includes credit to construct business plants and equipment, loans for business operating expenses, and loans for other business uses. It is the second largest loan category in dollar volume among the loan portfolio of U.S. commercial banks.

If banks consider the true credit risk of their portfolios when deciding on the total amount of capital, one would expect the buffer capital to vary positively with any risk measure included as a regressor. Essentially replicating the true risk profile of banks' portfolios rather than the risk weights in Basel I.

In addition to the influence that risk will have on the capital buffer formation, and vice verse, our model assumes that the target levels of both risk and capital will depend on a set of bank specific characteristics, captured in equations (5.9.) and (5.10.) by the X_{it} and Y_{it} vectors respectively. Different corporate finance theories produce a long list of factors that drive non-financial firms' capital structures (see Harris and Raviv, 1991; Frank and Goyal, 2003; Frank and Goyal, 2007). The empirical corporate finance literature has converged towards a set of variables that reliably predict leverage of non-financial firms in the cross section.[18] Recently, a set of authors developing models of target bank capital have confirmed the validity of these variables for a set of firms in a slightly different legal and institutional environment (Diamond and Rajan, 2000; Allen et al., 2006; and Gropp and Heider, 2008). Hence, variables included in the X_{it} and Y_{it} vectors above are drawn from the corporate finance literature and can be defined as follows:

Charter value: A more satisfactory account of bank risk taking emerges when allowance is made for the charter value of the bank. The larger the charter value, the greater the incentive to reduce risk taking and to maintain a capital buffer that is not in danger of falling below the regulatory minimum.[19] The charter value thus acts as a restraint against moral hazard in banking (Marcus, 1984; Keeley, 1990; Demsetz et al., 1997) and can explain the relationship between capitalization and risk appetite (Demsetz et al., 1997).

Defined as the net present value of its future rents, the charter value can hence be thought of as being the market value of assets, minus the replacement cost of the bank (Keeley, 1990; Demsetz et. al., 1997 and Gropp and Vesala, 2001). As is commonly done in the literature, we proxy the charter value of the bank by calculating Tobins q as follows:

$$q = \frac{bvl + mve}{bva} \tag{5.11}$$

Where bva, bvl and mve depict the book value of assets, the book value of liabilities and the market value of equity respectively. The benefit of using Tobins q to capture charter value is that it is a market based measure meaning greater market power in both asset and deposit markets are reflected in a higher q value. Moreover, it allows for comparability among banks of varying sizes in our analysis.

All market data is obtained from the Center for Research on Securities Prices (CRSP). We would expect to observe a positive relationship between q and the capital buffer; such that banks with higher charter values will hold larger capital buffers as a means to protect the valuable charter. Moreover a negative relationship between q and risk is expected, indicating that banks with higher charter values have a greater incentive to reduce their risk. Moreover, we would expect to observe a positive relationship between q and the

[18] See Titman and Wessels, 1988; Rajan and Zingales, 1995; and more recently Frank and Goyal, 2007.

[19] Banks with larger charter values will want to protect this value by lowering their risk taking.

capital buffer; such that banks with higher charter values will hold larger capital buffers as a means to protect the valuable charter.

Bank size: It is usually argued that larger firms are safer, better known in the market, and more exposed to agency problems (Jensen and Meckling, 1976) explaining why larger firms generally have lower degrees of capitalization. The size of a bank may additionally play a role in determining risk appetite through its impact on investment opportunities and diversification possibilities as well as access to equity capital. Large banks might be covered by the too-big-to-fail phenomenon whereby any distress will be bailed out by government assistance. Therefore, to capture size effects on both buffer and risk adjustments, we include the log of total assets (*size*) with an ambiguous expected sign in both cases.

Return on assets: Bank profitability may have a positive effect on bank capital if the bank prefers to increase capital through retained earnings rather than through equity issues. This might be the case since equity issues may convey negative information to the market about the banks value in the presence of asymmetric information. Return on assets (*roa*) is included as a measure of bank profits. The expected sign on the coefficient is positive since the level of buffer capital would, in this case, be expected to move in line with the level of bank profitability.

Loan loss provisions: A bank's current loan losses will have an impact on the risk level of a bank since a bank with a higher level of loan losses will tend to exhibit lower levels of risk adjusted assets in the future. We proxy these losses (*loanloss*), by the ratio of new provisions to total assets. The effect of loan losses on the capital buffer is expected to be positive since banks with greater expected losses can be assumed to raise their capital levels in order to comply with regulatory requirement and to mitigate solvency risk. We include the *loanloss* variable in the risk equation based on the assumption that banks with higher level of loan losses will exhibit lower future levels of risk adjusted assets. As a result, a negative relation should exist between target risk and loan loss provisions.

Liquidity: Banks with more liquid assets need less insurance against a possible breach of the minimum capital requirements. Moreover, the non zero risk weight associated with liquid assets means that banks can increase their capital buffers by liquidating assets. Therefore banks with more liquid assets generally have smaller target capital buffers and may also be willing to increase their levels of risk. We therefore expect a negative relationship between *liquidity*, calculated as the ratio of bond holdings, share holdings, and interbank assets to total assets, and the bank's capital buffer.

Dummy variables: The model presented in equations (5.9.) and (5.10.) assumes that the target level of both capital and risk depends on a set of bank specific characteristics including its charter value, size, profitability and liquidity. The speed at which the bank adjusts back to the target level however is assumed to be constant.

The capital buffer theory predicts that banks with small capital buffers will try to build capital towards an internally defined target buffer while banks with large buffers will maintain their buffer at the target level. Hence, adjustments in capital buffers and risk are expected to be positively *(negatively)* related for banks with larger *(smaller)* than average capital buffers. Moreover, banks with smaller *(larger)* capital buffers are expected to adjust both capital and risk faster *(slower)* than than well capitalized banks.

To allow for variations in capital and risk management to depend on the degree of bank capitalization, we create a set of dummy variables $Dcap_l$ and $Dcap_h$. The dummy $Dcap_l$ is set equal to one if the capital buffer of a bank is *less* than two percent; and zero otherwise. Similarly, the dummy $Dcap_h$ is equal to one if the capital buffer of a bank is greater than three percent; and zero otherwise.[20]

To test the predictions outlined above, we interact the $Dcap$ dummy variables with the variables of interest. For example, in order to capture differences in the speeds of adjustment of low and high buffer banks, we interact $Dcap_l$ and $Dcap_h$ with the lagged dependent variables buf_{it-1} and $risk_{it-1}$. Moreover, to assess differences in short term adjustments of capital and risk that depend on the degree of capitalization, we interact the dummy variables with $\Delta risk_{it}$ and Δbuf_{it} in the capital and risk equations respectively. Bank fixed effects and a full set of time dummies are included in all the regressions.[21]

5.4 Estimation: Methodology and Results

Our model, as outlined in equations (5.9.) and (5.10.) is estimated for a variety of combinations of risk measures outlined in Section 5.3.1. All variables adopted in the study are defined in Table 5.1. Table 5.2 presents correlations of our main variables in levels and in differences. Since theory suggests that banks with low risk aversion will choose high leverage *(low capital)* and high asset risk (see Kim and Santomero, 1988), we would expect to find a negative correlation between the level of portfolio risk and and bank capital ratios simply due to the cross sectional variation in risk preferences. The capital buffer theory suggests that there will be a positive time series correlation between adjustments in capital and risk. Banks with larger capital buffers reduce their endogenous risk aversion and increasing risk taking while increased opportunities to take on risky exposures lead banks to increase capital. Only the correlation between buf_{it} and $risk_{it}$ is negative. All other measures of risk appear to be positively correlated with the capital buffer.

The observed negative relationship is in line with previous findings. However, most of the authors to date have proxied risk by non performing loans (see Shrieves and Dahl, 1992; Jacques and Nigro, 2001 and Aggarwal and Jaques, 1998 for evidence of this for the US market). We are unable to replicate this negative finding with our npl_{it} measure of risk. By calculating correlations in various time periods, we are however, able to show that the correlations between the buffer of capital and most risk variables are negative prior to 1993. This relationship becomes positive after this time, driving the complete sample correlation presented in Table 5.2.

These simple correlation studies do not allow other variables to affect the relationship and therefore do not clarify whether the correlations noted are due to simultaneous

[20]The three percent threshold is consistent with the 25th percentile of buffer capital in the sample. It also corresponds to the FDIC definitions of *adequately* and *well* capitalized banks.

[21]Most important determinants of capital ratios are time invariant firm specific characteristics according to recent research (see Lemmon, Roberts, and Zender, 2008).

changes in the variables. Moreover, they do not allow for the numerator/denominator interactions in buf_{it}. Our dynamic estimations therefore serve to account for various additional factors that could affect the level of capital and risk held to provide a deeper understanding of the relationships.

