NHH

Bank Regulatory Capital Adjustment

Evidence from Norwegian Savings and Commercial Banks

Per Marius Pettersen

Supervisor: Øivind Anti Nilsen

Master thesis, MSc in Economics and Business Administration,

Financial Economics

NORWEGIAN SCHOOL OF ECONOMICS

Abstract

A growing body of theoretical literature suggests that banks have a target capital structure.[1] This idea is supported by the empirical findings that it exists a large cross sectional variation in regulatory capital ratios and that these ratios often are well above the minimum requirements. Rationalized by a simple cost-benefit analysis, the literature suggests that profit-maximising banks choose a target capital ratio to which they actively adjust over some time period.

This master thesis examines the regulatory capital adjustments of Norwegian banks over the period 1993q1 to 2013q1. Firstly, we analyse the factors contributing to banks' unobservable target capital ratios and the speed at which banks adjust their capital structure. Secondly, we investigate how these adjustments are performed.

We find evidence for capital optimization in terms of the Tier 1 capital ratio. A notable finding is that Norwegian banks face substantial costs of adjusting their capital ratios. On average, Norwegian banks close only 4.1 percent of the gap between their effective capital ratio and target each quarter. Cost of adjusting capital may therefore be an important explanation why they hold capital ratios above the regulatory minimum. Banks' target capital ratio is shown to decrease with bank size. On the other hand, an increase in earnings capacity and managers' perception of risk is shown to increase target capital ratios.

Adjustments towards target capital ratios have significant impact on both assets and capital. Our result indicates that Norwegian banks prefer to fine-tune their risk-weighted assets instead of making real changes to the size of their balance sheet when being away from their target capital ratio. Furthermore, we find that banks are more likely to increase their capital levels when they are below their target capital ratios, than they are to decrease it when they are above.

---

[1] See e.g. Berlin (2011), Berger et al. (2008) or Memmel & Raupach (2010).

Contents

1. Introduction and Motivation

It is well known that the capital structure of banks differ from that of non-financial firms in a number of dimensions. Due to their important role as financial intermediaries, banks have the ability to finance themselves with customer deposits. These deposits are generally insured by deposit guarantee schemes. Some banks have also gained an implicit guarantee of their debt. This may induce them to hold low capital levels. Moreover, banks' approach to managing their capital ratios can have important macroeconomic effects. As emphasised by Adrian and Shin (2010), a negative shock to banks' capital ratios can lead to downward shifts in credit supply, resulting in procyclical effects of bank capital management. Banks are therefore subject to regulatory capital requirements.

But banks' balance sheets displays capital ratios in excess of the regulatory minimum. This does not necessarily mean that they are not capital-constrained at all. Banks are very likely to hold a voluntary buffer over the regulatory minimum requirement in order to reduce the likelihood of supervisory intervention or the need to raise capital on short notice. Moreover, market participants may constrain banks to hold an institution-specific cushion over the regulatory capital level (Lindquist, 2003; Stolz & Wedow, 2005). A growing body of literature therefore suggests that banks chose a target capital ratio to balance the benefits and costs of increasing their capital level (Berlin, 2011; Memmel & Raupach, 2010). The process of capital adjustments towards this target can have important policy implications and should be closely monitored. Banks that have enough regulatory capital may nonetheless have large deviations from their optimal capital targets, which can potentially induce large fluctuations in credit supply.

The present master thesis seeks to analyse the following questions: First, what factors determine banks' internal target capital ratios? Second, how do deviations from these target capital ratios influence banks' actions in terms of adjustments in their capital and asset position?

In a first step, a partial adjustment model is developed in order to estimate the factors contributing to banks' target capital ratios. This step is justified by theory and empirical evidence supporting the idea that banks face capital adjustment costs that preclude them from achieving their desired levels immediately (Berrospide & Edge, 2010; Francis & Osborne, 2009b). Banks try to converge towards an implicit target while maximising their profit. We focus on the Tier 1 capital ratio and estimate banks' implicit targets as well as the speed of

adjustment at which they move towards these targets by using observables from bank balance sheets. The model is estimated on a panel of Norwegian banks over the period 1993q1 to 2013q1. The partial adjustment framework also allows us to compute the deviation between each banks effective and target capital ratio in each period.

In a second step, we investigate how these deviations influence banks capital decisions. Deviations from target capital ratios are likely to be reflected in adjustments to banks' balance sheets. For instance, when banks experience a capital shortfall relative to their target, they can increase the numerator of the capital ratio by issuing new equity or retaining earnings. Alternatively, they can reduce the denominator by slowing down their overall lending growth or seek to reduce their risk-weighted assets by replacing riskier loans with safer ones. By estimating the impact of banks' target capital ratio deviations on the growth in different capital and asset items, we are able to assess how banks perform their adjustments towards their targets.

The master thesis is organized as follows. In the next section we discuss banks choice of capital structure and the capital adjustment process from a theoretical point of view. In section 3 we discuss the basic considerations for bank regulations and present a review of the regulatory frameworks over the period of analysis. In section 4 we extend the discussion on bank capital structure and present a model on banks total adjustments costs. We review relevant literature in section 5 and describe the data in section 6. In section 7 we present and describe the partial adjustment model, and the models of growth in different capital and asset items on a banks balance sheet. In section 8 we discuss econometric methodology and its applications to our dataset. We display and discuss descriptive statistics and results in section 9. Section 10 summarizes and provides some concluding remarks.

2. Bank Capital Structure and Adjustment Decisions

The problem of how firms choose and adjust their capital structure has brought a great deal of attention from corporate financial economists and has been an intense source of debate. In a banking context, the outset of such debate is, among other issues, the question of the relevance of a bank's equity ratio for its total funding costs. This section provides a theoretical background for this question and discusses factors that might affect the ongoing costs of holding equity on a bank's balance sheet. It also discusses how market frictions are likely to affect the costs associated with raising new external equity, and how banks' choices among various strategies for adjustments in equity ratios can have macroeconomic outcomes.

2.1 Does Capital Structure Matter?

Financial firms generally hold less capital than non-financial firms. Spokespersons for the banking industry often assert that a higher reliance on equity will increase banks' funding costs, simply because equity holders require a higher return than debt holders, or equity is more expensive than debt. However, by itself this assertion has no sound basis in corporate finance (Vale, 2011).

One of the most important insights regarding capital structure is the Modigliani and Miller (1958) irrelevance theorem, henceforth MM. It states that the total value of a firm is independent of its capital structure, i.e. of the composition of its liability side. This implies also that the total funding costs of the firm are independent of its liability structure, or in our context that a bank's total financing costs are independent of its equity ratio. The essence of MM`s result is that the required return on equity depends on the equity ratio. Higher equity ratio implies lower volatility of the equity. Since rational pricing implies that a less-risky financial claim commands a lower risk premium, it follows that the required return on equity will fall. In addition, more equity relative to debt means that the debt becomes safer and also requires a lower return. Even if equity always is riskier than debt, MM´s result implies that the effect of the lower risk premiums is just enough to offset the increased weight on the more expensive equity, so that the weighted average funding costs remains constant[2].

However, MM critically depends on a set of ideal and stringent conditions – they include, for instance, no distortionary taxes, symmetric information and no transaction costs. Deviations from these conditions are likely to affect banks as well as non-financial firms.

---

[2] This result is mathematically expressed in appendix A.1

2.1.1 Effects of Debt Guarantee

A special feature of banks is an explicit and implicit guarantee of banks' debt. The existence of such a guarantee implies that bank owners do not have to compensate creditors fully for the risk of the debt. Consequently, the bank may have access to relatively cheap debt funding and can reduce its total funding costs by substituting equity with debt.

The explicit part of the guarantee is a deposit insurance, implemented in order to protect depositors in full, or in part, from losses caused by a bank's inability to pay its debt when due. The Norwegian Banks Guarantee Fund cover deposits in all banks with a head office in Norway up to a total amount of two million Norwegian kroner (Bankenes Sikringsfond, 2013). The implicit part stems from governments' inclinations to save a bank in distress rather than letting the bank fail. Crises in large and interconnected banks usually occur when the economy is in or heading into a recession. Closures of such banks will enhance the economic downturn and is thus something governments will try to avoid. Several banking crises have therefore been resolved by giving banks considered "too big to fail" direct government support. During Norway's banking crisis in the beginning of the 1990s, government capital was injected into failed banks and the existing share capital was written down. In cases where the losses exceeded the existing share capital, the entire capital was written down to zero so that no creditors suffered losses. As creditors might expect the same type of policy response from the government in the future, large banks have gained an implicit guarantee for all its debt (Moe & Vale, 2012).

With the debt guarantee in place, creditors do not have full incentives to monitor the bank and may not require an adequate risk-adjusted return. The banks have thus access to relatively cheap debt funding as long as the guarantor does not require the bank to pay an actuarially fair premium for the guarantee. If the bank either pays a zero premium for the guarantee or a flat premium independent of risk, the guarantee can be considered a subsidy to the banks' owners. Merton (1977) shows that the value of this subsidy can be considered a put option. The value of this put option increases with the level of guaranteed debt and the volatility in total assets. Hence, if a bank either pays a zero or a flat premium, higher debt will increase the value of the subsidy. The existence of such a subsidy might therefore be one reason why bank owners usually prefer low equity ratios in banks (Vale, 2011).

2.1.2 Effects of Taxes and Asymmetric Information

Having established that the existence of debt guarantees might cause bank owners to have a preference for low equity ratios rather than high equity ratios, one cannot rule out that other factors might also affect banks' preferences for a special capital structure. The tax treatment of debt and asymmetric information has implications for the validity of MM.

As for all firms, interest paid by banks on debt is tax-deductible, while dividend payments on equity are not. This feature of the taxation system reduces the cost of debt relative to equity. Other things being equal, a bank can therefore reduce its funding costs by issuing more debt. However, there are different opinions on the tax benefit of debt. In order to determine the actual value of the tax benefit a bank must take into account the taxes at the investor level. Differences in the tax rate on interest income and capital gains from equity have the potential to offset some of the tax advantage from debt. In particular, if the interest income is taxed more heavily than capital gains from equity, the value of the actual tax benefit is reduced (Berk & DeMarzo, 2011). This does not, however, apply for the Norwegian taxation system. The dividend taxation, introduced in 2006, implies that capital is taxed more heavily than debt. The Norwegian taxation system does consequently favour debt (Bøhren, 2013).

In addition to the tax treatment of debt, asymmetric information may cause bank owners to have preferences for high debt ratios rather than high equity ratios. Asymmetric information occurs when one party has more and better information than the other party. Informational asymmetries may be especially severe in banks and cause agency problems. The management's information on strategy and operational activities is likely to be superior of that of the owners. Regulations make it difficult to own more than ten percent of a bank, which means that the distance between ownership and daily control may be large in banks (NOU 2012:2). Moreover, banks' assets are highly liquid and therefore readily marketable. This means that bank owners are better served with high debt ratios. The reason for this is that creditors might be more effective in imposing discipline on bank owners. Small and uncoordinated owners are ineffective in putting pressure on managers to generate cash flows (Bøhren, 2013).

2.1.3 Effects of Costs Associated With Bankruptcy and Financial Distress

The existence of a debt guarantee, distortionary taxes and asymmetric information may be reasons why bank owners usually prefer low equity ratios. However, not everything about banks points towards debt. Costs associated with bankruptcy and financial distress occur

when a bank is expected to have difficulty in meeting its debt obligations and increase as the equity ratio declines. Theories like the "trade-off" theory therefore suggest that a bank must balance the benefits and costs of increasing debt level (Berk & DeMarzo, 2011).

Expected costs of financial distress and bankruptcy are likely to be especially high in the banking industry since it is a highly leveraged industry. The sale of bank loans are, for example, expected to happen at a lower price than the fundamental value because the buyers are less-informed about the quality of the loans. Also, the administrative costs related to bankruptcy are substantial for a bank. However, due to the effects of the debt guarantee, bank owners bear a smaller share of the expected financial distress and bankruptcy costs compared to other industries (Finanstilsynet, 2011).

2.2 Capital Adjustments

In the preceding subsections we have considered factors that make equity capital more expensive to banks than debt finance on an ongoing basis, no matter how the equity comes to be on the balance sheet. Information asymmetries may affect the way banks choose to raise equity or make adjustments to its equity ratios. As pointed out by Kashyap, Stein and Hanson (2010), a bank may be reluctant to raise equity in the market.

A bank that seeks to increase its equity ratio has a number of options available. One set of strategies relates to the numerator of the equity ratio. A bank can increase the numerator by issuing new equity in the market or accumulate equity over time via retained earnings. Issuing equity in the market is likely to be the less-attractive option because the bank can often become subject to frictions in that market. New share issues tend to reduce the market value of the existing bank owners' shares. Myers and Majluf (1984) provide a theoretical explanation for this phenomenon. The management's information about the true value of a firm is likely to be superior of that of outside investors. If the management acts on behalf of the existing shareholders, then a choice to issue new shares will often be interpreted as a negative signal by outside investors. This is because the management will be more inclined to issue new shares in the market when the firm is currently overvalued as opposed to undervalued. There is a typical "lemons problem" in the equity market.[3] Outside investors

---

[3] Akerlof (1970) uses the market for used cars as an example of quality uncertainty. Lemon is a slang term for a car that is found to be defective only after it is bought.

consider the firm is overvalued and are willing to pay less. Hence, the firm`s shares have to be sold at a discount in the issuance.[4]

This reasoning implies that the existing bank owners often will have a preference for increasing equity through retained earnings rather than through issuing new equity. In order to accumulate equity via retained earnings, the bank can seek to decrease the share of profits it pays out in dividend or alternatively boost the profits itself. A way to do so is to increase the spread between the interest rate it charges on loans and the interest rate it pays on its funding. Competitive pressures can make it difficult for one single bank to widen these spreads, but the lending spreads could rise across the system if all banks followed a similar strategy. Reducing overall expenses would also increase the bank's net income (Cohen, 2013).

Hence, the costs specifically associated with issuing new equity in the market can be avoided by an appropriate time period that allows banks to gradually accumulate equity through retained earnings. However, a bank that finds itself in an under- or overleveraged situation may also prefer a second set of strategies that involves changes to the asset side of the bank's balance sheet, i.e. the denominator of the capital ratio. The bank can run down on its loan portfolio, or sell other assets, in order to raise its equity ratio. Furthermore, the bank can seek to reduce its risk-weighted assets, i.e. the denominator of the bank's regulatory equity ratio. Banks are allowed to hold different levels of equity for various assets, based on those particular assets' risk characteristics. Hence, by replacing riskier loans with safer ones, the bank can reduce its risk-weighted assets and consequently increase its regulatory equity ratio.