Since we estimate a dynamic model, including the lagged endogenous variables, we employ the the one and two step Blundell-Bond system GMM estimators (Blundell and Bond ,1998). However, since they produce quite similar estimates, we present only the (asymptotically) more efficient two step estimates. However, the two step estimates of the standard errors tend to be severely downward biased (Arellano and Bond, 1991; Blundell and Bond, 1998). To compensate, we use the finite sample correction to the two step covariance matrix derived by Windmeijer (2005). Applying this methodology rather than the three stage least squares (3SLS) approach that is common in this literature[22], allows us to account for possible bank specific effects, providing unbiased estimates.[23] The methodology uses lagged levels as instruments in the first difference equations and lagged first differences (Δbuf_{it} *(*$\Delta risk_{it}$*))* in the levels equations. Moreover, in the simultaneous equations estimation, we include lags of $risk_{it}$ *(*buf_{it}*)* as instruments for $\Delta risk_{it}$ *(*Δbuf_{it}*)* to account for the simultaneity of capital and risk adjustments in the buf_{it} *(*$risk_{it}$*)* equation. The number of instruments chosen in each model was the largest possible, for which the Sargan -statistic for over identification restrictions was still satisfied.

5.4.1 Full Sample GMM:

We begin by estimating our model with different risk measures outlined above. As a first step, equations (5.9.) and (5.10.) are estimated as separate equations.

Single equation estimations

Capital equation: The results from estimating variations of equation (5.9.) are presented in Table 5.3. $\Delta risk_{it}$, $\Delta rwa/ta_{it}$, Δnpl_{it}, $\Delta c\&iratio_{it}$ are adopted as the risk measures in *Model I, Model II, Model III and Model IV* respectively. *Model V*, introduces a combination of Δnpl_{it} and $\Delta rwa/ta_{it}$. *Model VI* uses the risk index, $\Delta risk_{it}$, together with $\Delta rwa/ta_{it}$. Finally, in *Model VII*, $\Delta risk_{it}$ and Δnpl_{it} are considered together. In each case, the risk measure is taken to be the observed change in risk as discussed in detail in Section 5.3.

In general, observed changes in buffer capital are positively related to changes in risk. We do however, observe a negative relationship when $\Delta c\&iratio_{it}$ is included. The positive finding indicates that the target capital buffer is adjusted in accordance to the varying risk profile of the bank. A bank experiencing a positive *(negative)* shock to risk will therefore respond by increasing *(reducing)* its capital buffer.

In addition to the risk variables, the estimated coefficients for the bank specific variables generally carry the expected sign with mostly significant coefficients. The reported coefficients on the lagged dependent variable buf_{it-1} are highly significant. They show

[22]see among others Schrieves and Dahl, 1992; Jacques and Nigro, 1997; Aggarwal and Jacques, 2001; Rime, 2001; and Heid et al., 2004.

[23]As a robustness check, we additionally pool the cross sectional data over the entire sample and estimate using the 3SLS methodology. For our key variables, the findings are unchanged and are therefore not presented here for the sake of brevity.

the expected positive signs and lie within the required interval $[0;1]$. Hence they can be interpreted as speeds of capital adjustment. The significance of the speeds of adjustment are in line with the view that the costs of capital adjustment are an important explanation of the holding of large capital buffers. The fastest speed of adjustment is noted in *Model I*, where the composite $\Delta risk_{it}$ measure is adopted. Here on average banks close the gap between their actual and desired level of capital by around nine percent each quarter, corresponding to a 36 percent adjustment in the year period following a shock. This speed of adjustment is in line with findings of Flannery and Rangan (2006) who show that the mean firm acts to close its gap at the rate of more than 30 percent per year.

The expected positive sign on the q_{it} coefficient is found in all of the six models indicating that banks with higher charter values hold larger capital buffers. $size_{it}$ is consistently negative, but only significant in two of the seven cases *Model II* and *Model VI.* The negative coefficient is in line with the too-big-to-fail hypothesis as well as with the notion that smaller banks experience greater difficulty in accessing the capital markets. Furthermore, this finding could provide evidence in favor of scale economies whereby larger banks will generally enjoy a higher level of screening and monitoring than their smaller counterparts resulting in a reduction excess capital held as insurance. Moreover, the negative coefficient is consistent with the notion that smaller banks are less diversified than their larger counterparts and therefore hold larger capital buffers. roa_{it} is consistently positive and mostly significant, indicating the importance that BHCs place on retained earnings to increase their capital buffers. $loanloss_{it}$ is positive and significant in five of the seven cases, indicative that banks with greater expected losses raise capital buffers in order to comply with regulatory requirements and to mitigate solvency risk. Finally, the $liquidity_{it}$ variable shows that banks with higher liquidity ratios generally hold less capital. While the estimates have the correct sign, the results are only significant in two of the seven models *Model I and Model VII.*

Risk equation: Similarly to above, equation (5.10.) is estimated as a single equation, in this case varying the dependent variable. $\Delta risk_{it}$, $\Delta rwa/ta_{it}$, Δnpl_{it}, $\Delta c\&iratio_{it}$ are adopted for *Model I, Model II, Model III* and *Model IV* respectively.

The coefficients on Δbuf_{it} are generally positive and highly significant. The only exception being the coefficient associated with *Model IV*, where we observe a negative coefficient significant at the ten percent level. The positive relationship indicates that BHCs respond to a positive *(negative)* capital shock by increasing *(reducing)* risk taking. This finding is in line with the notion that banks aim to maintain an internally defined level of risk by either increasing or decreasing the size of the capital buffer.

The speed of adjustment captured by $risk_{it-1}$ is substantially slower than that noted in the buffer equation above. Again, we find that the speed of adjustment for *Model I* is the fastest. Here, banks generally close around three percent of the gap between desired and actual risk each quarter. This is equivalent to a reduction of around twelve percent of the gap within the year following an exogenous shock.

q_{it} is negative and significant for all of the models. This is in line with our expectations and with previous studies showing that charter values act as a disciplining mechanism with regard to risk taking. Similarly, banks with low charter values have little to lose and therefore may adopt riskier strategies. $size_{it}$ is positive in all case but significant only for *Model III* and *Model IV*. As above, this is consistent with the notion that larger banks have higher target levels of risk than smaller banks. The $loanloss_{it}$ coefficients are positive and significant indicating that contrary to expectations, banks with higher loan losses are riskier. Finally, the $liquidity_{it}$ coefficient is positive as expected, but not significant in any of the four cases.

Our findings indicate that the relationship between observed changes in capital and risk appears to be positive. BHC's that have increased their risk taking over our sample period, have similarly increased their capital buffers and vice verse. These estimations have however failed to account for the fact that short term adjustments to capital and risk are simultaneously determined and therefore should be interpreted with caution. The main purpose of these estimations was rather to determine how the relationships change with the various measures of risk used. In general, we see that regardless of the risk measure adopted, except for $\Delta c\&iratio_{it}$, the results are qualitatively unchanged. For the rest of this chapter, we therefore adopt $\Delta risk_{it}$ as our measure of risk. We chose the composite risk index $\Delta risk_{it}$ for several reasons. First, it appears to be the most accurate measure of risk for this study since it estimates risk in a manner that captures changes in management policy with regard to the risk profile of the bank at any point in time. Moreover, the expected negative correlation between risk and capital (see Table 5.2) is only evident when the $\Delta risk_{it}$ measure is adopted. Hence, we assume that this measure dominates others as discussed previously.

We therefore proceed to estimate equations (5.9.) and (5.10.) as a system of equations, acknowledging the simultaneity associated with decisions taken in this regard.

Simultaneous equation estimations

For the simultaneous estimations of equations (5.9.) and (5.10.), three varying specifications are considered. *Specification I*, is our baseline model defined in equations (5.9.) and (5.10.). *Specification II* allows the speed of adjustment back to the target level to interact with the degree of bank capitalization. Finally, *Specification III* allows for further interaction between capital and risk management and bank specific characteristics. In this specification, both the speed of adjustment, together with the management of short term adjustments in capital and risk interact with the size of the capital buffer. The results are presented in Table 5.5.

Under *Specification I*, the impact of capital buffer adjustments on risk and vice verse are both positive and highly significant. This is in line with the results obtained for the single equation estimations. The fact that simultaneous adjustments of capital and risk are positively related to each other can be associated with a number of theories of bank behavior. First, if banks manage their capital in such a way as to avoid, or minimize, costs associated with a breach of regulatory requirements, then banks would tend to increase *(decrease)* capital when they increase *(decrease)* portfolio risk, and conversely. This is the case since the value of expected bankruptcy costs increase with the probability of bankruptcy (see Orgler and Taggart, 1983). Through simultaneous adjustments of both capital and risk, banks are able to manage an internally optimal probability of default, defined as a function of both capital and risk. Moreover, the theory of managerial risk aversion in the context of banking (Saunders et al., 1990) views managers as agents of stockholders that may have an incentive to reduce the risk of bank insolvency below the level desired by stockholders. Managers, who are assumed to be compensated with risky fixed claims on the bank, and who have firm and industry specific human capital, have a great deal to lose personally in the event of a bank failure. In this case, the marginal cost associated with increases in risk or decreases in capital, is the incremental disutility experienced by bank managers. Thus, banks that have high risk portfolios may compensate for increases in risk by increasing capital and vice verse. Each case gives rise to a positive relationship between adjustments in risk and capital; and adjustments in capital and risk. The positive relationships between capital and risk are noted under all three specifications. The speeds of risk and capital adjustment under *Specification I* are in both cases positive and highly significant. As per the single equation estimations, the speed of risk adjustment is significantly slower than the capital adjustment over the sample period.

The interaction terms, $Dcapxbuf_{it-1}$ and $Dcapxrisk_{it-1}$ introduced in *Specification II*, shed further light on how the speed of adjustment towards the target level depends on the size of the capital buffer. Coefficients for both $Dcap_l xbuf_{it-1}$ and $Dcap_h xbuf_{it-1}$ are positive as expected. The magnitudes of the coefficients, together with their degree of significance imply that banks with small capital buffers, those with capital buffers *not* larger than two percent, adjust their buffers faster than their better capitalized counterparts. This is in line with the recent literature which allows the speed of adjustment towards targets to vary with firm specific characteristics (see Berger at al., 2008).[24] For the risk equation, coefficients, and degrees of significance, of $DCAP_l xrisk_{it-1}$ and $DCAP_h xrisk_{it-1}$ indicate that low buffer banks do not adjust their risk any faster than highly capitalized banks.

Under *Specification III*, we introduce a further interaction between the degree of bank capitalization and management of short term risk and buffer adjustments. Both $Dcap_l x\Delta risk_{it}$ and $Dcap_l x\Delta buf_{it}$ are negative and highly significant. This finding has two possible interpretations (i) lower capitalized banks reduce their risk taking *(capital buffers)* when capital *(risk)* is increased, thereby moving towards their target probability of default in the long run; or alternatively, (ii) banks with capital approaching the regulatory minimum will increase risk taking, gambling for resurrection in order to rebuild their capital buffer. As a consequence, buffers may temporarily fall even further. Both versions are consistent with the capital buffer theory. In contrast, banks with capital buffers substantially above the requirement increase *(reduce)* risk taking when capital increases *(falls)*, thereby maintaining a target probability of regulatory breach as predicted by theory. Our findings with regard to interacted speeds of adjustment confirm those noted under *Specification II.*

With regards to the bank specific variables, q_{it} is consistently highly significant in all

[24] Their findings suggest that BHCs adjust toward their target levels of capital relatively quickly; and that adjustment speeds are faster for poorly capitalized BHCs, but slower (ceteris paribus) for BHCs under severe regulatory pressure.

cases, regardless of the specification adopted. This is in line with predictions made by the capital buffer theory. Banks with a relatively high charter value will hold a larger capital buffer and will have a greater incentive to reduce risk taking. As per the single equations, larger banks will hold less capital and take more risk. The effect of *size* on risk is however, insignificant.

In addition, we note that BHCs will generally rely heavily on retained earnings in order to increase their capital buffers. This is in line with Aggarwal and Jacques (2001) who conduct a similar study for the US, however their sample is limited to commercial banks as well as to a much shorter time frame. Banks with greater expected losses appear to raise their capital buffers to comply with regulatory requirements and to mitigate solvency risk, while banks with higher loan losses, surprisingly, tend to exhibit higher levels of portfolio risk. The coefficients on the $liquidity_{it}$ variables carry the expected signs but are not significant at any level.

The most important findings can be outlined as follows: Short term adjustments in capital and risk are positively related and the relationship appears to be two way ie. large buffer banks maintain a target probability of default through positive adjustments in both capital and risk taking. Small buffer banks on the other hand, reach a target probability of default through negative adjustments. This finding is in line with the notion that banks with capital buffers approaching the regulatory minimum either (i) reduce their risk taking until the target capital level is reached or (ii) increase risk taking as a means to gamble for resurrection consequently reducing the capital buffer even further. Moreover, we find that BHCs adjust their capital buffers towards a target level faster than they adjust their risk. Banks with smaller capital buffers adjust significantly faster than larger buffer banks.

5.4.2 Further Investigation

Our findings above indicate that observed short term capital buffer and risk adjustments is a positive and significant two way relationship throughout the sample period. While these findings are broadly in line with previous research in this field (see Shrieves and Dahl, 1992; Jacques and Nigro, 1997; Aggarwal and Jacques, 2001; Rime, 2001; Heid et al., 2004) the driving force behind this relationship still remains unclear. It is not clear whether simultaneous adjustments in risk and capital is a universally adopted phenomenon among banks in the sample, neither can we be sure whether that relationship remains consistent over time. The remainder of the analysis therefore focuses on determining whether simultaneous adjustments are dependent on institutional characteristics among banks in our sample, and whether or not the relationship uncovered above has varied significantly over time.

Sub sample Approach

The effect that loan loss provisions has on adjustments in capital buffers and risks has largely varied between studies undertaken. One group of authors, (see among others Rime, 2001 and Heid et. al, 2004) are able to uncover only very little significant impact of loan losses on these variables of interest. Other authors, for example Aggerwal and

Jacques (2001), find that US commercial banks with higher loan loss provisions have higher risk weighted assets. Moreover, Peura and Keppo (2006) show that for a sample of US banks between 1983 and 2002[25], those banks with higher than average loan loss provisions have; (i) on average lower expected returns; (ii) on average higher standard deviations in expected returns; (iii) a positive and highly significant correlation between capital levels and the standard deviations of returns. The last observation is important since the standard deviations of returns should be the key parameter driving capital levels in the model. Their analysis suggests that for banks that have suffered below average loan losses, the capital buffer theory seems irrelevant. We test this finding here empirically by splitting our sample into two groups. Those banks with above average loan losses and those with below average loan losses. For each quarter, we take the mean value of loan loss provisions as a threshold and separate the sample accordingly.

Results for estimating equations (5.9.) and (5.10.) by these sub samples are presented in Table 5.7 and 5.8. Empirical results for those banks with above average loan loss provisions are broadly unchanged from the full sample GMM estimations presented above. Here we see that adjustments in capital and risk remain positively related. For banks with lower than average loan losses however, adjustments do not appear to have any significant impact on one another. This is verified through the insignificant coefficients on $\Delta risk_{it}$ in the buffer equation, and on Δbuf_{it} in the risk equation. With respect to the interaction terms, we are able to confirm the findings from our previous estimations. Banks with low buffers of capital appear to adjust their capital towards the target level significantly faster than higher buffer banks. Moreover, the coordination of short term adjustments in capital and risk is dependent on the size of the buffer of capital. Small capital buffer banks rebuild an appropriate capital buffer by raising capital while simultaneously lowering risk. In contrast, larger buffer banks try to maintain their capital buffer by increasing risk when capital increases.

Rolling GMM

Under the GMM approach adopted above, fixed coefficients are estimated so as to capture an average effect that each regressor will have on the dependent variable over the time period analyzed. Here, any changes to economic structure, such as changes in a policy regime etc. will not be captured directly, but rather effects will be averaged out to provide a single estimate over time. During much of the 1990s, (a large portion of the time frame during which we conduct this analysis), the regulatory restrictions imposed on BHC's underwent significant transformation. Basel I was initially introduced in 1990 which, for the first time in history, defined a numerical minimum amount of capital that banks were required to hold. These rules were subsequently amended slightly in 1992. Moreover, the FDIC improvement act came into force in 1991 which included a set of correctative actions that increased the cost of violating the regulatory minimum. Moreover, restrictions on permissible bank activities were removed allowing BHC's to select from a broader array of potential risk exposures. The typical BHC's risk exposure consequently increased, as the diversification effects of new business activities were outweighed by the higher risks

[25] Particularly in the years 1987, 1990, and 1991.

associated with the new lines of business.

In addition, the US economy faced several periods of change in terms of economic growth and prosperity as well the removal of restrictions placed on permissible bank activities, increasing the array of potential risk exposures. Therefore, to capture the changing environment in which BHCs have been operating and to assess the effects on the capital buffer risk relationship, we obtain a set of rolling coefficients for equations (5.9.) and (5.10.). We achieve this by estimating a series of rolling GMM equations over our sample period providing a continuous picture of the buffer risk relationship. We begin with windows of one year, including four time period observations in each window.[26] This gives us one coefficient for each year. These estimations are conducted only on the above average loan loss provision banks.

Results for the buffer and risk equations under *Specification I* are presented in Tables 5.9 and 5.10 respectively.[27] The relationship between risk and capital adjustments appears to have changed significantly over time.

In particular, the relationship between buffer and risk adjustments appears to be driven by the management of shocks to the capital buffer. Banks have consistently maintained their desired probability of default by reducing *(increasing)* risk taking following a negative capital *(positive)* shock. We do however see a slight shift in the relationship in the years directly post regulation. Between 1994 and 1997, we note that a capital shock has a negative impact on the adjustment of risk. Banks with an increase in capital reacted by reducing their risk taking, building up their capital buffers to meet requirements by adjusting their risk taking downwards. This build up of capital is reflected in Figure 5.2.