2.3 The Effects of Bank Capital Adjustments on the Real Economy

One important implication of what we have discussed in the preceding sections is that banks' capital decisions are likely to weigh negatively on the demand and supply of credit when they seek to increase their equity ratios, and positively when they seek to decrease their equity ratios. Firstly, banks will often attempt to pass on higher costs to borrowers through higher loan rates. Hence, to the extent that it is more expensive to finance lending with equity than debt, an increase in banks' capital ratio may dampen the credit demand. Secondly, banks' choices from among the various strategies of capital adjustments will have implications for bank credit supply. For instance, if banks seek to reduce the quantity of their assets in order to increase their equity ratios, they may cut down on lending. Furthermore, instead of reducing

---

[4] Related to our discussion of capital structure, this reasoning implies that firms may not be averse to hold high equity ratios if they can accumulate this equity over time via retained earnings.

the quantity, banks can also reshuffle their risk-weighted assets by substituting risker loans for safer. This may reduce the supply of credit to certain sectors, such as to firms (Norges Bank, 2013). To the extent firms and households are dependent on banks for credit, these capital decisions will have real economic effects.

Theories of financial intermediation investigate whether there are substitutes for bank loans in the financial marketplace, and at what price, and for which sectors these substitute products are available. These theories place a special emphasis on the effects arising from the information problems facing financial markets.[5] Borrowers know more about their use of a loan and their ability to repay than potential lenders. This asymmetric information causes borrowers with better information to use this advantage at the expense of the less-informed lenders. If not controlled, the problems can cause financial markets to function inefficiently and borrowers may find it difficult to obtain financing.

To reduce the problems of asymmetric information, the lender must be able to adequately monitor the borrower, or the borrower must be able to differentiate itself from other possible lower-rated borrowers. The information problems will therefore be less severe for large listed firms that are regularly assessed by international credit-rating agencies and where there is a lot of public information available. Large firms may consequently be able to access open market credit or borrow from non-bank financial intermediaries or other sources (NOU 2000:9, 2000).

Households, and small and medium-size businesses, which are more affected by asymmetric information, rely on banks for credit. Banks are able to reduce the problems of information asymmetry because they have an information advantage in judging borrowers' quality and creditworthiness. This advantage is in part due to the stable long-term relationships that often occur between banks and their clients, which provide banks with the ability to collect intensive information on their borrowers. It is also argued that the important role banks play in the payments system give them more insight into the creditworthiness of potential and existing clients than other financial intermediaries (NOU 2000:9, 2000). Since households and small and medium-size businesses have no access to alternative finance at all, or only at prohibitive costs, the supply of loans by banks is not perfectly substitutable for other funding.

---

[5] The theories of financial intermediation do also place emphasis on the existence of transaction costs. These costs arise due to different preferences of borrowers and lenders with respect to liquidity, denomination, maturity and other parameters of loans. Financial intermediaries reduce these costs.

3. Bank Capital Regulation

The banking system is among the most regulated sectors in the economy. In this section we describe the primary consideration for bank regulation and review the different regulatory frameworks imposed on the banking industry during our sample period.

3.1 The Rationale for Bank Regulation

Banking regulation, in the broadest sense, is justified on the basis of preserving stability in the financial system (Norges Bank, 2004). A well-function financial market is crucial for all other economic activities in a market-based economy. One of the primary functions to the financial system is capital intermediation. That is to transfer resources from savers to investors. Capital intermediation often takes the form of providing credit, which is the key to economic growth. New businesses cannot start without credit, and existing businesses cannot expand without it. Because banks are the primary provider of credit, crisis in the financial system impacts the supply of credit to the broader economy and in turn economic growth. Instability in the financial system will also impede banks ability to perform its other socially useful activities, which the distribution of risk and the provision of a system for payments (Allen, 2013).

3.1.1 Basis of Micro-Prudential Regulation

Banks' clients place deposits and buy products based on the notion that banks manage their funds in a responsible manner. However, individual depositors lack the tools to monitor banks adequately and the hence information to judge the safety and soundness of banks. Not only do the depositors lack the information and tools to assess bank risk, they also lack the incentives to do so as their deposits have become implicitly, or explicitly, insured and guaranteed. The depositors will only focus on expected return and put their deposits into banks providing them with the highest deposit interest rate. The insurance premium banks pay for the deposit guarantee does not reflect their relative riskiness. The result is therefore under-pricing of risk, which may potentially lead bank owners and managers to take on more risk than they otherwise would have done. One important purpose of micro-prudential bank regulation is therefore to protect the interests of small and uninformed investors (Norges Bank, 2004).

Micro-prudential regulation seeks to enhance the safety and soundness of individual banks. However, while banks may appear to be solid individually, the banking system as a whole may be vulnerable. Banking regulation must therefore include a macro-prudential perspective that focuses on the sources of systemic risk.

3.1.2 Basis of Macro-Prudential Regulation

Systemic risk involves the risk that the financial system is no longer capable of performing its tasks in a satisfactory manner. This type of risk can be derived from financial imbalances that build up over time or transmission effects between institutions. In other words, systemic risk has both a time and cross-sectional dimension.

The time dimension relates to the interactions between the financial system and the real economy. The dynamics of the financial system and real economy may reinforce each other over the economic cycle. When asset prices are increasing, credit risk may be perceived as low. Credit growth may then rise and contribute to even higher asset prices. Mutually reinforcing increases in credit and asset prices cumulate in a bubble that reaches its bursting point. The systemic risk increases with the debt-ratios, both within and outside the financial system. As the economic cycle turns, previously unseen risks may materialise and the willingness to take risk may decline, increasing the amplitude of the boom (Caruana, 2010).

The cross-sectional dimension of systemic risk focuses on the distribution of risk in the financial system at a given point in time. It relates to how a may shock increase widely and become systemic through direct and indirect linkages across institutions. Banks are directly exposed to one another, for instance, through settlement and interbank linkages. A shock hitting one bank can therefore easily spread and inflict losses on other institutions that are connected to it (Caruana, 2010). Banks may also share common exposures outside the banking system. Shocks to the financial system or adverse macroeconomic developments may therefore cause banks to suffer substantial losses indirectly. Systemic risk that arises through indirect linkages often becomes evident during a financial crisis. Banks may be forced to sell off assets. The value of these assets will then fall and weaken the balance sheets of other banks holding the same type assets (Olsen, 2013).

Unless each institution internalizes the costs of systemic risk, these institutions will have incentives to take risks that are not just borne by the individual institution, but instead by the society as a whole. Macro-prudential regulation aims to dampen the buildup of systemic risk by introducing instruments that force banks to internalize the costs imposed in the system. (Acharya, 2011). The macro perspective of banking regulation is relatively new. Frameworks for macro-prudential regulation are now being established in a number of countries for the first time (Olsen, 2013).

3.2 Capital Adequacy Requirements and the Basel Accords

Norwegian commercial banks have been subject to capital adequacy regulations since the law on "aktiebanker" in 1924. Originally, banks were required to hold a minimum level of 10 percent capital of their total assets. However, from the beginning of the 1960s to the end of 1980s a liberalization of the capital adequacy regulations took place. Both the minimum requirements and the quality of banks' capital were reduced. The liberalization contributed to a strong growth in credit and house prices, which ended in a banking crisis and a severe economic downturn in the early 1990s (Finanstilsynet, 2013a).

Lessons learned from the banking crisis have played an important role in the development of Norwegian capital adequacy regulations since the beginning of the 1990s. At the same time, the development has been towards greater international harmonization. In 1988 the Basel Committee on Banking Supervision proposed the first guidelines for a regulatory framework based on uniform guidelines. Within a few years, the new capital standards were incorporated into the national regulation of, among others, countries of the European Union (EU). In Norway, the framework is implemented through EU legislation. The EEA-agreement[6] that entered into force in 1994 commits Norway to adopt European Union rules.

3.2.1 Basel I

The aim of the Basel I proposals from 1988 was to preserve stability in the international banking system through harmonized and more stringent rules on capital adequacy. The framework introduced two new concepts: risk-weighted assets and tiers of capital. These concepts account for the fact that not all assets are equally risky and not all types of capital are equally capable of absorbing losses.

3.2.1.1 Risk-Weighted Assets

In a regulatory capital context, requirements are set in relation to the riskiness of assets rather than just the assets themselves. The Basel I accord defined risk weights for different categories of assets and off-balance sheet exposures[7]. The risk weights aim to measure the credit risk associated with a particular category of assets. Credit risk is the risk of losses due to the failure of a bank borrower or counterparty to meets its obligations. More risky categories are assigned a higher weight. In order to get the risk-weighted assets, which is the

---

[6] EEA = European Economic Area
[7] Off-balance sheet exposures or assets include futures, forwards, options etc.

denominator of a bank's regulatory capital ratio, one multiplies these risk weights with the corresponding assets and adds these values together,

$$Risk-Weighted\ Assets_i = \sum_i asset_{i,n} \cdot risk\ weight_n.$$

Thus, the more risky assets a bank holds, the more capital it is required to hold. Under Basel I the risk weight for residential mortgages was 50 percent, while the weight for commercial loans was set to 100 percent. In 1996, the Basel Committee refined the framework to also address market risk, i.e. the risk of losses due to changes in market prices, such as equity prices, interest or exchange rates (Federal Reserve , 2003).

3.2.1.2 Tiers of Capital

Just as all assets are not equally risky, all types of capital are not equally capable of absorbing unexpected losses. The Basel Committee therefore defined capital for regulatory purposes in two tiers. The key element of capital, or the capital of the highest quality, is common equity Tier 1.[8] It consists of common equity after regulatory capital detections. Intangible assets, such as goodwill and deferred taxes are some of the most important capital detections. Supplementary Tier 2 capital consists of subordinated debt and other debt and equity instruments that can be used to cover unexpected losses. Together, the Tier 1 and Tier 2 capital constitutes banks' total capital base. The minimum requirement to the total capital base was set to 8 percent of the value of its risk-weighted assets. The Basel Accord also required a bank's capital base to consist of at least 50 percent common equity Tier 1 capital (BCBS, 1988).

3.2.1.3 Criticism of Basel I

Basel I was an important step forward for banking regulation, but proved to be too simple to address the activities for the most complex banking organizations. The main criticism was directed at the limited differentiations among degrees of risk. Basel I defined only four broad risk weightings, for example, 100 percent for commercial loans. However, assets assigned the same risk weight could vary greatly in credit quality. This means that the calculated capital ratios often were uninformative and gave misleading information on a bank's capital adequacy relative to its risk (Federal Reserve , 2003). Furthermore, the limited differentiation among degrees of risk enabled banks with a high appetite for risk to shift their loan portfolio

---

[8]Common equity Tier 1 was originally only referred to as Tier 1 capital. However, under Basel II the definition of Tier 1 was expanded to also include subordinated debt. Common equity Tier 1 is today referred to as CET1. We return to this in the section on Basel II.

towards high-risk borrowers, and boost their profits in the short run, without this resulting in more stringent requirements. By the end of the 1990s, Basel I was seen as having outlived its usefulness (Finanstilsynet, 2013a).

3.2.2 Basel II

In response to the criticism of Basel I, the Basel Committee decided in 1999 to propose a new, more comprehensive capital standard. Basel II entered into force in 2007 and is built on three mutually reinforcing elements, or "pillars".

3.2.2.1 The Pillars

The first pillar addresses the minimum capital requirements. The minimum required Tier 1 and total capital ratio did not change from Basel I.[9] However, Basel II made substantial changes to the methodologies for determining a bank's risk-weighted assets in order to make the minimum capital requirements more sensitive to the bank's risk profile. While Basel I offered a single approach for determining required capital to cover credit risk, Basel II offered banks a choice between the standardised approach and the internal ratings-based (IRB) approach. The standardised approach is similar to Basel I in that the capital requirement is determined by categorising and weighing a bank's assets according to fixed risk weights set by the regulator. However, Basel II introduced more risk weights and the use of external credit rating to evaluate corporate risk exposures. The IRB approach encourages banks to create their own internal system to calculate the required capital to cover credit risk. Under the IRB approach each bank must evaluate its assets in terms of the most important elements of credit risk. These elements are probability of default during a given period, the likely size of the loss given default, the amount of exposure at default, and the effective maturity of the exposure. IRB banks use a formula stated by the regulator to calculate the risk weights. The formula is a function of the elements of credit risk. In addition to the modified treatment of credit risk, Basel II introduced capital requirements for operational risk to adequately guard against failure in internal processes, the decision-making of individuals, systems, and other external events (Federal Reserve , 2003).

The second pillar addresses supervisory oversight. It requires banks to make a comprehensive assessment for themselves of the whole spectrum of risk they might face, including those not captured in Pillar 1. It promotes the notion that banks should seek to perform for themselves a comprehensive assessment of whether they have sufficient capital to support their risk profile,

---

[9] Tier 1 must be equal at least 4 % and total capital at least 8% of the risk-wighted assets.

rather than simple compliance with minimum capital requirements. Furthermore, Pillar II gives supervisors discretion to create a buffer capital requirement over the minimum requirement as calculated in Pillar 1, if banks are seen to be avoiding the capital adequacy goals of the Basel Accord.

The third pillar is designed to increase market discipline by requiring banks to publicly disclose information on their risk management and risk distribution. This information includes statistics on the aggregate amounts of Tier 1 and Tier 2 capital, risk-weighted capital ratios, market and operational risk.

3.2.2.2 Criticism of Basel II

An important criticism of Basel II is its possible pro-cyclical effect on economic activity. Under the IRB approach, capital requirements are an increasing function of the banks estimates of the probabilities of default, and losses, given default of their loans and other assets. These inputs are likely to be higher in downturns and lower in upturns. Thus, during an economic downturn banks may fall under the required regulatory capital, which may induce them to contract the supply of credit, thereby amplifying the economic cycle. Conversely, during an economic upturn the decrease in capital requirements may induce banks to expand the supply of credit, which may fuel a credit-led boom (Andersen, 2009).

The determination of capital requirements under Basel II has been subject to further criticism. The IRB approach provided banks with incentives to improve their risk management because banks eligible for this approach could expect lower capital requirements than those who used the standardised approach. One important precondition was, however, that Basel II not should cause the aggregate level of regulatory capital in the banking system to decrease significantly. Supervisory oversight and a sounder basis for market discipline were intended to prevent this. Nevertheless, the transition from Basel I to Basel II led to a marked decline in capital requirements for large banks. Since the average risk weights under Basel II have declined, the difference between reported capital adequacy ratios and unweighted capital ratios have increased (Syvertsen, 2012).

The financial crisis that took hold of financial markets around the globe in 2007-2008 revealed weaknesses in the approach that had been developed under Basel II. Banks' capital adequacy was not sufficient to cover the losses that occurred. Basel II did not adequately anticipate sources of risk, such as a collapse in market liquidity or deep losses in the market value of securities held by banks. The crisis also showed the need to address systemwide risk

that can build up across banks as well as the pro-cyclical amplifications of these risks over time. In the light of the experiences, the Basel Committee put forward new recommendations on stricter capital regulations in 2010 (BCBS, 2010).