On the other hand, shocks to risk have started significantly influencing capital buffer adjustments only since 1999. Banks faced with riskier portfolios reacted by simultaneously increasing their capital buffers. Similarly, banks that experienced a decline in portfolio risk reduced their capital buffer in order to maintain their internally defined target probability of default. Interestingly, we do see a change in this relationship too, after 1993. Moreover, in the three years between 1993 and 1997, an increase in risk taking induced a build up of capital. Here it seems that banks tried to build up their capital buffers to new target levels through a positive risk capital strategy. That is, by increasing capital when risk was high, and reducing capital when risks were low. The coefficients of interest are presented in Figure 5.2.

From the time varying analysis conducted, it seems that from around 1999, banks have started to manage an internally optimal probability of default defined as a function of both capital and risk. Several theories can be put forward to try to explain the visibly increased importance that risk adjustments have on capital adjustments. First, the removal of restrictions on permissible bank activities, allowing BHC's to select from a broader array of potential risk exposures,[28] has consequently increased BHC's risk exposures. Moreover, as regulation moves towards becoming more risk sensitive, it is

[26] Both 1986 and 2008 are dropped from the sample since we only have two quarterly observations in each of these years.

[27] We additionally estimate time varying equations for *Specification II* and *II* however, we do not report the results here for the sake of brevity since they are qualitatively unchanged from those observed for the previous estimations.

[28] see Stiroh (2004).

possible that banks merely recognize the increased importance to be placed on managing risk taking.

Robustness

In order to verify the results obtained, several additional robustness tests have been conducted. First, we re-estimate equations (5.9.) and (5.10.), substituting Δbuf_{it} with total capital over total assets (Δcap_{it}). The results are qualitatively unchanged from the findings presented. The only notable difference is the speed of adjustment which appears much slower than the adjustment back to the target buffer level. When Δcap_{it} is estimated as the dependent variable, we find the gap between actual and target capital is closed by around two percent per quarter, when compared to nine percent for the buffer. In this framework, the gap between actual and target risk is closed by around one percent per quarter compared to three percent under the buffer capital framework. The speed of adjustment of Δcap_{it} is therefore still significantly faster than that of $\Delta risk_{it}$, but the difference is not as extreme as in the results presented. Second, we estimate equations (5.9.) and (5.10.), substituting $\Delta risk_{it}$ (Δbuf_{it}) with a lagged $\Delta risk_{it-1}(\Delta buf_{it-1})$. While the effects of the control variables do change somewhat, the sign and the magnitude of the key variables remain unchanged. Third, we experimented with the use of buf as an absolute level, again without qualitative changes to the relationships of key variables. Other tests involved including additional lags of $\Delta risk_{it}$ and Δbuf_{it} in equations (5.9.) and (5.10.) respectively. Furthermore, we adopted different thresholds of low versus high capital. Finally, we introduce a saw tooth in the capital ratios by allowing for the fact that dividend payments are made only every second quarter. This was done by introducing a dummy variable set equal to one when dividends were paid and zero otherwise.

5.5 Discussion

Building an unbalanced panel of US commercial bank and BHC data between 1986 and 2008, this chapter examines the relationship between short term adjustments in bank capital buffers and risk. Controlling for various determinants of capital buffers and risk levels put forward by the theoretical and empirical literature in this field, we find that the relationship appears to be positive and two way during the sample period. Moreover, we show that the management of short term adjustments to capital and risk is dependent on the degree of bank capitalization.

Our results identify a positive and significant relationship between capital buffer and risk adjustments over time. Our findings are broadly in line with the capital buffer theory, predicting that well capitalized banks adjust their buffer capital and risk positively. The relationship is negative for low buffer banks. These results are confirmed by a set of single equations as well as by simultaneous GMM equations. In addition, we note that the management of short term adjustments in capital and risk are dependent on the amount of capital the bank holds in excess of the required minimum. Banks with small capital buffers rebuild an appropriate capital buffer by raising capital while simultaneously lowering risk. In contrast, well capitalized banks maintain their capital buffers by increasing risk when capital increases. Our estimations further indicate that the speed with which banks adjust towards the desired level is also dependent on the size of the buffer. We show that small buffer banks adjust capital buffers significantly faster than their better capitalized counterparts. However, we are unable to find significant evidence of a similar trend for risk adjustment.

By splitting the sample and analyzing banks by degree of loan loss provisions, we show that the buffer theory holds only for high loan loss banks. Capital and risk adjustments for low loan loss banks on the other hand, do not appear to impact one another significantly. In addition, the relationship between capital and risk appears to have changed significantly over time. Shocks to the capital buffer have consistently, positively, affected adjustments in risk. For example, a bank faced with a reduced capital ratio (for example resulting from the recent collapse of the asset backed commercial paper as a source of funding), have reacted with a simultaneous reduction in their risk taking. On the other hand, short term shocks to risk have only really become important for buffer capital adjustments post-1999.

Despite the lack of parameters capturing the return towards the long run equilibrium, our results do provide substantial support for the buffer view that capital is not an exogenous decision, but rather determined simultaneously with internal risk choices. Moreover, we find that the relationship between capital and risk is not stable over time. Rather, it can be driven by either exogenous changes to risk aversion or, by shocks to either capital or to risk opportunities. Both of these underlying factors may have a cyclical component. In economic upturns, banks become more risk loving as they understate their risk relative to the objective measure of risk. Moreover, shocks to either capital or risk can also have a cyclical component, however this should not affect the buffer risk relationship significantly.

5.A Tables and Figures

Figure 5.1: *US BHC Tier One and Total Capital Evolution.*

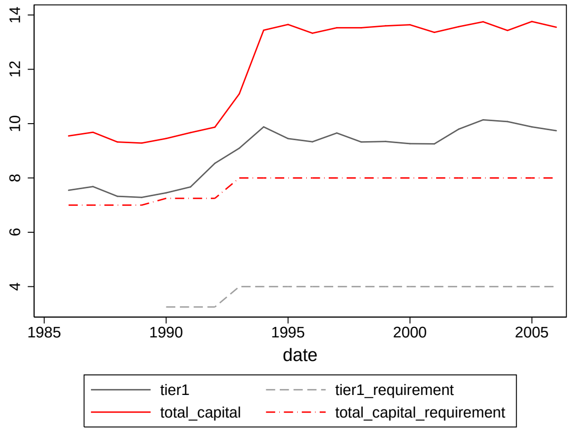


Table 5.1: Variable Descriptions.

		Expected sign	
Variable	Description	Buffer capital equation	Risk equation
Δbuf	Change in the total capital ratio minus regulatory required minimum.		
Δrisk	Change in the weighted sum of assets amounts as defined in Section		
Δrwa/ta	Change in the ratio of risk weighted asets to total assets.		
Δnpl	Change in the ratio of non-performing loans to total loans and credits.		
Δc&iratio	Change in the ratio of commercial and industrial loans to total loans.		
q	Tobins q.	+	-
size	Log of total assets.	ambiguous	ambiguous
roa	Return on assets.	+	
loanloss	Ratio of new provisions to total assets.	+	-
liquidity	Ratio of bond holdings + share holdings + interbank assets to total assets.	-	+
$\mathbf{Dcap}_l$	Dummy variable equal to 1 for low buffer banks and 0 otherwise .	ambiguous	ambiguous
$\mathbf{Dcap}_h$	Dummy variable equal to 1 for high buffer banks and 0 otherwise .	ambiguous	ambiguous

Table 5.2: Correlation Matrix.

	buf	risk	rwa/ta	npl	c&iratio	Δbuf	Δrisk	Δrwa/ta	Δnpl	Δc&iratio
buf	1									
risk	-0.29***	1								
rwa/ta	0.21**	0.42***	1							
npl	0.17**	0.39*	0.33***	1						
c&iratio	0.12**	0.37**	0.29***	0.22***	1					
Δbuf	-0.12***	0.27***	-0.25***	-0.14**	-0.22***	1				
Δrisk	0.34*	0.13***	0.41***	0.41**	0.36***	0.26***	1			
Δrwa/ta	0.25	0.22***	0.43**	0.22**	0.38*	0.19*	0.34*	1		
Δnpl	0.19**	0.19***	0.34**	0.34***	0.24**	0.23***	0.23***	0.38**	1	
Δc&iratio	0.45*	0.25***	-0.44***	-0.33***	0.21***	0.18*	0.19**	0.29**	0.27*	1

Note: *, **, *** denote significance at the ten, five and one percent levels of significance respectively.

Table 5.3: Single Equation GMM: Capital Buffer Equation.

	Model I	*Model II*	*Model III*	*Model IV*	*Model V*	*Model VI*	*Model VII*
buf_{it-1}	0.09 (9.74)***	0.05 (9.56)***	0.04 (12.99)***	0.06 (13.22)***	0.06 (12.96)***	0.07 (10.73)***	0.08 (17.94)***
$\Delta risk_{it}$	0.55 (14.76)***					0.65 (10.11)***	0.55 (12.76)***
$\Delta rwa/ta_{it}$		0.34 (2.98)***			0.27 (1.97)**	0.29 (0.95)	
Δnpl_{it}			0.24 (2.14)**		0.19 (1.95)**		-0.11 (4.87)***
$\Delta c\&iatio_{it}$				-0.28 (2.87)***			
q_{it}	0.34 (1.23)	0.46 (3.23)***	0.34 (2.06)**	0.32 (3.09)***	0.29 (1.98)**	0.39 (2.18)**	0.35 (2.79)***
$size_{it}$	-0.22 (1.10)	-0.35 (1.74)*	-0.29 (0.99)	0.33 (1.06)	-0.34 (1.16)	-0.18 (2.32)**	0.45(0.88)
roa_{it}	0.18 (1.96)**	0.12 (2.11)**	0.16 (3.42)***	0.14 (0.99)	0.12 (2.76)***	0.15 (2.49)**	0.16 (2.01)**
$loanloss_{it}$	-0.43 (1.88)*	0.23 (2.01)**	0.19 (1.93)*	0.22 (0.93)	-0.42 (2.00)**	0.19 (1.14)	0.40 (2.34)**
$liquidity_{it}$	-0.32 (1.99)**	-0.42 (0.09)	-0.33 (0.58)	-0.56 (1.20)	-0.55 (0.73)	-0.45 (1.32)	-0.33 (5.11)***
Sargan	19.87 (1.77)	25.73 (2.89)	54.78 (2.74)	16.79 (1.37)	27.77 (1.66)	31.51 (2.33)	22.06 (2.98)
a(1)	-1.97 (0.00)	-1.02 (0.00)	2.34 (0.00)	-1.43 (0.00)	2.04 (0.00)	-3.22 (0.00)	-1.20 (0.00)
a(2)	-2.01 (0.99)	1.92 (0.83)	1.23 (1.12)	2.65 (0.52)	1.02 (0.23)	-1.05 (0.68)	-1.18 (0.87)

Note: All regressions include bank fixed effects together with a full set of time dummies as control variables (not reported here). Dependent variable is $\Delta \mathrm{buf}_{it}$. Other variables as defined in Table 5.2. t-values presented in parentheses. a(1) and a(2) represent first and second order residual tests. *, **, *** denote significance at the ten, five and one percent levels of significance respectively.

Table 5.4: Single Equation GMM: Risk Equation.

	Model I	*Model II*	*Model III*	*Model IV*
$risk_{it-1}$	0.03 (5.55)***	0.01 (10.34)***	0.02 (9.45)***	0.02 (9.34)***
Δbuf_{it}	0.55 (10.23)***	0.65 (7.04)***	0.48 (5.33)***	-0.77 (1.66)*
q_{it}	-0.44 (4.34)***	-0.61 (2.31)**	-0.34 (2.49)**	-0.48 (6.99)***
$size_{it}$	0.22 (1.02)	0.19 (0.63)	0.21 (1.92)*	0.26 (2.07)**
$loanloss_{it}$	0.14 (1.00)	0.25 (2.28)**	0.24 (3.96)***	0.10 (3.02)***
$liquidity_{it}$	0.19 (0.34)	0.14 (0.41)	0.15 (1.99)**	0.15 (1.73)*
Sargan	15.34 (0.92)	32.34 (0.83)	21.31 (0.79)	12.43 (0.68)
a(1)	-1.32 (0.00)	1.23(0.00)	2.12 (0.00)	2.30 (0.00)
a(2)	1.21 (0.87)	-2.12(0.64)	1.98 (0.92)	-2.34 (0.76)

Note: All regressions include bank fixed effects together with a full set of time dummies as control variables (not reported here). Dependent variable is Δrisk$_{it}$ Δrwa/ta$_{it}$, Δnpl$_{it}$ and Δc&iratio$_{it}$ for Model I, II,III and IV respectively. Other variables as defined in Table 5.2. t-values presented in parentheses. a(1) and a(2) represent first and second order residual tests. *, **, *** denote significance at the ten, five and one percent levels of significance respectively.

Table 5.5: Simultaneous Equation GMM Estimations.

	Specification I		*Specification II*		*Specification III*	
	ceofficient	t-value	coefficient	t-value	coefficient	t-value
	Buffer capital equation					
buf_{it-1}	0.09	(10.87)***				
$Dcap_l \Delta buf_{it-1}$			0.09	(12.87)***	0.08	(7.98)***
$Dcap_h \Delta buf_{it-1}$			0.14	(2.51)**	0.12	(4.87)***
$\Delta risk_{it}$	0.42	(9.54)***	0.35	(8.54)***	0.38	(11.86)***
$Dcap_l \Delta risk_{it}$					-0.15	(2.50)**
$Dcap_h \Delta risk_{it}$					0.50	(7.52)***
q_{it}	0.32	(4.87)***	0.27	(1.72)*	0.42	(3.08)***
$size_{it}$	-0.39	(1.91)*	-0.44	(1.69)*	-0.37	(1.83)*
roa_{it}	0.09	(2.01)**	0.10	(2.19)**	0.09	(1.82)*
$loanloss_{it}$	0.05	(2.47)**	0.12	(2.49)**	0.09	(4.87)***
$liquidity_{it}$	-0.45	(1.42)	-0.37	(1.56)	-0.42	(0.98)
Sargan	27.79	(2.99)	29.78	(3.45)	17.79	(2.87)
a(1)	2.15	(0.00)	1.98	(0.00)	-2.65	(0.00)
a(2)	1.11	(0.54)	2.65	(0.21)	2.88	(1.05)
	Risk equation					
$risk_{it-1}$	0.02	(7.54)***				
$Dcap_l \Delta risk_{it-1}$			0.05	(1.98)**	0.04	(2.03)**
$Dcap_h \Delta risk_{it-1}$			0.06	(3.68)***	0.05	(2.48)**
Δbuf_{it}	0.43	(13.46)***	0.48	(4.27)***	0.51	(12.45)***
$Dcap_l \Delta buf_{it}$					-0.22	(5.24)***
$Dcap_h \Delta buf_{it}$					0.36	(8.35)***
q_{it}	-0.21	(3.98)***	-0.13	(4.98)***	-0.15	(6.87)***
$size_{it}$	0.25	(0.85)	0.26	(1.02)	0.32	(0.84)
$loanloss_{it}$	0.21	(1.75)*	0.15	(1.23)	0.25	(2.47)**
$liquidity_{it}$	0.67	(0.96)	0.47	(1.21)	0.44	(2.52)**
Sargan	26.87	(3.28)	32.15	(3.11)	16.98	(2.55)
a(1)	2.30	(0.00)	-1.98	(0.00)	-2.15	(0.00)
a(2)	-2.05	(1.05)	1.98	(0.98)	1.87	(1.12)

Note: All regressions include bank fixed effects together with a full set of time dummies as control variables (not reported here). Dependent variables are $\Delta \mathrm{buf}_{it}$ and $\Delta \mathrm{risk}_{it}$ for the buffer and risk equations respectively. Other variables as defined in Table 5.2. t-values presented in parentheses. a(1) and a(2) represent first and second order residual tests. *, **, *** denote significance at the ten, five and one percent levels of significance respectively.

Table 5.6: Summary Statistics and Correlations by Sub-Sample.

	Total Sample			*BHCs with above-avg loan loses*			*BHCs with below-avg loan loses*		
	buf	roa	std. dev roa	buf	roa	std. dev roa	buf	roa	std. dev roa
Minimum	2.55	0.00	0.47	3.32	0.00	0.29	2.46	0.00	0.45
Median	6.11	0.03	0.68	5.61	0.04	0.95	6.37	0.98	0.58
Maximum	11.29	0.07	1.11	8.35	0.09	1.01	11.52	0.08	0.86
variable correlations									
	buf	roa	std. dev roa	buf	ROA	std. dev roa	buf	ROA	std. dev roa
buf	1	0.23***	0.19***	1	-0.32***	0.25	1	0.42***	0.10***
roa		1	-0.29***		1	-0.38***		1	-0.23
std. dev roa			1			1			1

Table 5.7: Sub-Sample Estimations: Capital Buffer Equation.