3.2.3 Basel III and CRD IV

In Europe, the Basel III standard is reflected in the new Capital Requirements Directive IV (CRD IV). This will apply to Norway under the EEA agreement. The phase-in started summer of 2013 and will continue until summer of 2016. CRD IV contains new rules that increase the quality and quantity of a bank's capital. The minimum required total capital ratio will still be 8 percent, but a larger proportion of this has to be of the highest-quality capital – CET1. This proportion must be at least 4.5 percent of the risk-weighted assets, while Tier 1 capital must be at least 6 percent. Tier 1 capital includes certain forms for hybrid-capital. The aim of increasing the requirements for capital of highest quality is to bring banks' loss-absorbing capacity more in line with their actual risk (European Commission, 2013).

The new regulatory framework introduces additional capital buffers that banks are required to hold on top of the minimum capital requirements. The capital conservation buffer must consist of 2.5 percent CET1 capital and is, as the name indicates, intended to conserve capital. CRD IV also introduces a systemic risk buffer in order to prevent and mitigate long-term systemic or macroprudential risks. Currently, Norwegian banks must hold a systemic risk buffer of 2 percent CET1, but the buffer requirement will increase to 3 percent in July 2016. On top of that, systemically important banks must hold a buffer of 1 percent. This requirement will increase to 2 percent in July 2016. Failure to meet the capital buffer requirements will imply constraints on distributions on dividends and repurchase of its own shares. The conservation buffer and capital buffers for systemic risk and systemic importance will be permanent add-ons.

3.2.3.1 Countercyclical Capital Buffer

Another key element, proposed in Basel III and reflected in CRD IV, is the countercyclical capital buffer. The aim of the countercyclical capital buffer is to strengthen banks' resilience to an economic downturn and to counter the pro-cyclical effects of banks' credit supply that may reinforce the economic cycle. It is a time-varying requirement and will normally be between zero and 2.5 percent of a bank's risk-weighted assets. In economic upturns, when credit growth is high, the requirement will increase. This may increase banks' funding costs and consequently reduce their supply of credit. When the economic cycle turns, the

requirement may be released in order to allow banks to draw on the capital buffer in the event of large losses. This may induce banks to reduce their lending less than they otherwise would have done (European Commission, 2013).

Norges Bank will provide The Norwegian Ministry of Finance with advice on the level of the countercyclical buffer. The setting is going to be explained and announced four times a year. Based on the purpose of the countercyclical buffer, Norges Bank has formulated three criteria for setting the appropriate buffer rate:

1) *"Banks should become more resilient during an upturn."*
2) *"The size of the buffer must also be viewed in the light of other requirements applying to banks."*
3) *"Stress in the financial system should be alleviated."*

Norges Bank`s advice on the buffer rate will primarily be based on four key indicators, found useful in theoretical and empirical literature in signaling the buildup of financial imbalances. The indicators are as follows:

a) The ratio of total credit[10] to mainland GDP.
b) The ratio of house prices to household disposable income.
c) Commercial property prices.
d) The wholesale funding ratio of Norwegian credit institutions.

As the basis of its advice, Norges Bank will perform comprehensive assessments of the development in these indicators and compare historical trends and averages to the current situation (Norges Bank, 2013).

---

[10] C2 households and C3 enterprises mainland Norway.

4. Defining a Bank Capital Target

Debt guarantees, distortionary taxes and asymmetric information cause bank owners to have a preference for low equity ratios. Indeed, based on traditional moral hazard theory, several theoretical models on bank capital structure therefore predict that banks want to hold less capital than what is required by the regulatory authorities (Keeley, 1990; Marshall & Prescott, 2000). These predictions imply that a bank will set its capital ratio at the lowest level permitted by capital regulations. Moreover, they suggests that there should be little variation in capital levels across banks and over time, since the Basel regulatory regime prescribes a uniform capital ratio. However, banks' balance sheets displays a large variation in capital ratios, well in excess of the minimum required. In the following we extend our discussion in section 2 and provide some possible explanations to the observed capital levels among banks. Furthermore, we propose a simple derivation of a model that shows us that a profit-maximising bank's choice of capital level can be understood as an adjustment cost story with costs/benefits to deviate from an optimal level.

4.1 What Do We Know About Banks` Target Capital?

Academic studies argue that banks hold capital in excess of the regulatory minimum in order to reduce the likelihood of a regulatory intervention or the need to raise capital or reduce assets at short notice (Lindquist, 2003; Stolz & Wedow, 2005; Berger, DeYoung, Flannery, Lee, & Öztekin, 2008). When a bank experiences an unexpected decrease in its capital ratio, close to or below the required minimum, the bank become subject to supervisory intervention, which in turn implies costs that decrease the value of the bank. Furthermore, adjustments to the capital ratio bear both direct and indirect costs, i.e. issuing new shares may be interpreted as a signal that the shares are overvalued. Hence, excess capital may act as an insurance that lower failure costs due to a decrease in the probability of failure. As Lindquist (2003) points out, the price and the value of this insurance are likely to affect the level of capital held by banks. The price will affect capital negatively. The value of the insurance depends on the risk embedded in the bank's assets, i.e. the probability of experiencing unexpected losses, and should vary positively with capital.

A high capital ratio may also be interpreted as a signal of the bank's low probability of failure and work as an instrument, which the bank is willing to pay for in the competition for uninsured deposits and money market funding (Lindquist, 2003). Uninsured depositors compensate for bank risk by demanding a higher return. A bank may therefore have

incentives to reduce its risk and hence the costs of funding by holding relatively high capital ratios. The relevance of this argument depends on the extent of the governmental debt guarantee, the bank's share of uninsured liabilities and how well the creditors are the able to observe the bank's risk behaviour. Thus, the first factor reduces the banks incentives to hold excess capital, but the other factors encourage it to limit the risk of insolvency by increasing the capital ratio (Tabak, Noronha, & Cajueiro, 2011). Furthermore, a well-capitalized bank may be in a better position to obtain funds quickly. As argued by Jokipii and Milne (2008), this may improve a bank's ability to exploit unexpected investment opportunities. In the case of a sudden increase in loan demand, a poorly capitalized bank with difficulties in raising capital and additional funds on a very short notice may lose market share to its well-capitalized competitors.

Alfton et al. (2005) argue that larger banks may be less liquidity-constrained and have smaller costs in adjusting their capital ratios. Hence, there may be a negative relationship between bank size and capital as large banks can issue more capital and debt on demand rather than holding substantial amounts of excess capital. This negative relationship may also have alternative explanations. Unexpected losses may be due to information asymmetries in the lender-borrower relationship. As argued by Lindquist (2003), the risk-management techniques of large banks may be more developed than those of smaller banks. Economies of scale in screening and monitoring borrowers provide large banks with advantages in measuring risk involved in each project they lend money to. Thus, they require less capital as insurance against failure. Moreover, if portfolio diversification increases with bank size, larger banks are likely to face a lower probability of experiencing a large drop in the capital ratio. Another argument for the negative size effect is related to the "too-big-to-fail" hypothesis. There is a higher probability that larger banks will be bailed out by the government in the case of financial distress, due to potential systemic effects. Hence, if this kind of support is not expected to the same extent by small banks, large banks are likely to target a relatively lower capital ratio.

4.2 A Model of Capital Adjustment

A profit-maximizing bank may want to reach a target capital ratio. If the bank is over-capitalized, i.e. holds a higher capital ratio than its target, the bank faces an opportunity cost. It can reduce its total funding costs by reducing its capital level because equity is more expensive than debt. If the bank is under-capitalized, i.e. has a capital deficit with respect to its target, it may face both supervisory and market constraints. This translates into higher

uncertainty and higher interest on debt. The bank may thus have incentives to raise its equity levels.

However, as explained earlier, the bank also faces costs in adjusting its capital ratio. Profit-maximising banks will consequently try to minimize the sum of these two types of costs. A simple model of banks' total costs related to capital adjustment can be considered in order to understand the key mechanism at stake. If we assume that the costs of deviations from target capital ratio and the costs of capita adjustments are both quadratic and additive, the banks' total adjustments costs can be expressed as:

$$C_{i,t} = \alpha(k_{i,t}^* - k_{i,t-1})^2 + \gamma(k_{i,t} - k_{i,t-1})^2, \qquad (2)$$

where $C_{i,t}$ is the total cost capital adjustments. The first term in equation 2 reflect costs associated with deviations between the target capital ratio $k_{i,t}^*$ and the actual capital ratio $k_{i,t-1}$. The weight on the costs of this deviation is captured by α. The second term reflects the costs of capital ratio adjustments, with the corresponding weight γ. In order to minimize C_t with respect to $k_{i,t}$, we derive the first order condition:

$$\frac{\partial c_{i,t}}{\partial k_{i,t}} = \alpha 2(k_{i,t}^* - k_{i,t-1}) + \gamma 2(k_{i,t} - k_{i,t-1}) = 0,$$

or

$$k_{i,t} - k_{i,t-1} = \frac{\alpha}{(\alpha+\gamma)}(k_{i,t}^* - k_{i,t-1}). \qquad (2)$$

Equation 2 is a partial adjustment equation in the case of a profit-maximising bank. In each period *t,* a bank *i* tries to close a proportion $\alpha/(\alpha + \gamma)$ of the deviation between its target capital ratio at time *t* and its actual capital ratio in time *t-1* (Dang, Garrett, & Nguyen, 2012). This proportion is often referred to as the adjustment speed, which increases with α and decreases with γ. That is to say, the higher weight on the costs associated with deviations from the target capital ratio, the faster the convergence towards the target capital ratio, and the higher weight on costs associated with capital adjustments, the slower convergence towards the target capital ratio.

5. Other Relevant Literature

This master thesis relates to the empirical literature on the determinants of optimal capital structure and how fast firms (banks) can adjust towards this optimal level. Using a partial adjustment model, a large stand of this literature indicates that firms do have entity-specific targets for their capital structures and speed of adjustments towards these. For instance, Flannery and Rangan (2006) find in their well-known study that a typical firm closes over 30 percent of the gap between its target and its actual debt ratio each year. Berger et al. (2008) focus on the capital structure of US banks and finds that they on average close between 28 percent and 41 percent of the gap between its actual and its desired capital ratio in one year. Further, that poorly capitalized banks tend to adjust their capital ratio more quickly than their better-capitalized competitors. Banks that record high volatility in their return on assets tend to have higher capital ratios. The authors also find that optimal capital structure depend on bank size. Smaller banks tend to have higher optimal capital ratios than larger institutions. In their study of German banks, Memmel and Rupach (2010) show that corporate banks as well as banks with a high share of liquid assets adjust to their capital level more quickly. The authors also find that the target capital ratio increases with asset volatility and decreases with the speed of adjustment. Brewer et al. (2008) studies capital ratios across countries by modeling capital structure as a function of important country-level public policy and bank regulatory characteristics, as well as of bank-specific variables and macroeconomic conditions. The results indicate that the bank-desired level of capital increases with risk. Banks maintain higher capital ratios in countries where the banking industry is relatively small and in countries with effective regulatory frameworks that prompt corrective actions and good corporate governance.

The papers mentioned above study the determinants and speed of adjustments towards optimal capital structures. Of similar importance is how banks adjust towards these. Maurin and Toivanen (2012) investigate how banks in the Euro area react to a deviation from their target capital ratio in terms of adjustments in their asset composition. Their results suggest that the adjustment towards the target has significant effect on banks' assets. Moreover, the impact on the composition of security holdings is greater than the impact on the composition of loans. Kok and Schepens (2013) accounts for the fact that banks' reaction may be asymmetric, depending on whether they are above or below their target. They find that European banks prefer to increase equity levels or reshuffle risk-weighted assets without making any real changes to the total assets when they are above their target Tier 1 capital

ratio. On the other hand, when below the target, banks prefer to reshuffle assets or increase their assets holding in order to adjust towards the target again.

Francis and Osborne (2009a) study how deviations from optimal capital levels affect the growth in different balance-sheet components, while especially focusing on the impact of bank-specific capital requirements. The authors find that banks with capital surplus tend to have higher growth in loans and other on- and off-balance sheet assets than those with capital shortfall. At the same time, they find that banks with capital surplus have lower growth in regulatory capital and Tier 1 capital. Based on these finding, they argue that tighter regulatory standards may have cost in terms of reduced loan supply.

Several other papers within this literature focus on how the target capital deviation affects lending. Hancock and Wilcox (1994) show that bank lending was restrained by capital shortfalls relative to internal targets during the 1990s. The authors indicate that some of the banks reduced lending to satisfy higher capital requirements implied by the introduction of Basel I. However, of similar importance, they find that the shortfall of bank capital below their own target level was a limiting factor on banks' credit flow. Berrospide and Edge (2010) studied how the capital ratios of US banks impact the growth in their credit flow. They find that changes in bank capitalization have a very modest effect on bank lending. Their results suggest that factors like economic activity and perceived macroeconomic uncertainty play the most important role in determining total loan growth.

6. Data

We estimate our models by using quarterly panel data on Norwegian banks between 1993Q1 and 2013Q1. The data are provided by Norges Bank and has their origin in quarterly financial statements that all banks are obliged to report (ORBOF). We have access to data back to 1991Q1, but have chosen not to apply data before 1993Q1 due to the 1988-1992 banking crisis in Norway. During this period, banks' capital was subject to large disturbances due to substantial loan losses and capital injections from the Government Bank Insurance Fund and other governmental programs (Vale, 2004). Including these years in our sample might distort our findings.

To adjust the data for mergers and acquisitions (M&A), we create a new bank after such events[11]. The motivation for creating a new bank is to capture the possible change in the unobserved heterogeneity of the acquiring bank. Bank-specific factors such as management, group of clients and the mix of markets in which the banks operate may be different in the post-merger period. Information provided by The Norwegian Saving Banks Association and Finance Norway (FNO) on the structural developments in the Norwegian banking industry was used to identify M&A activity.[12] We further adjust for structural changes in banks that may not be captured by the identification of M&A activity by creating a new bank whenever both capital and assets fall or rise more than 50 percent.

We make adjustments to our dataset in order to reduce the influence of missing and extreme values. We exclude observations where total assets and risk-weighted assets are missing. This leads to a fall of 793 observations. The drop is mainly due to missing values of risk-weighted assets on Norwegian-registered foreign banks (NUFs), which are not obliged to report information of their capital adequacy. In addition we exclude observations where key variables to construct our explanatory variables are missing.

Extreme values will not add value to our analysis. Hence, variables that contain observations that with reasonable certainty can be deemed extreme, by investigating their distribution, are winsorized. Subtracting the 75% percentile value from the 25% percentile value, then adding this value to the median of the distribution provides us with the cutoff points. Observations outside this interval are excluded. Finally, we drop banks with less than 10 consecutive

---

[11] Alternatively, we could include a dummy variable equal one for the acquirer in the quarter of the merger and zero otherwise. However, by this approach we would assume that the unobserved idiosyncratic factors affecting banks optimal target to be the same in the post-merger period as in the pre-merger period.
[12] Information on structural development and mergers, see The Norwegian Savings Banks Association (2013) for saving banks and Finance Norway (FNO) (2013) for commercial banks.

observations for econometric purpose. This leaves us with an unbalanced panel with 8707 observations of 132 savings banks and 20 commercial banks. Data on macroeconomic indicators and central bank policy are provided by Statistics Norway (SSB). We do not make any adjustments to these data.