	BHCs with above-avg loan loss provisions			*BHCs with below-avg loan loss provisions*		
	Specification I	*Specification II*	*Specification III*	*Specification I*	*Specification II*	*Specification III*
buf_{it-1}	0.05 (4.87)***			0.09 (1.99)**		
$Dcap_l \Delta buf_{it-1}$		0.05 (9.54)***	0.06 (8.79)***		0.07 (1.24)	0.08(1.92)*
$Dcap_h \Delta buf_{it-1}$		0.10 (4.78)***	0.11 (2.53)**		0.17 (1.35)	0.11 (0.95)
$\Delta risk_{it}$	0.64 (7.87)***			0.35 (0.35)		
$Dcap_l \Delta risk_{it}$		-0.29 (1.69)*	-0.31 (3.15)***		-0.10 (0.95)	-0.32 (1.21)
$Dcap_h \Delta risk_{it}$		0.39 (8.44)***	0.29 (3.05)***		-0.09 (1.24)	0.21 (1.79)*
q_{it}	0.33 (4.80)***	0.39 (5.78)***	0.36 (2.87)***	0.29 (1.84)**	0.30 (1.99)**	0.42 (2.07)**
$size_{it}$	-0.35 (1.54)	0.22 (0.64)	-0.35 (1.97)**	-0.28 (2.98)***	-0.15 (3.12)***	-0.28 (4.15)***
roa_{it}	0.11 (2.01)**	0.14 (1.71)*	0.13 (1.97)**	0.11 (2.05)**	0.14 (1.84)*	0.09 (0.95)
$liquidity_{it}$	-0.34 (1.25)	-0.36 (0.98)	-0.38 (1.06)	-0.35 (1.75)*	-0.40 (1.87)*	-0.52 (2.01)**
Sargan	25.78 (2.98)	15.97 (4.50)	29.87 (3.02)	16.87 (9.78)	29.78 (3.60)	32.55 (5.54)
a(1)	-1.57 (0.00)	1.98 (0.00)	2.36 (0.00)	2.98 (0.00)	2.78 (0.00)	3.05 (0.00)
a(2)	-2.36 (0.97)	1.54 (1.11)	-2.05 (0.85)	1.87 (0.88)	1.78 (1.02)	-2.45 (0.78)

Note: All regressions include bank fixed effects together with a full set of time dummies as control variables (not reported here). Dependent variable in buffer equation is Δbuf_{it}. For the risk equation we make use of Δrisk_{it}. Other variables as defined in Table 5.2. *t*-values presented in parentheses. a(1) and a(2) represent first and second order residual tests. *, **, *** denote significance at the ten, five and one percent levels of significance respectively.

Table 5.8: Sub-Sample Estimations: Risk Equation.

	BHCs with above-avg loan loss provisions			*BHCs with below-avg loan loss provisions*		
	Specification I	*Specification II*	*Specification III*	*Specification I*	*Specification II*	*Specification III*
$risk_{it-1}$	0.03 (7.87)***			0.01 (1.74)*		
$Dcap_l \Delta risk_{it-1}$		0.05 (1.96)**	0.01 (2.50)**		0.04 (1.11)	0.06 (1.52)
$Dcap_h \Delta risk_{it-1}$		0.06 (2.45)***	0.05 (3.23)***		0.07 (1.96)**	0.09 (2.01)**
Δbuf_{it}	0.56 (6.78)**			0.74 (8.62)***		
$Dcap_l \Delta buf_{it-1}$		-0.15 (3.64)***	-0.12 (2.35)**		-0.19 (1.24)	-0.20 (1.97)**
$Dcap_h \Delta buf_{it-1}$		0.30 (2.27)**	0.27 (5.78)***		0.34 (1.23)	0.39 (2.41)**
q_{it}	-0.32 (3.78)***	-0.57 (4.78)***	-0.39 (2.13)**	-0.42 (1.66)*	-0.44 (2.37)**	-0.28 (0.93)
$size_{it}$	0.25 (1.85)*	0.32 (2.25)**	0.19 (1.02)	0.36 (0.88)	0.18 (0.96)	0.29 (1.34)
$liquidity_{it}$	0.21 (1.04)	0.23 (1.15)	0.31 (0.95)	0.32 (1.26)	0.26 (1.96)**	0.23 (1.23)
Sargan	19.87 (2.65)	26.87 (2.68)	27.89 (4.11)	25.69 (2.94)	15.87 (4.87)	19.87 (3.63)
a(1)	-1.25 (0.00)	2.65 (0.00)	1.68 (0.00)	-1.58 (0.00)	2.69 (0.00)	-3.02 (0.00)
a(2)	-1.64 (0.77)	1.47 (0.32)	-1.78 (0.54)	2.02 (0.69)	-1.06 (0.61)	-2.23 (0.94)

Note: All regressions include bank fixed effects together with a full set of time dummies as control variables (not reported here). Dependent variable in buffer equation is Δbuf_{it}. For the risk equation we make use of $\Delta risk_{it}$. Other variables as defined in Table 5.2. t-values presented in parentheses. a(1) and a(2) represent first and second order residual tests. *, **, *** denote significance at the ten, five and one percent levels of significance respectively.

Table 5.9: Time Varying Coefficients Estimation: Capital Buffer Equation (Specification I).

	buf_{it-1}	$\Delta risk_{it}$	q_{it}	$size_{it}$	roa_{it}	$liquidity_{it}$	Sargan	a(1)	a(2)
1987	0.15 (1.02)	0.47 (0.96)	0.42 (1.02)	-0.49 (1.80)*	0.04 (1.34)	-0.23 (1.64)*	32.45 (2.36)	-2.55 (0.00)	-1.98 (1.02)
1988	0.12 (1.64)*	0.63 (0.74)	0.43 (1.73)*	0.32 (1.04)	0.02 (1.23)	-0.32 (1.70)*	27.89 (3.54)	1.25 (0.00)	-2.36 (1.05)
1989	0.14 (0.69)	0.62 (1.20)	0.39 (2.34)**	0.38 (0.84)	0.07 (2.24)**	-0.28 (1.96)**	19.56 (2.98)	-1.23 (0.00)	-2.56 (1.11)
1990	0.13 (1.11)	0.79 (0.83)	0.32 (2.01)**	-0.25 (1.48)	0.10 (1.87)*	-0.24 (1.75)*	32.45 (1.87)	-3.54 (0.00)	3.05 (0.87)
1991	0.12 (1.72)*	0.30 (0.85)	0.34 (1.84)*	-0.22 (1.73)*	0.01 (1.94)*	-0.29 (1.76)*	27.65 (2.69)	-2.00 (0.00)	-2.11 (1.15)
1992	0.11 (1.74)*	0.54 (0.56)	0.49 (2.10)**	-0.19 (0.75)	0.12 (2.23)**	-0.33 (1.67)*	33.33 (2.86)	1.67 (0.00)	-2.08 (0.86)
1993	0.09 (2.00)**	-0.31 (1.06)	0.49 (3.03)***	-0.19 (1.74)*	0.04 (0.64)	-0.03 (1.15)	41.32 (3.05)	-4.03 (0.00)	2.00 (1.67)
1994	0.05 (2.97)***	-0.29 (1.77)*	0.32 (2.39)**	-0.26 (1.89)*	-0.05 (0.79)	-0.21 (1.26)	52.78 (2.89)	3.15 (0.00)	-2.78 (1.14)
1995	0.07 (2.85)***	-0.12 (2.76)***	0.27 (0.85)	-0.25 (1.85)*	0.04 (1.99)**	-0.30 (1.92)*	42.45 (3.05)	-3.21 (0.00)	-2.99 (0.96)
1996	0.06 (1.77)*	-0.13 (1.64)*	0.29 (1.11)	0.23 (0.99)	-0.11 (0.94)	-0.35 (2.00)**	32.12 (4.56)	2.05 (0.00)	-1.69 (0.36)
1997	0.09 (2.76)***	-0.25 (1.96)**	0.36 (2.32)**	0.28 (0.86)	0.08 (1.78)*	-0.29 (1.99)**	19.87 (3.68)	-2.58 (0.00)	-2.45 (1.00)
1998	0.09 (2.13)**	-0.15 (1.03)	0.30 (2.01)**	-0.19 (1.69)*	0.11 (1.95)*	-0.27 (1.65)*	19.87 (3.78)	-2.12 (0.00)	-2.65 (0.96)
1999	0.07 (2.18)**	-0.12 (1.30)	0.32 (3.59)***	-0.31 (2.03)**	0.10 (1.74)*	0.34 (1.79)*	35.69 (5.45)	-3.25 (0.00)	-12.64 (0.61)
2000	0.08 (4.30)***	0.14 (0.39)	0.25 (5.00)***	-0.16 (1.51)	0.08 (2.10)**	-0.18 (0.88)	16.55 (2.14)	-2.54 (0.00)	2.68 (1.06)
2001	0.09 (2.97)***	0.29 (1.95)*	0.37 (4.30)***	-0.18 (1.71)*	0.10 (1.37)	-0.16 (1.86)*	18.66 (6.54)	1.96 (0.00)	-3.02 (1.11)
2002	0.08 (3.12)***	0.44 (2.17)**	0.20 (1.99)**	0.19 (0.99)	0.06 (1.94)*	-0.26 (1.78)*	17.68 (3.25)	2.55 (0.00)	1.25 (0.34)
2003	0.07 (2.94)***	0.36 (4.30)***	0.48 (1.86)*	0.19 (0.67)	0.06 (1.79)*	-0.21 (1.07)	32.56 (4.25)	1.25 (0.00)	-1.26 (0.65)
2004	0.06 (4.12)***	0.30 (5.40)***	0.36 (5.40)***	0.29 (0.22)	0.03 (2.19)**	-0.25 (2.62)***	35.68 (3.36)	2.65 (0.00)	-3.22 (0.87)
2005	0.09 (3.85)***	0.32 (3.11)***	0.30(5.30)***	0.29 (0.75)	0.05 (1.78)*	-0.32 (2.47)**	37.25 (4.87)	2.65 (0.00)	-1.87 (1.19)
2006	0.07 (4.02)***	0.33(1.99)**	0.59 (3.99)***	0.32 (0.84)	0.06 (1.52)	-0.26 (1.09)	16.87 (5.47)	-3.65 (0.00)	-3.25 (1.23)
2007	0.06 (3.13)***	0.43(5.34)***	0.45 (4.23)***	0.31 (0.12)	0.02 (1.82)*	-0.18 (1.98)**	25.65 (3.02)	2.65 (0.00)	-2.56 (0.87)

Note: All regressions include bank fixed effects. Dependent variable is Δbuf_{it}. Other variables as defined in Table 5.2. t-values presented in parentheses. a(1) and a(2) represent first and second order residual tests. *, **, *** denote significance at the ten, five and one percent levels of significance respectively.