7. Empirical Strategy

In this section we present our empirical strategy. We describe the empirical approach we use to estimate banks' implicit target capital ratios and to estimate and assess how they move towards these targets. Our approach draws on Francis and Osborne (2009a), and Kok and Schepens (2013). It involves three steps. In the first step we specify and estimate a partial adjustment model of bank capital. This step is justified by theory and empirical evidence that banks face rigidities and adjustment costs that may prevent them from making instantaneous capital adjustment. The model allows us to investigate banks-specific determinants of the implicit target capital ratios, and the speed with which they adjust towards them. In the second step we use the estimated parameters from this model to derive each bank's long-run capital target and calculate the deviations from it in each period in time. Finally, we use the measure of these deviations to estimate models of capital and asset growth to assess how banks move towards their long-run target capital ratios.

7.1 Estimating the Bank Capital Targets

We begin our empirical analysis by estimating a model of the factors that govern banks capital choices. A bank's capital ratio is likely to fluctuate around an unobserved target. At each time period *t*, the bank observes the deviation from its target at the end of period *t-1* and takes action to close this gap during the next period *t*. Deviations from the target capital ratio impose some costs to the bank, for example, by increasing its funding costs. On the other hand, adjustments in the capital ratio may also be costly due to market frictions and asymmetric information. Banks more or less rapidly adjust towards their target depending on this cost-benefit analysis (Duprey & Lé, 2014). As we do not observe the capital ratio target, we have to approximate it. We estimate the target as a linear combination of some important factors affecting the capital ratio, bank-fixed effects and time-fixed effects. As suggested by the model (see equation 2) we estimate banks' capital ratios in a partial adjustment framework.

$$k_{i,t} - k_{i,t-1} = \lambda\left(k_{i,t}^* - k_{i,t-1}\right) \tag{3}$$

Equation 3 is a partial adjustment model where $k_{i,t}$ denotes the capital ratio of bank *i* at time *t* and $k_{i,t}^*$ the corresponding target capital ratio. The model specifies that at each period *t* the

bank tries to close a proportion λ[13] of the deviation between the target capital ratio in period t and the actual capital ratio in t-1. In this symmetric partial adjustment model, the speed of adjustment is assumed to be identical across banks. In a frictionless world, a bank would always be able to maintain its target capital ratio at any point in time. In that case, λ would be equal to one. However, the positive cost of capital adjustment precludes immediate adjustments to a bank's target capital ratio (Verbeek, 2012). A high λ would thus indicate substantial adjustments costs and a rather passive management of the capital ratio.

Assuming that the target capital ratio can be correctly approximated by some observable characteristics of banks, as well as by a bank-specific time invariant and unobserved component η_i and a constant δ_0, we specify the target capital ratio as follows:

$$k_{i,t}^* = \delta_0 + \sum_{n=1}^{N} \beta_n x_{n,i,t-1} + \eta_i. \tag{4}$$

The target capital ratio depends on n observable and bank specific I factors x at time t-1. This makes sense because the change in the capital ratio occurring during the quarter t depends on the factors observed at the end of quarter t-1. By substituting equation (1) into equation (4), rearranging and adding a well-behaved error term $u_{i,t}$, we obtain the partial adjustment model in its full form:

$$k_{i,t} = (1 - \lambda)k_{i,t-1} + \lambda\left(\delta_0 + \sum_{n=1}^{N} \beta_n x_{n,i,t-1} + \eta_i\right) + u_{i,t}, \tag{5}$$

Based on equation (5), our estimated specification of the partial adjustment model takes the following form:

$$k_{i,t} = \pi_0 + \pi_1 k_{i,t-1} + \sum_{n=1}^{N} \pi_n x_{n,i,t-1} + \alpha_i + u_{i,t}, \tag{6}$$

where the π_0 is a constant term equal to $\lambda\delta_0$, the parameter π_1 corresponds to $(1 - \lambda)$, and π_n to π_N represents the parameters of the vector $x_{n,i,t-1}$, and is equal $\lambda\beta_n$ to $\lambda\beta_N$. Finally, α_i represent the bank-fixed effects and corresponds to $\lambda\eta_i$ in equation (5).

---

[13] This proportion λ is equal to $\alpha/(\alpha + \gamma)$ as defined in equation 2. Hence, λ increase with the weight on the costs associated with deviations from the target capital ratio (α) and decrease with the weight on costs associated with capital adjustments.

We approximate the target capital ratio based on a restricted but important set of observables from banks' balance sheets ($x_{n,i,t-1}$). In line with our discussion of factors affecting a bank's capital ratio, we include proxies for bank size, risk and market discipline. The proxy for bank size (*SIZE)* is calculated by taking the logarithm of total assets. The expected sign of the coefficient is expected to be negative.

Another key determinant of bank capital decisions is the expected cost of failure, which depends on the risk profile of the bank. In general, increasing risk level would require a higher level of capital. A positive relationship between optimal capital ratios and risk level may therefore reflect a market discipline effect as banks attempt to mitigate the impact of market reactions on, e.g. their funding costs or access to capital market activities. However, moral hazard behavior of banks may cause this relationship to be negative, as regulations and guarantees, such as the deposit insurance system, can increase the risk appetite of banks. Following Francis and Osborne (2009b) we control for the cost of failure by incorporating an ex-post measure of risk, calculated as the ratio of risk-weighted assets to total assets (*RISK*). Increasing value of this measure implies increasing risk and consequently increasing cost of failure. This ratio will have a value of zero if all assets are zero-weighted and one if all assets are 100 percent weighted. It may in rare cases exceed one for banks with substantial off-balance sheet activities. Since *RISK* can be thought of as a regulatory measure of risk, we also include the ratio of loan loss provisions to total assets (*PROV*) to proxy for banks' internal view of the risk embedded in its asset portfolio. Hence, it may be more in line with the banks own perception of risk. Again, relatively higher ratios suggest more risk.

The profitability of banks should also exert some influence on bank capital decisions. From the insurance against falling below the minimum requirement perspective, banks may substitute high capital ratios with high levels of earnings. However, this is a highly uncertain option if earnings are highly variable. The probability of falling below the minimum requirement is therefore assumed to increase with the variance of profits. To measure the value of the insurance, we include the standard deviation of return on asset (*STDROA*). The standard deviation is calculated based on the eight preceding quarters. We expect the value of the insurance, and hence the capital ratio, to vary positively with *STDROA*. Furthermore, holding capital above the minimum requirement implies direct costs of remunerating. Ayuso et al. (2004) and Francis and Osborne (2009a) use each institution's return on equity (*ROE*) to proxy the alternative cost of capital. In this context one would expect a negative relationship between the return on equity and the target capital ratio, as a bank's incentives to hold a

capital ratio above the required minimum depend on costs of holding excess capital. However, as stressed by Jokipii and Milne (2008) banks' return on equity may exceed the demanded remuneration required by equity holders, and hence reflect a measure of revenue rather than costs. A positive relationship between return on equity and capital may therefore reflect banks' preference to raise capital levels through retained earnings. Hence, we include *ROE* with an ambiguous expected sign.

Subordinated or other uninsured debt holders may be effective in imposing discipline on bank behavior. Banks may hold higher capital levels to mitigate the disciplinary impact on funding costs or access to capital market activities. To control for the extent the bank is exposed to market discipline, we include the ratio of subordinated debt to total assets (*SUBD*) and expect the sign of the coefficient to be positive. For almost half the banks in our sample, this variable is missing. In order to conserve sample size we create a dummy variable (D_*SUBD*), which is equal to one for banks whose value of subordinated debt is missing and zero otherwise. At the same time, we set the missing values of subordinated debt to zero. Finally, we include the average capital ratio of the other banks at the same time period (*AVTR*), in order to proxy for the possible signalling mechanism of a bank's relative capital ratio. We expect banks that want to differentiate themselves from their peers, in order to change the perception of market participants, to hold higher capital levels. A summary of the discussion on variables used to approximate the target capital ratio is given in table 1 below.

Table 1. *Bank observables used to approximate the target capital ratio*

Variable	Definition	Expected Sign
SIZE	The natural logarithm of total assets	-
RISK	Risk-weighted assets over total assets	+
PROV	Loan loss provisions over total assets	+
STDROA	Standard deviation of return on assets	+
ROE	Return on equity	+/-
AVTR	Average Tier 1 ratio of the other banks	+
SUBD	Subordinated debt over total assets	+

Notes: The table summarises the variables included in the vector $x_{n,i,t-1}$ that are used to approximate the target capital ratio $k_{i,t}^*$. The vector $x_{n,i,t-1}$ also include a dummy variable equal one for missing values of *SUBD*.

7.2 Deriving Bank Capital Targets and Capital Deviations

With the set of estimated parameters of equation (6), we can calculate the target in equation (4) by first deriving the long-run parameters δ_0, β_n and η_i. It follows from the derivation of our estimation equation (6) that the long-run effect of each explanatory variable is given by:

$$\beta_n = \frac{\pi_n}{(1 - \pi_1)},$$

and the time invariant long-run effect for each bank is given by:

$$\delta_0 + \eta_i = \frac{(\pi_0 + \alpha_i)}{(1 - \pi_1)}. \text{ }^{14}$$

Hence, we recover each bank's time-varying target capital ratio as follows:

$$\hat{k}_{i,t}^* = \sum_{n=1}^{N} \frac{\hat{\pi}_n}{(1 - \hat{\pi}_1)} \cdot x_{n,i,t-1} + \frac{(\hat{\pi}_0 + \hat{\alpha}_i)}{(1 - \hat{\pi}_1)}. \quad (7)$$

Finally, we build the estimated deviation by subtracting the target capital ratio from the observed capital ratio:

$$\widehat{dev}_{i,t} = k_{i,t-1} - \hat{k}_{i,t}^* \quad (8)$$

A positive value denotes a situation where the bank is under-capitalised with respect to its target capital ratio, while a negative value denotes a situation where the bank is over-capitalised. Note that we define the deviation at period *t* as the difference between the observed capital ratio at period *t-1* and the target capital ratio at time *t*. This is because the target capital ratio at time *t* is based on observables at the end of period *t-1*. When a bank chooses the magnitude of its adjustment during period *t,* it considers the difference between its actual capital ratio and its target at the end of period *t-1*.

7.3 Estimating Models of Balance Sheet Growth

The partial adjustment model allow us to asses the factors that determine banks' capital targets and the average speed at which the banks move towards these targets. The model does, however, not tell us anything about how the targets are implemented. How do deviations from the target impact a bank's asset and liability composition? In order to address this question we

---

[14] An estimate of the time-invariant bank-fixed effects a_i is obtained by the following procedure. After estimating equation (6) by the xtabond2 command in Stata, we predict the residuals and regress them on an index variable based on our panel variable. The fitted values from this regression correspond to our a_i. When the assumptions our estimate of equation (6) are valid, the residuals are consistent. Hence will the estimates of the fixed effects based on them be consistent too.

develop and estimate models of the change in capital and asset components on the estimated deviation from equation (8). We estimate six different equations. The explanatory variables are the same in all of the equations, while the dependent variable differ.

When deviating from its optimal level, a bank may adjust the numerator of the capital ratio. In order to assess banks' responses with respect to capital changes, we model capital in two different ways; using (i) change in the total capital base (*CB*) and (ii) the change in the higher quality Tier 1 capital (*TR*), as dependent variables. The bank may also adjust the numerator of the capital ratio. We model banks' assets in four different ways; using the change in (iii) total assets (*TA*), (iv) risk-weighted assets (*RWA*), (v) loans to households (*Hloans*) and (vi) commercial loans (*Cloans*) as dependent variables in the different equations.

In each of these regressions we include control variables for macroeconomic conditions and central bank policy. In particular, we control for general macroeconomic conditions and the demand for credit by including real quarterly GDP growth of mainland Norway (*GGDP*) and the inflation rate (*INFL*). To capture the tightness in the Norwegian monetary policy, we include the changes in the central bank rate (*FOLIO*). We also include quarterly dummies to control for seasonal effects (*Q*).

$$\Delta\ln(I_{i,t}) = \gamma_0 + \gamma_1 dev_{i,t} + \gamma_2 GGDP_{i,t-1} + \gamma_3 INFL_{i,t-1}$$

$$+\gamma_4 FOLIO_{i,t-1} + \sum_{s=2}^{4}\gamma_s Q_s + \varepsilon_{i,t}, \tag{9}$$

where $\Delta\ln(I_{i,t})$ is the change in the (i) to (vi) different capital and asset items. We expect the deviation to be positively correlated with assets and negatively correlated with capital. The relative magnitude on the estimated coefficients of the deviation from regression (i) to (iv) will provide us with some information on which strategies Norwegian banks have found important to convert to the optimal capital target, over our sample period.

In addition to studying how Norwegian banks on average adjust towards their capital ratio target, we control for potential asymmetries in the adjustment behavior. Especially, we are interested in the extent to which banks react differently when they are below or above their desired ratio. Thus, we create a dummy variable that is equal to zero for observations of banks with capital surpluses and one for observations of deficits relative to their target. We use interaction terms to control for the potential asymmetric reactions:

$$\Delta I_{i,t} = \gamma_1 CV_{i,t-1} + \gamma_2 dev_{i,t} + \gamma_3 dev_{i,t} * Db_{i,t} + \gamma_4 Db_{i,t} + \varepsilon_{i,t}. \tag{10}$$

$CV_{i,t-1}$ is the control variables for general economic conditions and central bank policy, and $Db_{i,t-1}$ is the dummy variable for banks that are below their optimal capital level. We calculate the impact of banks that are above and below their optimal capital ratios based on equation (10). The impact for a bank that is below its target is equal to $\gamma_3 + \gamma_4$, while the impact for a bank that is above its target is equal to γ_3. We expect the impact for a bank that is below its capital target to be greater than for a bank that is above its target.

7.3.1 Identification Issues – Supply vs. Demand Shifts

The model specifications (9) and (10) are intended to capture the effect on the change in banks' different capital and asset items from capital target deviations. In other words, they are supposed to give us information about banks' capital decisions when they are deviating from their optimal capital ratios. However, one important point to discuss is what we capture and what we do not. For instance, changes in loans on banks' balance sheets may have two sources. First, banks may alter their lending as a result of having to make adjustments to their balance sheet because they are constrained by their target. They are likely to increase their lending when they are above their target, and decrease their lending when they are below their target. Hence, the change in loans on a bank's balance sheet is a result of a shift in supply. But changes in bank loans may also be a result of shifts in the demand from borrowers. In other words, it is equally possible that the change in loans on banks' balance sheets is a demand-driven shift.

It is difficult to disentangle the supply- and demand-side effects in our framework. However, we try to control for changes in the demand for credit, macroeconomic conditions and changes in monetary policy by including the growth rate in GDP, inflation rate, and the changes in the key monetary policy interest rate. Furthermore, we intend to capture factors that affect the target capital ratio deviations and changes in lending equally, by including time dummies.

8. Econometric Methodology

Various econometrical issues occur when dealing with panel data. In this section, we describe how we address them. Sub-section 8.1 to 8.3 discusses potential estimators, while sub-section 8.4 summarizes the discussion of the application of the econometric methods. 8.5 describe the relevant model diagnostics.

The regression equations in (6), (9) and (10) includes a bank-specific component (α_i). This allows us to control for potential unobservable omitted factors that vary across banks and are constant over time (fixed effects), such as differences in managerial skills and risk preference. However, the fixed effects are a potential source of endogeneity. In particular, explanatory variables that are expected to correlate with the fixed effects are endogenous.[15] This is because the fixed effects are hidden in the error term, $(\alpha_i + u_{i,t})$.

8.1 Removing the Fixed Effects

We assume that one or more of the included explanatory variables in equation (6), (9) and (10) correlate with the fixed effects (α_i). Managerial skills may for instance be related to bank size. Larger banks are likely to attract managers with more experience and education than smaller banks. We further assume that the disturbances $(u_{i,t})$ are serially uncorrelated. Jointly, these assumptions imply that the ordinary least square (OLS) estimator will produce biased and inconsistent coefficient estimates, since some of the included explanatory variables correlates with the error term $(\alpha_i + u_{i,t})$, due to the presence of fixed effects (α_i).[16] Moreover, this correlation does not vanish with increased sample size (Bond, 2002). Thus, in order to eliminate this source of endogeneity, we should employ estimation techniques that account for the fixed-effects component on the error term. One way is to apply a mean-deviation transformation to each variable to remove the fixed effects:

$$k_{i,t} - \bar{k}_{i,t} = \pi_1\left(k_{i,t-1} - \bar{k}_{i,t-1}\right) + \pi_2\left(x'_{i,t-1} - \bar{x}'_{i,t-1}\right) + (\alpha_i - \bar{\alpha}_i) + \left(u_{i,t} - \bar{u}_i\right). \quad (11)$$

Using equation (6) as an example, we see that the original observations are expressed as deviations from their individual means.[17] Since the individual mean of α_i is α_i itself, it is eliminated in the transformation. The OLS estimator for π_1 and π_2 obtained from this

---

[15] Explanatory variables that are correlated with the error term are said to be endogenous (Verbeek, 2012).

[16] A crucial assumption of the OLS estimator is that $E\{(\alpha_i + u_{i,t})\big|, k_{i,t} x'_{i,t}\}=0$

[17] Where $\bar{k}_{i,t-1} = \sum_{t=2}^{T} \frac{k_{i,t-1}}{T-1}$ and the other individual means are defined in a similar way.

transformed equation is often called the fixed effects (FE) estimator (Verbeek, 2012). We prefer this estimator for equations (9) and (10).

However, applying this approach to equation (6) introduces a new source of endogeneity. The mean-deviation transform induces a correlation between the transformed lagged dependent variable $(k_{i,t-1} - \overline{k}_{i,t-1})$ and the transformed disturbance term $(u_{i,t} - \overline{u}_i)$. In particular, the lagged dependent variable $(k_{i,t-1})$ is negatively correlated with $\overline{u}_i$, because $u_{i,t-1}$ are included in $\overline{u}_i$. In fact, this correlation continues with lags of $k_{i,t-1}$ because they too are embedded in $\overline{u}_i$ (Roodman, 2009).[18] The FE-estimator therefore yields a downward-bias in the estimate of π_1. As the panel length increases, $u_{i,t-1}$ becomes a smaller part of $\overline{u}_i$, and as a result the correlation between the lagged dependent variable and the disturbance term declines (Flannery & Hankins, 2012). However, even for a large number of time periods, the bias in the coefficient estimate may be substantial. By simulations, Judson and Owen (1999) find that the bias may be as great as 20% of the true value of the coefficient of interest for panels with 30 time periods.

Another commonly used transformation is the first-difference transform, which involves subtracting the previous observation of a variable from the contemporaneous one:

$$k_{i,t} - k_{i,t-1} = \pi_1\big(k_{i,t-1} - k_{i,t-2}\big) + \pi_2\big(x'_{i,t-1} - x'_{i,t-2}\big) + (\alpha_i - \alpha_i) + \big(u_{i,t} - u_{i,t-1}\big). \quad (12)$$

Since the fixed effects are time invariant, they are eliminated from equation (6) by first differencing. The OLS-estimator will still yield inconsistent and downward-biased estimates of π_1 because $k_{i,t-1}$ and $u_{i,t-1}$ are by definition correlated.[19] But unlike with the mean-deviation transformation, first-differencing does not introduce all realisations of the disturbances $(u_{i,2}, u_{i,3} \dots u_{i,T})$ into the transformed equation of period t (Bond, 2002). Hence, consistent estimates of π_1 can now be obtained by applying an instrument-variable approach with instruments drawn from within the dataset.

---

[18] $k_{i,t-2}$ correlates with $\overline{u}_i$, because $\overline{u}_i$ includes $u_{i,t-1}$ etc.

[19] Likewise, any variables in $x'_{i,t-1}$ that are not strictly exogenous become endogenous because they might also be related to $u_{i,t-1}$ (Roodman, 2009).

8.2 Instrument Variables Approach

An instrument variable should satisfy two conditions. First, the instrument should be exogenous. In other words, no correlation between the instrument and the error term should exist. Second, the instrument should be relevant, which means that it must correlate with the endogenous explanatory variable (Wooldridge, 2009).

Natural instrument candidates for the first-differenced lagged dependent variable $(\Delta k_{i,t-1})$[20] are $k_{i,t-2}$ and $\Delta k_{i,t-2}$. These instruments are not correlated with the transformed disturbance term $(\Delta u_{i,t})$, unless $u_{i,t}$ exhibits autocorrelation. Moreover, if π_1 is different from zero, $\Delta k_{i,t-1}$ is correlated with $k_{i,t-2}$ and $\Delta k_{i,t-2}$. Instrument variable estimation using 2SLS to incorporate either $k_{i,t-2}$ or $\Delta k_{i,t-2}$ as instruments for the first-differenced lagged dependent variable $(\Delta k_{i,t-1})$ are known as the Anderson and Hsiao estimators. In order to identify the parameters in the model, these estimators impose one moment condition in estimation. The level instrument estimator is based on $E\{(\Delta u_{i,t})k_{i,t-2}\} = 0$, while the difference instrument estimator is based on $E\{(\Delta u_{i,t})(\Delta k_{i,t-2})\} = 0$.[21] However when available, imposing more moment conditions improves the efficiency of the estimators. One can therefore take Andersen and Hsiao further by using longer lags of the dependent variable as instruments. To the extent this introduces more information, i.e. the additional moment conditions are valid, this should improve efficiency. But using standard 2SLS to incorporate longer lags will reduce sample size substantially since observations for which lag observations are missing are dropped (Roodman, 2009).

The general method of moments (GMM) provides a convenient framework in this context. Arellano and Bond (1991) develop a first-difference GMM (DGMM) model for dynamic panels using all available lagged dependent variable levels to instrument for the first difference for the lag. Within this framework, the first-differenced model is specified as a system of equations, with one equation per time period. GMM excludes observations for which no valid instruments are available. However, it does include observations for which only a subset of the lags is available. This implies that the instruments available for each time period will differ. While only $k_{i,1}$ can be used in period *t=3,* both $k_{i,2}$ and $k_{i,1}$ are available in period *t=4.* And finally in period t=T, the vector $(k_{i,1}, k_{i,2,} \ldots, k_{i,T-2})$ can be used as an

---

[20] In the following we denote a variable indifference by Δ. For instance $\Delta k_{i,t-1} = \left(k_{i,t-1} - k_{i,t-2}\right)$

[21] The moment conditions states that the instrument is assumed to be uncorrelated with the equations transformed error term, i.e. that it is exogenous.

instrument for the first differenced equation. This gives rise to an instrument matrix on the form:

$$Z_i = \begin{bmatrix} k_{i,1} & 0 & 0 & \cdots & 0 & \cdots & 0 \\ 0 & k_{i,2} & k_{i,1} & \cdots & 0 & \cdots & 0 \\ . & . & . & \cdots & . & \cdots & . \\ 0 & 0 & 0 & \cdots & k_{i,1} & \cdots & k_{i,T-2} \end{bmatrix} \tag{13}$$

The rows in the matrix (Z_i) corresponds to the first-differenced equation (6) for period $t=3,4,...,T$ for bank i. The resulting columns correspond to the set of exploited moment conditions:

$$E[Z_i'\Delta u_i] = 0 \qquad \text{for } i=1,2,...,N \tag{14}$$

where $\Delta u_i = (u_{i,3}, u_{i,4}, ..., u_{i,T})'$. Based on this set of moment conditions, the DGMM-estimator minimizes the criterion:

$$J_N = \left(\frac{1}{N}\sum_{i=1}^{N}\Delta u_i' Z_i\right) W_N \left(\frac{1}{N}\sum_{i=1}^{N}Z_i'\Delta u_i\right) \tag{15}$$

where W_N is the weighting matrix:

$$W_N = \left[\frac{1}{N}\sum_{i=1}^{N}\left(Z_i'\widehat{\Delta u_i}\widehat{\Delta u_i'}Z_i\right)\right]^{-1} \tag{16}$$

The resulting estimator is called the two-step DGMM-estimator because consistent estimates of the first-differenced disturbances ($\widehat{\Delta u_i}$) are obtained from a preliminary consistent estimator. Under the assumption that the disturbances (u_i) are independent and identically distributed, an asymptotically equivalent estimator can be obtained in one step, using the weighting matrix:

$$W_{1N} = \left[\frac{1}{N}\sum_{i=1}^{N}(Z_i'HZ_i)\right]^{-1} \tag{17}$$

Here, H is a $(T-2)(T-2)$ matrix with 2´s on the main diagonal, -1 on two sub-main diagonals and zeros elsewhere. The resulting estimator is called the one-step DGMM-estimator, in which W_{1N} does not depend on any estimated parameters (Bond, 2002).

Alonso-Borrego & Arellano (1996) show that the DGMM-estimator suffers from a large finite sample bias and poor precision if the data generating the process is highly persistent. The loss in asymptotic efficiency makes intuitive sense because when a variable is persistent, past levels convey little information about future changes. Hence, lagged levels are weak

instruments for first-differenced variables in this case. This weak instrument problem is likely to be relevenat to our dataset. Table 2 reports estimation results from a simple *AR(1)* specification for the Tier 1 capital ratio series ($k_{i,t}$). The series is found to be highly persistent. The OLS-estimator suggests an autoregressive coefficient close to unity, the FE-estimator a coefficient around 0.9, whilst the DGMM estimates are found to be significantly lower. This downward bias in the DGMM estimate of *AR(1)* model is consistent with the finite sample bias expected in highly persistent series.[22]

The high persistence in the process of $k_{i,t}$ could also indicate a unit root. Hence, we additionally test for a unit root. The test is carried out in a Fisher-type approach. The main motivation for using this approach is that it can handle unbalanced panels, like ours. Fisher-type tests combines p-values of the test statistic for a unit root test in each cross-sectional unit (Hoang & Mcnown, 2008).[23] We use a general specification where we allow for fixed effects, time trend, and for serial correlation in the errors. The Fisher-type test strongly reject the null hypothesis that all the panels contain a unit root.

Table 2. *AR(1) specifications for the Tier 1 Capital ratio series*

	OLS	**FE**	**DGMM**
$k_{i,t-1}$	0.972[***]	0.892[***]	0.680[***]
	(0.002)	(0.008)	(0.032)
N	8392	8392	8108

Note: The table reports the estimation results from an AR(1) specification the Tier 1 capital ratio, i.e the dependent variable is $k_{i,t}$. Robust standard errors is reported in parentheses. *** indicates statistical significance at the 1 percent leve. Instruments in first-difference are dated t-2 and earlier in the DGMM estimations.

---

[22] See Bond (2002) for a discussion and simulations of this bias.
[23] The unit root test perfomed in each cross section is an Augmented Dickey Fuller test. See Wooldridge (2009) for a discussion on this test.

8.3 System GMM

Altough the series does not appear to have an exact unit root, we do have to account for the high persistence in the process of $k_{i,t}$ and the fact that lagged values in levels are likely to be weak instruments for the first-difference transformed variable. Blundell and Bond (1998) suggest using a so-called system GMM (SGMM) estimator. The SGMM estimator sets up a problem in which the model is specified as a system of equations in levels and first-differences. Lagged levels are used as instruments for the endogenous variable in first-difference. This gives rise to a set of moment conditions as specified in (14). The SGMM estimator further use lagged differences as instruments for the endogenous variable in levels. For variables with high persistence, past changes are likely to convey more information about current levels than past levels about future changes. Hence, these instruments may be more relevant. The new instruments are valid under the additional assumption that changes in the instrument variable (k) are uncorrelated with the fixed effects (α_i). That is to say, $E[\Delta k_{i,t}\alpha_i] = 0$ for all i and t, and further $E[k_{i,t}\alpha_i]$ is time-invariant. If this holds, $\Delta k_{i,t-1}$ is a valid instrument for the equation in levels. The additional moment conditions can then be specified as:

$$E\left[\Delta k_{i,t-1}(\alpha_i + u_{i,t})\right] = 0 \quad \text{for } i=1,2,...,N \text{ and } t=1,2,...,T \tag{18}$$

The SGMM estimator combines the set of moment conditions specified for the first-differenced equations with the additional moment conditions specified for the equations in levels. This estimator is therefore expected to produce efficiency gains over the DGMM estimator, provided that the additional moment conditions are valid. Furthermore, in the SGMM context the gain in efficiency from using the two-step estimator over the one-step estimator is likely to be greater than in the DGMM context. This is because there is no longer a known weight matrix that can be used to construct a one-step estimator that is asymptotically equivalent to the two-step estimator (Bond, 2002).

8.4 Applications of The Econometric Techniques

We have now discussed several estimators that can be used to produce consistent estimates of the parameters in the regression equations (6), (9) and (10). We use the FE estimator to estimate the two last. As they not include a lagged dependent variable, the mean-deviation transform eliminates the endogeneity problem that arises from the unobserved and time invariant bank-fixed effects. While both GMM estimators may produce consistent parameter

estimates of equation (6), the SGMM estimates are likely to be the most efficient, mainly because the Tier 1 capital ratio is found to be highly persistent.

In addition to the lagged dependent variable ($k_{i,t-1}$), we believe that the variable that captures portfolio risk (*RISK*), calculated as the ratio of risk-weighted assets to total assets, becomes endogenous when transforming the data. Both variables are therefore instrumented with lagged values in levels and lagged values in differences as instruments. The rest of the explanatory variables are treated as exogenous.