Table 5.10: GMM Time Varying Coefficients Estimation: Risk Equation (Specification I).

	$risk_{it-1}$	Δbuf_{it}	q_{it}	$size_{it}$	$liquidity_{it}$	Sargan	a(1)	a(2)
1987	0.02 (2.01)**	0.43 (1.73)*	-0.25 (1.73)*	0.22 (0.96)	0.32 (0.98)	19.64 (3.98)	-1.54 (0.00)	-2.45 (1.06)
1988	0.01 (2.11)**	0.45 (2.23)**	-0.29 (2.11)**	0.15 (0.98)	0.21 (1.86)*	32.15 (4.55)	-3.25 (0.00)	-2.15 (0.96)
1989	0.00 (1.11)	0.46 (3.05)***	-0.23 (1.03)	0.22 (1.06)	0.25 (1.52)	27.89 (3.58)	-2.36 (0.00)	-1.58 (0.86)
1990	0.01 (1.99)**	0.42 (0.95)	-0.27 (1.05)	0.21 (2.11)**	0.27 (1.68)*	19.58 (6.54)	-1.99 (0.00)	2.54 (1.17)
1991	0.04 (3.00)***	0.54 (1.99)**	-0.24 (1.85)*	0.28 (1.64)*	-0.27 (0.85)	35.68 (3.69)	4.12 (0.00)	-2.67 (1.19)
1992	0.03 (2.49)**	0.55 (4.13)***	-0.23 (2.74)***	0.27 (2.27)**	0.26 (0.95)	35.65 (2.98)	1.15 (0.00)	-1.99 (0.98)
1993	0.04 (1.98)**	0.46 (2.06)**	-0.26 (3.11)***	0.27 (1.15)	0.26 (1.23)	36.89 (2.98)	1.59 (0.00)	2.64 (1.00)
1994	0.02 (2.31)**	-0.26 (2.38)**	-0.23 (2.07)**	0.26 (1.09)	0.35 (1.69)*	237.89 (6.25)	-2.13 (0.00)	-2.98 (0.96)
1995	0.03 (1.83)*	-0.27 (4.95)***	0.25 (0.98)	0.29 (1.95)*	0.36 (1.67)*	19.78 (7.86)	-2.21 (0.00)	3.25 (0.96)
1996	0.02 (1.86)*	-0.32 (5.72)***	0.24 (0.74)	0.24 (1.73)*	0.29 (0.94)	26.98 (4.68)	1.56 (0.00)	-1.98 (1.04)
1997	0.03 (4.00)***	0.39 (2.01)**	-0.25 (0.84)	0.32 (2.22)**	0.31 (0.74)	26.56 (2.89)	-2.69 (0.00)	-1.98 (1.22)
1998	0.05 (3.96)***	0.43 (3.63)***	-0.26 (1.20)	0.35 (1.96)**	0.34 (1.85)*	39.68 (6.54)	2.33 (0.00)	-2.36 (0.96)
1999	0.04 (5.93)***	0.47 (2.96)***	-0.28 (1.78)*	0.27 (1.55)	0.37 (1.73)*	35.68 (6.87)	-3.25 (0.00)	-2.11 (0.68)
2000	0.03 (2.99)***	0.53 (1.06)	-0.25 (1.99)**	0.27 (1.64)*	0.34 (2.39)**	52.14 (2.88)	-1.54 (0.00)	-2.56 (1.06)
2001	0.06 (2.38)**	0.55 (6.94)***	-0.25 (2.04)**	0.26 (1.63)	0.26 (3.07)***	19.86 (3.67)	2.65 (0.00)	-1.56 (0.96)
2002	0.04 (1.84)*	0.48 (3.74)***	-0.31 (2.23)**	0.25 (1.13)	0.26 (7.96)***	38.97 (5.64)	1.89 (0.00)	-2.45 (0.67)
2003	0.02 (3.06)***	0.46 (3.85)***	-0.36 (1.85)*	0.14 (1.33)	0.31 (3.97)***	17.89 (3.62)	-1.68 (0.00)	-3.02 (1.01)
2004	0.01 (7.05)***	0.48 (6.00)***	-0.37 (2.00)**	0.19 (1.99)**	0.34 (4.97)***	44.56 (3.68)	-2.69 (0.00)	-2.56 (1.03)
2005	0.03 (6.14)***	0.48 (7.94)***	-0.36 (3.48)***	0.24 (1.74)*	0.38 (8.64)***	56.98 (4.65)	2.68 (0.00)	2.06 (0.86)
2006	0.01 (5.96)***	0.43 (3.07)***	-0.36 (1.97)**	0.25 (2.01)**	0.35 (4.23)***	29.87 (2.78)	1.26 (0.00)	-1.25 (0.73)
2007	0.02 (2.94)***	0.50 (4.33)***	-0.33 (2.50)**	0.26 (1.78)*	0.34 (7.87)***	29.45 (6.45)	4.32 (0.00)	1.26 (0.93)

Note: All regressions include bank fixed effects. Dependent variable is Δrisk_{it}. Other variables as defined in Table 5.2. t-values presented in parentheses. a(1) and a(2) represent first and second order residual tests. *, **, *** denote significance at the ten, five and one percent levels of significance respectively.

Figure 5.2: *Time Varying Coefficients.*

5.B Data Manipulations

5.B.1 Commercial bank dataset

All bank level data is obtained from the Consolidated Report of Condition and Income (referred to as the Call Reports) published by the Federal Reserve Bank of Chicago. Since all insured banks are required to submit Call Report data to the Federal Reserve each quarter we are able to extract income statement and balance sheet data for around 14,000 commercial banks. The dataset spans from $1976Q1 - 2006Q2$.

This particular dataset poses several problems for us to deal with in terms of cleaning the data and obtaining a consistent set of data series. There are several reasons for this. First, through time, definitions change for some of the variables of interest, therefore, looking merely at the Report documentation that that banks are required to fill in is not always sufficient. Therefore it is necessary, on some occasions, to join series together in order to yield sensible series through time. Moreover, most of the large banks only provide data on a consolidated foreign and domestic basis requiring the exploration of which series to use.

RCON vs. RCFD series In general, larger banks only provide data on a consolidated foreign and domestic basis. Therefore, it is necessary to use the $RCFD$ series rather than the $RCON$ series for each variable. For banks that do not have foreign operations however, it is possible to assume that the two series ($RCON$ and $RCFD$) will be identical, although it is necessary to bear in mind that foreign deposits in this case are not available.

The definition for total securities changes several times through our sample. It is therefore necessary for us to combine various individual series through time to create a consistent variable to work with. Prior to 1984, it is not possible to combine all of the items that are now considered as investment securities. We therefore need to approximate the securities variable. Pre-1984 we combine $RCFD0400$ (US Treasury securities), $RCFD0600$ (US Government agency and corporation obligations), $RCFD0900$ (obligations of states & political subdivisions) and $RCFD0380$ (other bonds, stocks and securities). In 1984q1 however, we are able to separately add up the items making up investment securities because a) trading account securities for sale at book value ($RCFD1000$) is replaced by *securities for sale at market value* ($RCFD2146$) and b) there is no guarantee that the securities are held to maturity match across the break in 1984. i.e. there is no guarantee that $RCFD0402$ (securities issued by states and political subdivisions in the US) + $RCFD0421$ (other domestic securities) + $RCFD0413$(foreign securities) = $RCFD0900$ (obligations of states and political subdivisions) + $RCFD0950$(other securities). For the pre and post 1984 series to be consistent, these two summations must be equal. We therefore combine the series $RCFD0390$ (book value of securities) and $RCFD2146$ (assets held in the trading account) for the period 19841 to 1993q4. After this time, $RCFD0390$ (book value of securities) is no longer available. From 1994q1 we therefore proceed by summing up $RCFD1754$ (total securities held to maturity), and $RCFD1773$ (total securities available for sale). Moreover, $RCFD1754$ (total securities held to maturity), and $RCFD1773$ (total securities available for sale) excludes securities held in the trading account, which is part of $RCFD3545$ (total trading assets). We therefore create an additional securities variable (securties2) which is the summation of $RCFD1754$ (total securities held to maturity), $RCFD1773$ (total securities available for sale) and $RCFD2146$ (assets held in trading accounts). We generally make use of the securities2 variable since this eliminates a break in the series in 1993.