In the GMM context, one may use the entire set of lagged values of the endogenous variables as instruments, provided that the residuals exhibit no autocorrelation. However, as Roodman (2009) states, using too many instruments may bias the coefficient estimates towards those from non-instrumenting estimators. We therefor restrict the number of instruments to be less than the number of individual banks.[24] In particular, we start by using a number of instruments equal to the number of individual banks and reduce them step-by-step. For each regression we run, we compare the Hansen statistic to the Hansen statistic of the last regression. We then use the specification with the lag length that has the highest p-value for the Hansen test.[25] To further reduce the problem of too many instruments we collapse the optimal instrument matrix. This means that we use only one instrument for each variable and lag distance, rather than one for each time period, variable and lag distance.[26]

The first-difference transform has a weakness of magnifying gaps in unbalanced panels. Roodman (2009) therefore suggest that we use another transformation called orthogonal deviations, when transforming equation (6). Instead of subtracting the previous observation from the contemporaneous one, this method subtracts the average of all future available observations from each observation of a variable. It is computable for all observations expect the last for each bank, no matter how many gaps. Thus, it is used to preserve sample size. We apply both transformations to equation (6) and report the one with the better statistical diagnostic. Roodman (2009) further suggest that we use two-step estimation method that is robust to any patterns of heteroskedasticity that exist in the dataset. The potential downward bias of the estimated asymptotic standard errors is corrected by using Windmeijer finite sample correction.

---

[24] The Stata Xtabond2 command suggest that the number of instruments should be less that the number of groups.
[25] This procedure for determining the optimal lag length is suggested by Andrews & Lu (2001).
[26] See Roodman (2009) for details.

8.5 Model Diagnostics

An important procedure in testing the statistical properties of the model in equation (6) is testing the validity of the instruments. The system GMM estimator assumes that the idiosyncratic error term, $u_{i,t}$, is not autocorrelated.[27] If the $u_{i,t}$ is serially correlated of order one, then for example $k_{i,t-2}$ is correlated to the last term in $(u_{i,t} - u_{i,t-1})$ and hence not available as a valid instrument after all.[28] In order to test for autocorrelation, we apply the Arellano-Bond test to the error terms in differences.[29] The m_1 and m_2 procedure tests for first- and second-order autocorrelation, respectively. First-order autocorrelation in differences is expected since $(u_{i,t} - u_{i,t-1})$ and $(u_{i,t-1} - u_{i,t-2})$ are mathematically related via the shared $u_{i,t-1}$ term. Thus, we look for second-order autocorrelation in differences in order to check for first-order autocorrelation in levels. According to Roodman (2009), this procedure is based on the idea that it will detect correlation between the $u_{i,t-1}$ term in $(u_{i,t} - u_{i,t-1})$ and the $u_{i,t-2}$ term in $(u_{i,t-2} - u_{i,t-3})$. The null-hypothesis in the Arellano-Bond test is that the residuals in difference are free from autocorrelation. Hence, we need to be able to reject the null in the m_1 test, but not reject it in the m_2 test.

The strength of the instruments is also assessed in the Hansen test of overidentifying restrictions. This test regresses the residuals from the estimated regression on all the instruments. The null-hypothesis is that all instruments are uncorrelated with the residuals, i.e. all instruments are valid. Furthermore, the instruments in the system GMM depend on the assumption that changes in the instrument variables are not correlated with the fixed effect. Roodman (2009) therefore argues that the estimated coefficient on lagged dependent variable should indicate convergence by having an absolute value less than unity.

Bond (2002) suggests an additional detection for the validity of the GMM estimates. As explained earlier, the OLS estimator tends to overestimate the coefficient estimate of the lagged dependent variable in dynamic models. On the other hand, the FE estimator tends to underestimate the coefficient. Hence, as suggested by Bond (2002) the estimated value of the coefficient estimate should lie between the estimates obtained by the OLS and FE-estimators.

---

[27] However, the full error term before transformation, $\varepsilon_{i,t} = u_{i,t} + \alpha_i$, is indeed presumed to exhibit autocorrelation since it contains the fixed effects α_i.

[28] Confer the first condition for a valid instrument: the instrument should be exogenous.

[29] The test is also run on residuals in difference after estimation in orthogonal deviations. This is because all residuals in deviations are interrelated (see Roodman (2009)).

Finally, for all of our regression equations, we report a Wald test for jointly significance of the set of coefficients. If the null-hypothesis can be rejected, the variables we have included in the models are doing well in predicting the dependent variable.

9. Results

9.1 Descriptive Statistics

9.1.1 Tier 1 Capital Ratio

Figure 1 shows the development in Norwegian banks' average Tier 1 capital ratio over the years 1993 to 2013. In order to better assess the development in the average regulatory capital ratio across banks, we include the average equity ratio, defined as common equity over total unweighted assets. As evident from the figure, Norwegian banks operate with capital ratios that remain significantly above the regulatory minimum, throughout our sample. The average Tier 1 ratio was 15.77 percent over our sample period. The banks started out with an average Tier 1 ratio of 14 percent in 1993 and gradually increased their regulatory capital ratio until reaching a top in 1995. Then it declined steadily until 2000. Interestingly, we note the divergent movement between the regulatory capital ratio and the equity ratio from 2000 to 2009. While the equity ratio exhibited a downward trend, the Tier 1 ratio remained stable between 14 and 16 percent. This development may partly reflect differences arising from the denominator of the capital ratio.[30]

Figure 1. *Bank Capital Ratios, Quarterly Unweighted Means*
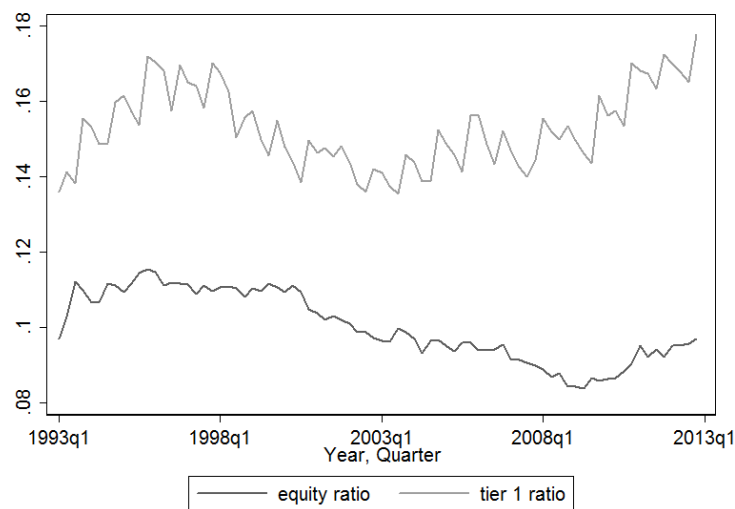
Notes: This figure shows the development in the average Tier 1 ratio and equity ratio over the years 1993 to 2013. The Tier 1 ratio is defined as Tier 1 capital over risk-weighted assets, while the equity ratio is defined as equity over total assets.

---

[30] It may also reflect differences in the development in regulatory capital relative to common equity.

In particular, it is consistent with a rise in banks' total assets relative to risk-weighted assets. Andersen (2010) points to a fall in the average risk-weight of banks' assets over this period. The share of residential mortgages of banks' total loan portfolio increased from 35 percent in the late 1990s to 60 percent by the end of 2005. Residential mortgages have a low risk-weight compared to other bank assets. Hence, a substitution to residential mortgages leads to a lower average risk-weight. The development in Norwegian banks' capital ratios contradicts the US banks' risk-behavior over the same period. For these banks, Berrospide and Edge (2010) showed that the risk-weighted assets increased faster than the total assets over the period from 2004 to 2007. This led to an upward trend in regulatory capital ratios and a downward trend in equity ratios.

In line with the need for recapitalisation after the financial crisis and the introduction of higher capital requirements, both the regulatory ratio and the common equity ratio have exhibited an upward trend since 2009. Finally, we also note that the regulatory capital ratio seems to follow a systematic seasonal pattern with a peak in the fourth quarter.

9.1.2 Other Variables

Table 3 below provides descriptive statistics on the variables used in regression equation (6), (9) and (10). Panel A reports the variables used to construct the partial adjustment model in equation (6), while panel B reports the variables from our regressions of growth in different capital and assets items, equation (10). Starting with panel A, we note that none of the banks experienced capital ratios (k) below the required minimum. The average bank had a *ROE* of 6.3 percent, but the standard deviation suggests a substantial variation. We also note observations of *RISK* above one, which suggest substantial off-balance sheet activities in some banks.

The first 6 rows in panel B report the dependent variables used to estimate equation (9) and (10). First, we see that the average growth in total assets (*TA*) is somewhat higher than the average growth in risk-weighted assets (*RWA*). Further, that the growth in commercial loans (*CLOANS*) is higher than loans to households (*HLOANS*). *CLOANS* displays, however, a sizeable variation. In the next section we empirically investigate whether banks targeting behavior towards optimal capital levels may explain the variation in these variables.

<p align="center">**Table 3.** *Descriptive Statistics*</p>

Variable	Obs.	Mean	Std. Dev.	Min	Max
Panel A:					
k	8707	.157779	.0449531	.0513306	.3339769
SIZE	8707	14.43221	1.30868	11.23783	19.17183
ROE	8707	.0628976	.0406324	-.108065	.2211621
RISK	8707	.6306283	.0754525	.3677599	1.219541
PROV	8669	.0119834	.0071883	1.70e-06	.0400447
STDROA	7629	.0034692	.0014353	.0005262	.0163729
AVTR	8707	.1617536	.0108228	.1440847	.1848462
SUBD	8708	.0075435	.0122117	0	.0785149
Panel B:					
TC	8566	.0231885	.0560727	-.4790259	.7614146
RWA	8566	.0221642	.0404629	-.2907719	.7170583
TA	8566	.0240013	.0382622	-.2396678	.8288831
LOANS	8566	.0245196	.0332719	-.4128095	.6692616
CLOANS	8566	.0342046	.1426749	-1.932661	7.242212
HLOANS	8566	.0235129	.0393033	-.6087568	1.283813
GDP	8566	.0072716	.0101999	-.0137039	.0426351
INFL	8566	.0048934	.0067033	-.0167626	.027766
FOLIO	8566	-.0006753	.0069433	-.0275	.035

Notes: The table presents descriptive statistics of the variables used to estimate our equations. Panel A represents the variables used in equitation (6), while panel B represents the variables used in (9) and (10).

9.2 Banks' Target Capital Ratio and Speed of Adjustment

Table 4 displays the estimation results of the partial adjustment equation (6). The Tier 1 capital ratio is regressed on its own one-period lagged value and a set of bank-specific variables, while also taking into account time-fixed effects. The first column presents the results from an OLS regression. The second and third columns present the results from FE and SGMM regressions, respectively, which also accounts for the bank-fixed effects. The SGMM estimator is preferred since the dynamic setup of the model specification (6) leads to biased and inconsistent results when using the OLS or FE estimator. However, the results from these regressions are included as a robustness check of the SGMM results. A good coefficient estimate of the lagged dependent variable should lie in the interval between the OLS and FE estimates. This is the case for our SGMM estimate.

We treat the lagged dependent variable, $k_{i,t-1}$, and the $RISK_{i,t-1}$ variable as endogenous in the SGMM regression and use lags in levels and differences as instruments. The instrument set is collapsed and the number of instruments is restricted to 161 in order to ensure that the estimation does not suffer from instruments' proliferation. The validity of these instruments is confirmed by the Arellano-Bond and Hansen tests. As we see from table 2, the m_2 procedure suggests that we cannot reject the null-hypothesis of no second-order autocorrelation in the first-differenced residuals. Neither can we reject the null-hypothesis of joint validity of all the instruments. Thus, first-order autocorrelated residuals in levels or over-identifications are not a source of concerns. The Wald test for the null-hypothesis that all coefficients are equal to zero is safely rejected in all three regressions.

Looking at the results in table 4, we first note that the SGMM coefficient estimate of the lagged dependent variable appears to be reasonable. It is statistically significant, above the FE estimate and below the OLS estimate. Although the process of $k_{i,t}$ is highly persistent, it does not have an exact unit root.[31] We therefore interpret the results in favor of the adjustment cost hypothesis, indicating that Norwegian banks do adjust towards an optimal Tier 1 capital ratio. However, they do this rather slowly. The coefficient for the lagged dependent variable is equal to $(1 - \lambda)$, where λ denotes the adjustment speed. Thus, we find that Norwegian banks on average close 4.1 percent of the gap between their effective and target capital ratio per quarter. This speed of adjustment is significantly lower than European banks. Kok and Schepens (2013) find that the average European bank uses 3.1 quarters to close its Tier 1

---

[31] Confer our unit root test in section 7.4.

capital gap. Our corresponding measure is 16.9 quarters.[32] The slow speed of adjustment among Norwegian banks is in line with the idea that costs of adjusting capital are an important explanation of why they hold capital ratios above the regulatory minimum. Frictions in the market for equity imply that banks cannot costlessly adjust their capital levels. Banks attempt to minimize these costly adjustments by holding higher capital ratios.

We keep in mind, however, that the estimated coefficient represents the adjustment speed of the average Norwegian bank. The speed is likely to vary significantly across banks and over time.[33] For example, Berger et al. (2008) finds that banks nearer the minimum required capital ratio adjust towards their capital target at a faster speed than well-capitalized banks.

Consistent with the previous literature on bank capital structure, we find a statistically significant negative relationship between Tier 1 capital ratios and bank size (*SIZE*). This finding is in line with the view that scale economies in screening and monitoring may reduce the need for large banks to hold a capital buffer as an insurance against falling below the regulatory minimum. As Lindquist (2003) also points out, a negative correlation between capital ratio and size may come from a diversification effect not captured by the risk measures. In addition, this relationship may also be related to the too-big-to-fail hypothesis as well as the notion that smaller banks may experience greater difficulties in accessing the capital markets (Jokipii & Milne, 2008).

According to our regression analysis, banks with a higher *ROE* have a higher capital adequacy ratio. As discussed in the previous section, we would expect a negative relationship if we were to interpret this variable as the alternative cost of capital for banks. Hence, our results suggest that the profitability effect of *ROE* surpassed the cost of capital effect for the banks that are included in our analysis. Moreover, the positive and highly significant coefficient also contradicts the view that banks substitute high levels of earnings with excess capital as an insurance against falling below their required minimum. Berrospide and Edge (2010) also report a positive (although not significant) relationship between the capital ratio and earnings. They argue, on the other hand, that a positive relationship was as expected as sticky dividend payments result in an accumulation of retained earnings and bank capital.

---

[32] The half-life is calculated by using the formula: $\frac{\ln(2)}{\lambda}$, where λ is the speed of adjustment.

[33] In unreported results we find that the speed of adjustment varies with the quality of the capital, i.e. the speed of adjustment appears to be even slower for common equity capital and higher for the total capital base. However, we could not confirm the validity of the instruments in these models.

Table 4. *Determinants of Bank Capital*

	OLS	FE	SGMM
$k_{i,t-1}$	0.973***	0.903***	0.959***
	(332.63)	(100.46)	(97.25)
$SIZE_{i,t-1}$	-0.000503***	-0.00141	-0.000386*
	(-5.36)	(-1.22)	(-2.09)
$ROE_{i,t-1}$	0.0168***	0.0216***	0.0238***
	(4.65)	(5.37)	(5.43)
$RISK_{i,t-1}$	-0.00588***	-0.00810**	-0.0282***
	(-3.76)	(-2.88)	(-6.06)
$PROV_{i,t-1}$	0.0486***	0.0766***	0.125***
	(3.40)	(3.38)	(4.88)
$STDROA_{i,t-1}$	-0.0740	0.0632	0.0660
	(-1.02)	(0.63)	(0.75)
$AVTR_{i,t-1}$	-0.00598	0.0534***	-0.0239*
	(-0.68)	(4.87)	(-1.99)
$SUBD_{i,t-1}$	0.00603	0.0327	0.00296
	(0.39)	(1.71)	(0.17)
$D\_SUBD_{i,t-1}$	-0.0000246	-0.000825	0.000417
	(-0.06)	(-1.48)	(0.84)
$Constant$	0.00510**	0.00703*	0.0222***
	(2.71)	(2.53)	(5.76)
Observations	7358	7358	7358
Time FE	YES	YES	YES
Bank FE	NO	YES	YES
m_1 Test			0.000
m_2 Test			0.330
Hansen Test			0.400
Wald Test	0.000	0.000	0.000

Notes: The dependent variable is Tier 1 capital ratio ($k_{i,t}$). One minus the coefficient estimate on $k_{i,t-1}$ corresponds to the speed of adjustment. $k_{i,t-1}$ and $RISK_{i,t-1}$ are treated as endogenous in the SGMM estimation. Lagged differences are used as instruments for equations in levels in addition to lagged levels for equations in first differences. Absolute t-values are presented in parentheses. ***,** and * indicate statistical significance at the 1, 5 and 10 percent level in a two-tailed t-test. Hansen Test refers to the test of overidentifying restrictions. m_1 and m_2 refers to the test of no first-order and second-order autocorrelation in the first-differenced residuals. Wald Test refers to the test of jointly significance of the coefficient estimates. P-values are reported for these tests.

The results in table 4 suggest that the bank's level of portfolio risk, captured by a regulatory measure (*RISK*) and a measure that is more aligned with the bank's own perception (*PROV*), are statistically significantly related to capital ratios. *RISK* is negatively associated with the Tier 1 capital ratio. This may indicate a moral hazard behavior of Norwegian banks. However, as Lindquist (2003) and Francis & Osborne (2009a) point out, a negative relationship between risk and capital does not necessarily imply that high-risk banks are poorly capitalized relative to their level of asset risk. Banks evaluate and respond differently to risk. It may, for instance, be that riskier banks hold less capital against a given asset-risk due to better systems and controls for risk. Moreover, the statistically significant coefficient estimate on loan-loss provisions (*PROV*) suggests that banks hold higher capital ratios when they perceive their asset-portfolio to be more risky. This is inconsistent with moral hazard. The coefficient on (*STDROA*) is not statistically significant different from zero. Thus, we find no evidence in favor of the hypothesis that banks substitute high levels of earnings for high capital ratios.

We failed to find any significant relationship between capital and the traditional measure of market discipline, subordinated debt (*SUBD*), and the coefficient estimate on the average capital ratio (*AVTR*) is somewhat counterintuitive (statistically significant on a 10 percent level).

Having estimated the long-run determinants of bank capital ratios, we proceed to calculate the long-run target, as defined in equation (4) and the resulting capital deviations, as defined in (8). In order to obtain a target that is as precise as possible, we dropped from the model in (6) those variables that were not significant in the first specification and re-estimated the equation.[34] Figure 2 presents the Tier 1 capital deviation over time. We report the 25th, 50th and 75th percentiles to capture the distribution among banks as well as over time. Overall, the estimations suggest relatively small deviations from the target Tier 1 capital ratio. From the figure we see that capital deviations are narrowed from the start of our estimation period and up to year 2000. For more than 50 percent of the banks, the capital deviation turns negative in 2007. Consistent with the upward trend in regulatory capital ratios in the last few years of our estimation period, the capital deviations becomes smaller for banks with capital deficits and larger for banks with capital surpluses in the years 2009 to 2013. In what follows we analyze how these deviations affect the growth in the banks' different capital and asset items.

---

[34] We dropped *STAROA*, *SUBDTA* and *D_SUBDTA* from the first specification.

Figure 2. *Tier 1 Capital deviation*

Notes: This figure shows the evolution of the Tier 1 capital deviation. The 25th, 50th and 75th percentiles in each year are presented.

9.3 Impact of Capital Ratio Deviations

The results in section 9.2 suggest that Norwegian banks Tier 1 capital ratios converge towards internal targets. This means that they respond to deviations from their optimal target by making adjustments in their capital and asset positions. In the case of a capital shortfall a bank may either raise more capital or shrink its risk-weighted assets. In the following we try to capture the impact of Tier 1 capital deviations on six different capital items. For each dependent variable, we run 2 regressions. In subsection 9.3.1 we present the results when not taking into account potential asymmetric reactions in terms of being below or above the target Tier 1 capital ratio. In subsection 9.3.2 we examine whether banks' responses to capital surpluses are different from that of deficits, by interacting a dummy variable equal one for banks that are below their target and zero for banks that are above the target, with the deviation variable (*dev*). In all regressions we include controls for macroeconomic conditions and central bank policy. We also control for unobserved bank-specific time invariant heterogeneity and seasonal influences by adding bank and time-fixed effects.

9.3.1 Banks' Response on Capital Deviations – Symmetric Reactions

Table 5 provides the results from the regressions of growth in the total capital base (*CB*), Tier 1 capital (*TC*), risk-weighted assets (*RWA*) and total assets (*TA*), on the capital deviation (*dev*) and a set of control variables. Deviations are negatively correlated with growth in capital and positively correlated with growth in assets. These findings provide support for the idea that banks facing a deficit relative to their target capital ratio take action to raise capital levels and/or reduce their risk-weighted assets.

Looking at the two measures of capital, we see that the adjustment is somewhat larger in the total capital base over our estimation period. Francis and Osborne (2009a) suggest that adjustments in higher-quality Tier 1 capital are likely to be more costly than adjustments in the total capital base, based on a "pecking order" idea of capital structure. However, the coefficients are not statistically different on a 5 percent significance level. Norwegian banks do therefore not appear to favor adjustments in the less-costly total capital measure of capital.

The third column of table 5 shows the impact of deviations from target Tier 1 ratio on the change in risk-weighted assets. The highly significant coefficient on the deviation suggests that making changes to the risk-weighted assets is an important strategy for Norwegian banks to revert to their target capital ratios. Changes in risk-weighted assets can be caused by a real change in total assets and/or altering assets among risk-weights. The last column in table 5 provides more information on this issue. The coefficient of the deviation is statistically significantly lower in the regression of total assets. This result indicates that Norwegian banks prefer to fine-tune their risk-weighted assets by, for example, altering the composition of assets instead of making real changes to the size of their balance sheet when being away from their target capital ratio.

Table 6 reports results from the regressions of growth in bank loans. The results provide evidence for a significant effect of Tier 1 deviations on growth in loans to households and corporate lending on 5 and 10 percent significance levels, respectively. These findings are consistent with the notion that banks facing a capital deficit reduce their lending, by for example, raising interest rates. The other coefficients of the regressions in table 5 and 6 have more or less the expected signs.

Table 5. *Regressions of growth in capital and asset on capital deviations*

	Growth in:			
	CB	**TC**	**RWA**	**TA**
$dev_{i,t}$	-0.371***	-0.351***	0.226***	0.0799**
	(-7.21)	(-7.40)	(6.76)	(2.69)
$GGDP_{i,t-1}$	0.493***	0.320***	-0.169***	0.192***
	(7.87)	(6.36)	(-3.60)	(3.64)
$INFL_{i,t-1}$	-0.162	-0.231**	-0.463***	0.269***
	(-1.62)	(-2.94)	(-6.53)	(3.80)
$FOLIO_{i,t-1}$	0.275	0.297	0.237	-0.254
	(1.60)	(1.73)	(1.42)	(-1.63)
Constant	-0.00128	0.000256	0.0193***	0.0144***
	(-0.90)	(0.23)	(18.91)	(14.30)
N	7358	7358	7358	7358

Table 6. *Regressions of growth in loans on capital deviations*

	Growth in:	
	HLoans	**CLoans**
$dev_{i,t}$	0.117**	0.167*
	(3.26)	(2.49)
$GGDP_{i,t-1}$	0.279***	0.0583
	(7.99)	(0.22)
$INFL_{i,t-1}$	0.0389	0.149
	(0.75)	(0.80)
$FOLIO_{i,t-1}$	0.460***	-0.170
	(3.99)	(-0.29)
Constant	0.00831***	0.0416***
	(10.97)	(12.38)
N	7358	7358

Notes to table 5 and 6: Table 5 displays the results from regressions of growth in the total capital base (*CB*), Tier 1 capital *(TR)*, risk-weighted assets *(RWA)* and total assets *(TA)*. Table 6 displays the results from regressions of growth in loans to households (*HLoans*) and commercial loans (Cloans). $dev_{i,t}$ is the Tier 1 capital deviation defined as the effective Tier 1 capital ratio minus the target ratio. The other explanatory variables in row 2-4 are growth in GDP, inflation rate and the folio rate, respectively. All regressions include bank- and time-fixed effects. Absolute t-values are presented in parentheses. ***,** and * indicate statistical significance at the 1, 5 and 10 percent level in a two-tailed t-test.

9.3.2 Banks' Response to Capital Deviations – Asymmetric Reactions

The results in the previous subsection suggest that banks raise capital and/or reduce their risk-weighted assets when deviating from their target Tier 1 ratios. However, the results do not take into account potential differences in the adjustment behavior between banks that are below or above their target. Table 7 provides results from regressions of the change in capital and assets where we account for potential asymmetric reactions by interacting the deviations from target Tier 1 ratios with a dummy variable equal one if the bank is below its target level and zero otherwise.

As evident from the first two columns of table 7, banks' response to Tier 1 deviations on growth in capital is significantly stronger when being below their target. The findings indicate that banks below their target capital ratios mostly drive the results in column 1 and 2 in table 5. Indeed, we do not find evidence for a significant effect of capital deviations on changes in Tier 1 capital for banks with capital surplus. This does not mean that banks above their capital ratios are not interested in getting back to their targets, but indicates that they prefer other measures to adjust their Tier 1 ratio.

We do not find any significant asymmetric adjustment behavior in the regressions of risk weighted assets and total assets. Neither do we find any difference in the adjustment behavior in loans of banks that are below and above their targets.

Table 7. *Regressions of growth in capital and assets*

	Growth in:			
	CB	**TC**	**RWA**	**TA**
$dev_{i,t}$	-0.0165*	-0.0156	0.0292	0.0148
	(-2.03)	(-1.90)	(1.70)	(0.73)
$Db_{i,t-1}$	-0.00434*	-0.00398*	0.000874	0.00291
	(-2.38)	(-2.49)	(0.52)	(1.77)
$dev_{i,t-1} * Db_{i,t-1}$	-0.0688**	-0.134***	0.0154	0.0139
	(-3.03)	(-5.62)	(0.68)	(0.51)
$GGDP_{i,t-1}$	0.203***	0.333***	-0.171***	0.194***
	(4.43)	(6.60)	(-3.64)	(3.66)
$INFL_{i,t-1}$	-0.271***	-0.228**	-0.460***	0.268***
	(-3.46)	(-2.92)	(-6.48)	(3.76)
$FOLIO_{i,t-1}$	0.123	0.295	0.243	-0.251
	(0.75)	(1.75)	(1.46)	(-1.62)
Constant	0.0116***	-0.00245	0.0193***	0.0134***
	(7.67)	(-1.96)	(11.03)	(6.99)
N	7358	7358	7358	7358

Notes: The table displays the results from regressions of growth in the total capital base *(CB)*, Tier 1 capital *(TR)*, risk weighted assets *(RWA)* and total assets *(TA)*. $dev_{i,t}$ is the Tier 1 capital deviation defined as the effective Tier 1 capital ratio minus the target ratio. $Db_{i,t-1}$ is a dummy equal one for banks with a negative value of $dev_{i,t}$. $dev_{i,t-1} * Db_{i,t-1}$ is an interaction variable. The other explanatory variables in row 4-6 are growth in GDP, inflation rate and the folio rate, respectively. All regressions include bank- and time-fixed effects. Absolute t-values are presented in parentheses. ***,** and * indicate statistical significance at the 1, 5 and 10 percent level in a two-tailed t-test.

10. Summary and Concluding Remarks

In this thesis, we have examined the regulatory capital adjustments of Norwegian banks. In particular, we have tried to answer the following questions. First, what factors determine banks' internal capital ratio targets? Second, how do deviations from these capital ratio targets influence banks' actions in terms of adjustments in capital and asset positions?

In order to answer the first question, a partial adjustment model of factors contributing to banks' target capital ratios is developed. The model is estimated on a panel of Norwegian commercial and saving banks over the period 1993q1 to 2013q1. We focus on the Tier 1 capital ratio. The results indicate that banks' target Tier 1 capital ratios decrease with bank size, which is consistent with other studies in the banking literature. One important reason for this relationship may be that larger banks are less liquidity-constrained and have smaller costs in adjusting their capital ratios. Furthermore, an increase in return on equity is shown to increase the target capita ratio. Since the return on equity may exceed the demanded remuneration required by banks, we interpret this variable as a measure of revenue rather than cost of capital. The positive relationship therefore indicates that banks increase their capital levels through retained earnings when the return on equity is high. There is a systematic variation between banks' target capital ratio and level of portfolio risk. Using a regulatory measure of portfolio risk, we find a negative effect. However, this does not necessarily mean that Norwegian banks have engaged in moral hazard behavior. Taken into account that most banks hold capital ratios above the regulatory minimum requirement, a negative relationship between risk and target capital ratios may indicate that risker banks hold less capital against a given asset-risk due to better risk-management. Moreover, an increase in banks' own assessment of the losses embedded in their asset portfolio is shown to increase the target capital ratio.

Norwegian banks face high costs of adjusting their capital ratios. On average, they close only 4.1 percent of the deviation between their effective and target capital ratio each quarter. We therefore conclude that high cost of adjusting capital is an important explanation of why they hold capital ratios in excess of the regulatory minimum.