For total loans, we again see that there is a break in the series in March 1984. In the third quarter of 1984, the series includes the variable $RCFD2165$ (lease financing receivables). From March 1984 we adopt $RCFD1400$ (total loans & leases, gross) as our total loans variable. Prior to this however, we replace the series with a sum of $RCFD1400$ (total loans & leases) and $RCFD2165$ (lease financing receivables). Similarly for net loans we have $RCFD2122$ (total loans, net of unearned income) for the period between 1984q1 and 2006q2. Prior to this, we again combine $RCFD2122$ (total loans, net of unearned income) with $RCFD2165$ (lease financing receivables).

Commercial and Industrial loans has a change in definition as well. From 1976 until 1984q3, we make use of the $RCFD1600$ (commercial and industrial loans). Here, each bank's own acceptances are included. From 1984q3 however, the series starts to include holdings of bankers' acceptances which are accepted by other banks. We therefore replace this series with a combination of the $RCFD1755$ (acceptances of other banks) and $RCFD1766$ (commercial and industrial loans, other). It remains impossible to create a consistent series here that would exclude banker's acceptances.

A further change in definition occurs with the Fed Funds series. Considering first the Fed Funds Sold series. From 1976 until 2002q1 we are able to make use of $RCFD1350$ (Fed Funds Sold). However, the series discontinues thereafter. We subsequently form a continuation by summing $RCONb987$ (Fed Funds sold in domestic offices) and RCFDb989 (securities purchased under agreement to sell).

Similarly, for Fed Funds Purchased, the series $RCFD2800$ (Fed Funds Purchased) discontinues at the end of 2001. We are then able to replace the series in 2002q2 with $RCFDb993$ (Fed Funds purchased in domestic offices) summed with RCFDb995 (securities sold under agreement to repurchase).

Other issues in the commercial bank dataset In most of the graphical analysis we find a kink in the series in 1997q1. Looking closer at the cause of this disturbance in the data, we find that the number of institutions falls in 1997q1 to 8,648 from 9,772 in 1996q4. The number subsequently rises again in 1997q2 when the number of reporting institutions jumps again to 9,248. Investigating the issue further, we find that there appears to be a fault in the dataset for this period. It seems that information reported for around 800 banks are all returned with 0 values. We therefore correct the data by setting values equal to those of the previous period where data is missing.

Dealing with mergers With respect to the treatment of bank mergers in the data, several possible alternative approaches are considered: *Option 0*: All observations affected by a merger are simply dropped from the sample. Note however,if using any lagged growth rates or differences in the model, this means dropping future observations as well as the observation when the merger takes place. This option is applied by many existing studies in the banking literature (see for example Kashyap and Stein, 2000). *Option 1*: This option is preferable when a large bank acquires a very much smaller bank. Here, all past balance sheet and income observations are rescaled, using a constant ratio, from the beginning of the sample up to the quarter preceding the merger. This ratio is equal to the increase in total assets triggered by the merger. *Option 2*: This option is preferable to Option 1 when two merging banks are of similar size. Here, the merged entities are reconstructed backwards as the sum of the merging banks. In this case a new new bank id, different from any existing id, is created and applied to all subsequent observations.

In this chapter, we adopt a mixture of Options 1 and 2; When merging banks are of different sizes we adopt Option 1 while for a small number of mergers where the merging banks are of similar size, we create a new bank id as per Option 2.

Merging the Commercial and BHC datasets The following steps were undertaken to merge the holding company data with with commercial bank data from the Federal Reserve Bank of Chicago. We start with the commercial bank data set and start by identifying those banks that belong to foreign call family:

1. We start by generating a foreign call identity as follows:

gen fgncall_ind = 0

replace fgncall_ind = 1 if fgncallfamily > 0 & fgncallfamily ˜ = .

We then created a variable called *identifier* which tells us the name of the financial high holder. (this is equal to the rssd9348 variable in the dataset:

gen identifier = high holder $/* = rssd9348 */$

If however, the high holder is a foreign call family, the variable gives the number of it instead:

replace identifier = $fgncallfamily$ if $fgncall\_ind == 1$

2. We then make use of the *identifier* variable to collect holding company data from the BHC data.

By changing the name of $rssd9001$ to identifier in BHC data. Moreover, we drop all observations equal to 0.

3. Finally we merge this dataset back to the commercial bank data. First we copy the commercial bank dataset and the BHC data into the same directory. Opening the commercial bank data, we type the following:

merge $rssd9001$ dateq using BHCpanel, unique sort $update\_merge(\_mergeBHC)$

Chapter 6

Discussion

The work undertaken in this study serves to address some of the key issues that have arisen since the proposal to modify the Basel I regulatory requirement framework.

One of the primary aims of the new accord, Basel II, is to align bank capital more closely with risks inherent in the system at any point in time. Several concerns relating to the potential broader effects that the requirements can have on the economy have however, been raised. One key issue relates to the potential cyclicality effects that could arise from the adoption of the new framework. Due to the closer link between capital and risks, the new requirements will become more dependent on the business cycle, requiring banks to hold larger amounts of capital during economic downturns. Since capital is particularly costly during a recession, banks might be forced to reduce their loan portfolios even further in order to meet rising requirements. As a consequence, the downturn of the cycle is more likely to be accentuated, creating an undesired effect on banking system stability.

Questions regarding the meaningful distinction between disclosure and market discipline have additionally been posed. Regulators have long emphasized market discipline as a means to improve the safety and soundness of the banking system since their inability to effectively discipline financial institutions has been deemed as an important component of several crises over the last decades. However, if banks have already identified an internal disciplining mechanism to curb risk taking and drive capital management, it remains unclear how the third pillar will affect this. In addition, policy makers have become concerned with banks' attitudes towards risk taking under an increasingly risk sensitive regulatory accord. However, if banks already risk adjust their capital levels, more than implied by Basel I, then the new framework may be less harmful than feared. This study serves to answer some of these outstanding questions relating to the possible effect that Basel II might have on the global banking system.

In Chapter 3, we asked whether European bank capital buffers are procyclical under the Basel I framework. We show that comovement between the capital buffers of European banks and the cycle does in fact highlight a cause for concern in this regard. Our estimations indicate that under the Basel I regime, larger banks, notably the commercial and savings banks, have increased capital cushions significantly during economic downturns. Given the countercyclical nature of credit risks, this could be interpreted as evidence of shortsightedness on the part of the banks, such that banks expand their portfolios during economic upturns without anticipating future downturns. Under the Basel I framework, capital requirements remained constant over the cycle. Under the new framework however, requirements will increase during a recession, when more banks are likely to be downgraded than upgraded. The new rules will therefore require banks to increase capital even further in the trough of the cycle, when it is difficult and costly for them to do so.

In Chapter 4, we focused on understanding the long run relationship between bank capital and charter values. We note that a high charter in itself does have a significant disciplining effect on bank capital management. Banks appear to manage capital in such a way so as to protect their valuable charter. Only once their charter value has fallen below a median threshold do banks change their behavior and become significantly more risk loving. Contrary to predictions however, we show that higher charter value banks do not necessarily hold more capital. The existence of government safety nets, or the ease of banks with larger charters to access capital markets might serve as explanations for this finding. Our findings show that adjustments to capital regulations over the years have removed many of the moral hazard incentives from the banking system.

In our final research chapter, Chapter 5, we assessed bank capital management decisions with regard to the simultaneous adjustment of capital and risk. Our results indicate that introducing a more risk sensitive capital regulation (Basel II) is unlikely to affect US bank holding companies to a large extent since they appear to account for the true value of their risk when managing their capital buffers. These findings are in line with the hypothesis that financial institutions throughout the world have been developing frameworks for economic capital management in response to the diversification of banking businesses, rapid progress in financial engineering, and the implementation of Basel II.

In each chapter of this thesis, we acknowledge the endogenous nature of the capital decision of a bank, and assume that banks will define an internally optimal probability of default (a function of risk and capital) to be managed over the long term. Adjustment costs, illiquid markets, as well as consequences of a regulatory breach together affect a banks' internal decision when setting a target capital ratio. Treating capital in this way, we note that it is the amount of capital held above the requirement that determines a banks attitude towards risk. Importantly, this work has shown that excessive risk taking is rarely a consequence of insufficient capital. It is worth noting that the findings documented in each of the three research chapters correspond to capital management under the Basel I framework. There have been two major changes since the time period on which this research was conducted. First, Basel II has since been agreed and is now applied to most banks in Europe. Second, and more importantly, there has been a major global disturbance to the banking industry. While the results presented in this thesis do provide evidence on how banks managed capital and how relationships between key variables looked in the run up to the crisis, the widespread problems associated with the US sub-prime and structured securities have completely changed what were previously stable relationships between bank exposures and risks. Banks worldwide are now struggling to cope with substantial loan losses and write downs, together with ongoing uncertainty about their future business. The management of bank capital in these new and challenging circumstances has to be a subject for future research.

The work undertaken in this thesis has important policy implications for bank regulators and supervisors. Since bank capital management is endogenous by nature, it is essential that regulation is structured in such a way as to evolve with inherent risks and exposures. While the introduction of a more risk sensitive approach to capital management is welcomed at a time of considerable turmoil, the question of whether this will adequately capture unknown risks that are continuously evolving remains to be seen. It is vital to acknowledge the ever changing complexity of the financial system and to capture this aspect in modern day bank regulation.

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