Models of asset and capital growth are developed to assess how deviations from the target Tier 1 capital ratio influence banks' actions. We find that a deviation is negatively associated with the growth in banks' total capital base and Tier 1 capital, whereas it is positively associated with the growth in banks' risk weighted assets and total assets. The effect of a

deviation on adjustments in risk-weighted assets is significantly stronger than for total assets. We therefore conclude that re-shuffling assets in order to increase or decrease the Tier 1 capital ratio is an important strategy for Norwegian banks to adjust towards their target capital ratios. Furthermore, we find that a deviation from the Tier 1 capital ratio is positively correlated with the growth in loans to households and commercial loans (although, only at a 10 percent significance level in the commercial loans regression). We also show that banks' reactions to deviations are asymmetrical. In particular, we find that banks response to deviations on growth in both the total capital base and Tier 1 capital is significantly stronger when being below their target.

Bibliography

Acharya, V. V. (2011). Measuring and Regulating Systemic Risk. *NYU Stern Systemic Risk Rankings* .

Adrian, T., & Shin, H. (2010). Liquidity and Leverage. *Journal of Financial Intermediation , 19* (3), 418-437.

Akerlof, G. A. (1970). The Market for "Lemons": Quality Uncertainty and the Market Marketmechanism . *Quarterly Journal of Economics , 84* (3), pp. 488-500.

Alfon, I., Arguimón, I., & Bascuñana-Ambrós, P. (2005). How Individual Capital Requirements Affect Capital Ratios in UK Banks and Building Societies. *Working Paper No. 515, .*

Allen, H. J. (2013). A New Philosophy For Financial Stability Regulation. *Loyola University Chicago Law Journal , 45* (173), pp. 173-231.

Alonso-Borrego, C., & Arellano, M. (1996, September). Symmetrically normalised instrumental variable estimation using panel data. *Working Paper No. 9612* .

Andersen, H. (2009). Norwegian banks in a recession: Procyclical implications of Basel II. *Working Paper, Financial Department* (04).

Andersen, H. (2010). Sammenligning av norske bankers kapitaldekning. *Penger og Kreditt , 38* (1), 11-20.

Andrews, D., & Lu, B. (2001). Consistent Model and Moment Selection Procedures from GMM Estimation with Application to Dynamic Panel Data Models. *Journal of Econometric , 101*, 123-164.

Arellano, M., & Bond, S. (1991). Some tests of specification for panel data: Monte Carlo evidence and an application to employment equations. *The Review of Economic Studies , 58*, 277-297.

Ayuso, J., Perez, D., & Saurina, J. (2004). Are capital buffers pro-cyclical? *Journal of Financial Intermediation* (13), 249–264.

Bøhren, Ø. (2013, Mars 26). Ingen idealverden. *Dagens Næringsliv* , 25.

Bankenes Sikringsfond. (2013). Retrieved October 12, 2013, from www.bankenessikringsfond.no

Bauman, U., & Nier, E. (2006). Market discipline, disclosure and moral hazard in banking. *Journal of Financial Intermediation , 15* (3), 332–361.

BCBS. (2010). *Basel III: A global regulatory framework for more resilient banks and banking systems.* Bank For International Settlements.

BCBS. (1988). International Convergence of Capital Measurement and Capital Standards. *Basel Committee on Banking Supervision .*

Berge, A., Herring, R. J., & Szegö, G. (1995). The Role of Capital in Financial Institutions. *Whorton, Working Paper , 1.*

Berger, A., DeYoung, R., Flannery, M., Lee, D., & Öztekin, Ö. (2008). How do Large Banking Organizations Manage Their Capital Ratios? *Journal of Financial Services Research 34 ,* 123-149.

Berk, J., & DeMarzo, P. (2011). *Corporate Finance* (2nd ed.). Essex: Pearson Education Limited.

Berlin, M. (2011). Can We Explain Banks' Capital Structures? *. Business Review Q2 ,* pp. 1-11.

Bernanke, B. S. (1983). Non-Monetary Effects of the Financial Crisis in the Propagation of the Great Depression. *The American Economic Review, The American Economic Association , 73* (3), 257-276.

Berrospide, J. M., & Edge, R. M. (2010). The effects of bank capital on lending: What do we know, and what does it mean? *Finance and Economics Discussion Series .*

Blundell, R., & Bond, S. (1998). Initial conditions and moment restrictions in dynamic panel data models. *Journal of Econometrics ,* pp. 115-143.

Bond, S. (2002). Dynamic Panel Models: A Guide to Micro Data Methods and Practice. *Portoguese Economic Journal , 1,* 141-162.

Brewer, E. I., Kaufman, G., & Wall, L. (2008). Bank Capital Ratios Across Countries: Why do they vary? *Journal of Financial Services Research, 34 ,* 177-201.

Caruana, J. (2010). *Systemic risk: how to deal with it?* Retrieved 2013, from Bank for International Settlements (BIS): http://www.bis.org/publ/othp08.htm

Cohen, B. H. (2013, September). How have banks adjusted to higher capital requirements? *Bank For International Settlements: Quarterly Review* .

Crisis, L. b. (2009). Berrospide, Jose M.; Edge, Rochelle M. *Federal Reserve Board Working Paper* .

Dang, V., Garrett, I., & Nguyen, C. (2012). Asymmetric Partial Adjustment toward Target Leverage:International Evidence. *Working Paper* .

Diamond, D. W. (1984). Financial Intermediation and Delegated Monitoring. *Review of Economic Studies , 21* (3), 393-414.

Diamond, D. W., & Rajan, R. (2009). The Credit Crisis: Conjectures about causes and remedies. *American Economic Review 99* .

Duprey, T., & Lé, M. (2014). *Bank Capital Adjustment Process and Aggregate Lending.* Retrieved March 2014, from The Institut Louis Bachelier: http://risk2014.institutlouisbachelier.org/fichiers/bibliotheque/files/slide/parallel-session-7/paper-thibaut-duprey.pdf

ECB. (2011). Common equity capital, banks riskiness and required return on equity. *Financial Stability Review, December* , 125-131.

European Commission. (2013). Capital Requirements - CRD IV/CRR. *MEMO 13/690* .

Federal Reserve . (2003). Capital Standards for Banks: The Evolving Basel Accord. *Federal Reserve Bulletin September* , pp. 395-405.

Finance Norway (FNO). (2013). *Finans Norge.* Retrieved 2013, from Forretningsbanker i Norge - fusjoner og opphør: og http://www.fnh.no/Hoved/Statistikk/Bank/Forretningsbanker-i-Norge---fusjoner-og-opphor/

Finanstilsynet. (2013a). Bankregulering 8. Februar. *Valutaseminaret* . Oslo: Finanstilsynet.

Finanstilsynet. (2013, Mars 4). *Finanstilsynet.* Retrieved September 5, 2013, from Høringsnotat:

http://www.finanstilsynet.no/Global/Venstremeny/Aktuelt_vedlegg/2013/1_kvartal/Kapitalkr
av_og_risikovekter_for_boliglan_horingsnotat.pdf

Finanstilsynet. (2011). Rapport: Mars 2011. *Finansielt utsyn* .

Flannerey, M. J., & Rangan, K. P. (2006). Partial adjustment toward target capital structures. *Journal of Financial Economics , 79* (3), 469-506.

Flannery, M. J., & Hankins, K. W. (2012). Estimating dynamic panel models in corporate finance. *Journal of Corporate Finance , 19*, 1-19.

Francis, W. B., & Osborne, M. (2009b). On the Behavior and Determinants of Risk‑Based Capital Ratios: Revisiting the Evidence from UK Banking Institutions. *Occasional Paper Series* (31).

Francis, W., & Osborne, M. (2009a). Bank regulation, capital and credit supply: Measuring the impact of Prudential Standards. *FSA: Occasional Paper Series 36* .

Furfine, C. (2001). Bank Portfoilio Allocation: The Impact of Capital Requirements, Regulatory Monitoring and Economic Conditions. *Journal of Financial Services Research , 20* (1), 33-56.

Hancock, D., & Wilcox, J. A. (1994). Bank Capital and the Credit Crunch: The Roles of Risk-Weighted and Unweighted Capital Regulations. *Real Estate Economics , 22* (1), 59-94.

Hancock, D., Liang, A., & Wilcox, J. A. (1995). Bank capital shocks: Dynamic effects on securities, loans, and capital. *Journal of Banking & Finance , 19* (3-4), 661–677.

Hoang, N. T., & Mcnown, R. F. (2008). Panel Data Unit Roots Tests Using Various Estimation Methods. *Working Paper University of Colorado at Boulder* .

Jacobsen, H., B.Kloster, T., B. Kvinlog, A., & Larsen, U. (2011). Makroøkonomiske virkninger av høyere capitalkrav for bankene. *Staff Memo* (14).

Jokipii, T., & Milne, A. (2008). The cyclical behaviour of European bank capital buffers. *Journal of Banking & Finance , 32*, 1440–1451.

Judson, R. A., & Owen, A. L. (1999). Estimating dynamic panel data models: a guide for macroeconomists. *Economics Letters* (65), 9-15.

Kashyap, A. K., Stein, J. C., & Hanson, S. (2010). An analysis of the impact of "substantially Heightened" capital requirements on large financial institutions. *Working Paper* .

Keeley, M. (1990). Deposit Insurance, Risk, and Market Power in Banking. *The American Economic Review* , *80* (5), pp. 1183-1200.

Kok, C., & Schepens, G. (2013). Bank reactions after capital shortfalls. *Working Paper Series European Central Bank* , *1611*.

Kragh-Sørensen, K. (2012). Oprimal kapitaldekning for norske banker. *Staff Memo, 29* .

Lindquist, K.-G. (2003). Banks Capital Buffer: How Important is Risk? *Working Paper 2003/11* .

Marshall, D., & Prescott, E. (2000). Bank capital regulation with and without statecontigent penalties. *Working Paper* .

Maurin, L., & Toivanen. (2012). Risk, capital buffer and bank lending. A granular apporach to the adjustment of euro area banks. *Working Papers Series No 1499* .

Memmel, C., & Raupach, P. (2010). How Do Banks Adjust Their Capital Ratios? Evidence from Germany. *Journal of Financial Intermediation* , *19* (4), 509-528.

Merton, R. C. (1977). An analytical derivation of the cost of deposit unsurance and loan guarantes. *Journal of Banking and Finance* , *3* (39), 1-37.

Miller, M. H. (1995). Do the M & M propositions apply to banks? *Journal of Banking and Finance,19* , 483-489.

Modigliani, F., & Miller, M. H. (1958). The cost of capital, corporation finance and the theory of investment. *The American Economic Review* , 261-297.

Moe, T. G., & Vale, B. (2012). Initiativer internasjonalt for å håndtere systemrisikoen ved store banker. *Aktuell Kommentar* (13).

Myers, S. C., & Majluf, N. S. (1984). Corporate financing and investment decisions when firms have information that investors do not have. *Journal of Financial Economics,13* , 187-222.

Norges Bank. (2010). *Finansiell Stabilitet 1/2010.* Retrieved 2013, from Norges Bank: http://www.norges-bank.no/upload/80064/finansiell_stabilitet_rapport_1_2010.pdf

Norges Bank. (2013). Kriterier for en god motsyklisk kapitalbuffer. *Memo nr. 1* .

Norges Bank. (2004). Norske finansmarkeder - pengepolitikk og finansiell stabilitet. *Norges Banks Skriftserie nr. 34* , 66-74.

NOU 2000:9. (2000). *Konkurranseflater i finansnæringen.* Retrieved May 2013, from Finansdepartementet: http://www.regjeringen.no/nb/dep/fin/dok/nouer/2000/nou-2000-9/4/1/1.html?id=357504

NOU 2012:2. (2012). *Regjeringen.* Retrieved from NOU-er: http://www.regjeringen.no/nb/dep/ud/dok/nou-er.html?id=2109

Olsen, Ø. (2013). Countercyclical capital buffer - creiteria for use and interaction with monetary policy. *Annual meeting of ACI Norge.* Oslo: Norges Bank.

Olsen, Ø. (2013). Macroprudential policy and financial stability. *A Meeting at Norwegian Savings Banks Association 31 October.* Oslo: Bank for International Settlements.

Rime, B. (2001). Capital requirement and bank behaviour: Evidence from Switzerland. *Journal of Banking & Finance 25* , 789-805.

Roodman, D. (2009). How to do Xtabond2: An introduction to difference and system GMM in Stata. *The Stata Journal , 9* (1), 86-136.

Stolz, S., & Wedow, M. (2005). Banks`regulatory capital buffer and the business cycle: evidence for German savings and cooperative banks. *Deutche Bundesbank: Discussion Paper, Series 2 No 7* .

Syvertsen, B. D. (2012). Sammenligning av nordiske og norske banker basert på ulike soliditetsmål. *Aktuell Kommentar* (9).

Tabak, B. M., Noronha, A. N., & Cajueiro, D. (2011). Bank capital buffers, lending growth and economic cycle: empirical evidence for Brazil. *Paper prepared for the 2nd BIS CCA Conference.* Ottawa.

The Norwegian Savings Banks Association . (2013). *Sparebankforeningen.* Retrieved 2013, from Sparebankgrupperinger: http://www.sparebankforeningen.no/id/1493

Vale, B. (2011). Effects of higher equity ratio on a bank´s total funding costs and lending. *Staff Memo No.10* .

Vale, B. (2011). Effects of higher equity ratio on a bank's total funding cost and lending. *Staff Memo, 10* .

Vale, B. (2004). The Norwegian Banking Crisis. *Norges Bank skriftserie No. 33 Chapter 1* .

Verbeek, M. (2012). *A Guide to Modern Econometrics.* Chichester: John Wiley & Sons Ltd.

Wooldridge, J. M. (2009). *Introductory Econometrics: A Modern Approach* (4 ed.). South-Western, a part of Cengage Learning.

A.1 The Modigliani and Miller Irrelevance Theorem

This appendix provides a mathematical expression of Modigliani and Miller`s irrelevance theorem of capital structure. We follow Vale (2011) who expresses the theorem in the following way: A bank is funded by equity E and debt D. The required return on equity is R_E and the required return on debt is R_D. The banks total funding costs C relative to total liability is:

$$C = \frac{R_E \cdot E + R_D \cdot D}{D + E}$$

The total funding cost C can be expressed as:

$$C = R_E(\underline{e})e + R_D(\underline{e})(1 - e),$$

by defining e as the equity ratio $E/(D + E)$ and taking into account that R_E and R_D are decreasing in e as explained in subsection 2.1. Under MM the effect on total funding cost of higher equity ratio becomes:

$$dC = (R_E - R_D)de + \frac{\partial R_E}{\partial e} \cdot e \cdot de + \frac{\partial R_D}{\partial e}(1 - e)de = 0$$

It follows from the discussion in subsection 2.1 that the first term is positive since equity is more risky than debt. Furthermore, both the second and the third term are negative since higher equity ratio reduces the risk of equity and debt. Under MM, the negative effects of the reduced debt and equity premium offset the positive effect of the increased use of the more expensive equity. The effect on total funding cost of higher equity ratio is zero under MM.