An Empirical Analysis

of

Bank Capital and Capital Requirements' Impact on Lending: Evidence from Scandinavia in the period 2013 to 2016

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Abstract

The effect of bank capital and capital requirements on bank lending is a key determinant of the linkage between the financial conditions of the banking sector and real activity in the economy through credit supply. Quantifying the relationship has therefore been subject to increasing attention from researchers in trajectory with the general increase in capital requirements in the past decades. We estimate a panel data regression on a sample of 137 Scandinavian banks between 2013-2016 to test the effect of bank capital and Basel III capital requirements on bank lending. The empirical study's research design is informed by theoretical insights from the 'bank capital channel' literature. The thesis adds to the discussion in the academic literature on capital requirements on lending by considering the recent implementation of Basel III requirements, which has not yet been studied. Our results can be summarised as follows.

First, we find that an increase in the equity-to-assets ratio leads to a modest increase in lending growth. We thus confirm the findings of previous empirical studies like Berrospide & Edge (2010). Secondly, in contrast to other empirical studies, we find no evidence of a direct significant relationship between capital requirements and lending growth. Neither, do we find evidence of a relationship between excess capital held above capital requirements and bank lending. Further, we some find evidence that under-capitalised banks are associated with significant lower lending growth compared to adequately capitalised banks. Finally, evidence is found that that lending behaviour of listed banks is less negatively affected by an increase in capital ratios compared to non-listed banks. Some evidence is also found in support of differences in lending behaviour across bank size but not across the three Scandinavian countries, Denmark, Sweden and Norway.

Keywords: Bank capital, bank lending, regulatory capital requirements, capital buffer.

Preface

Copenhagen, Monday 15th of May, 2017

This thesis was written during the spring of 2017. We would like to thank our supervisor Peter Ove Christensen for his guidance and qualified inputs in the process of creating this thesis.

Further thanks to FinansDanmark for accepting us to be part of their ThesisLab and for putting their offices and other resources at our disposal. The ThesisLab and the atmosphere amongst the participating students has made the writing process much more enjoyable. Those students also deserve appreciation for their intellectual and moral support.

Lastly, we are very grateful for our significant others. Without their patience and support, the completion of this thesis would not have been possible.

Anders Skindhøj and Nicolai Kjær Jacobsen

Layout and typography are made in LaTeX

List of Abbreviations

General	**Abbreviations**
FE	Fixed Effects
RE	Random Effects
LB	Listed Banks
M&M	Modgliani & Miller

Variable	**Abbreviations**
T1CR	Tier 1 Capital Ratio
TCR	Total Capital Ratio
T1CRR	Tier 1 Capital Requirement Ratio
E/A	Equity to Assets
RWA	Risk Weighted Assets
GDP	Gross Domestic Product

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Chapter 1

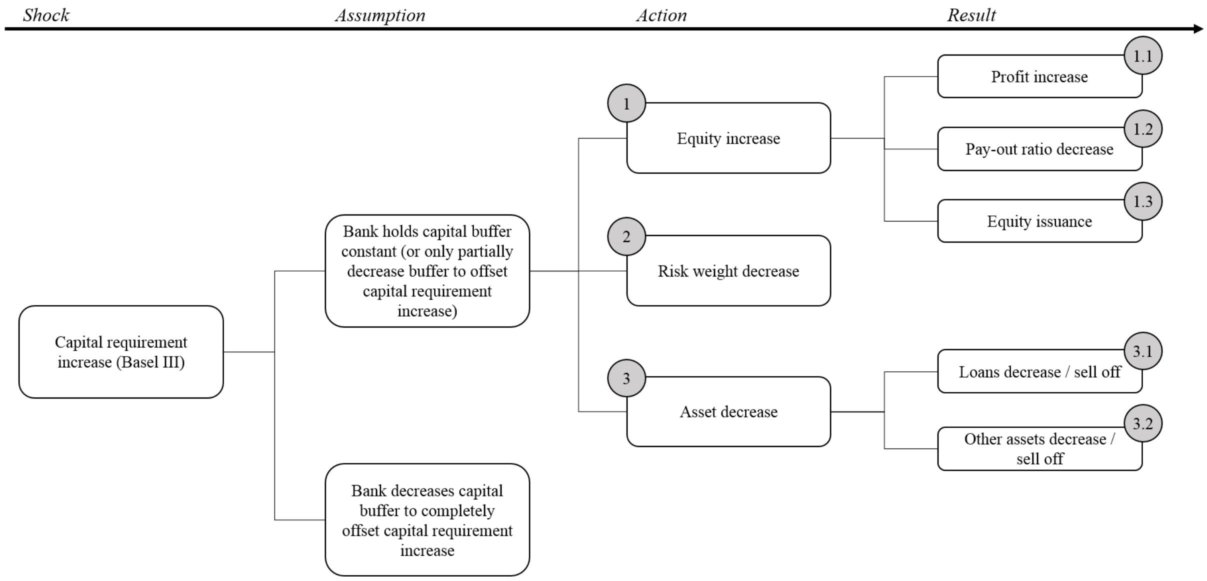
Introduction

The effect of bank capital and capital requirements on bank lending is a key determinant of the linkage between the financial conditions of the banking sector and real activity in the economy through credit supply. Quantifying the relationship has therefore been subject to increasing attention from researchers in trajectory with the general increase in capital requirements in the past decades. The implementation of the latest Basel accord, Basel III, in Scandinavia in the period 2013-2019 requires banks to hold an unprecedented high level of total capital to risk-weighted assets (RWA). The period 2013-2016 therefore provides an interesting period in which to investigate the aforementioned relationship to add to the discussion in the academic literature on the relationship of bank's capital and capital requirements effect on lending growth.

Intuitively, a bank facing rising capital requirements has three options available to increase its risk-adjusted total capital ratio, $Total\,Capital/Risk\,Weighted\,Assets$, assuming that it holds its capital buffer constant. Figure 1.1 illustrates the three options. The first option is for the bank to increase its total capital. The bank can increase its total capital in three ways. Firstly, the bank can increase its retained earnings (assuming constant profits) by reducing the pay-out ratio[1] (the share of profit that is paid out to shareholders in the form of dividends) to build a larger capital base. Secondly, the bank can seek to increase its profits (assuming constant dividend pay-out ratio) to build a larger capital base, e.g. by increasing the spread between the interest rate that it charges on its loans, and the interest rate that the bank pays on its financing. Thirdly, the bank may issue new equity. In chapter 3, we show that issuing new equity might be an expensive solution. The second option available to the bank is to reduce risk weights on its loan portfolio. The third option available to the bank is to reduce its assets. We distinguish between reductions in its loan portfolio (e.g. by writing off its loans, selling its loan portfolio to another bank or less drastically reduce its loan growth) and reductions in other assets. Reductions in loan growth affects the credit available in the economy, and capital requirements can thereby affect the overall credit available to the economy. It is the effect of bank capital and capital requirements on banks' loan growth that the thesis seeks to understand.

1. Or reduce the amount of share buyback

Figure 1.1: Transmission Flow Chart



1.1 Objective and Research Design

The objective of the thesis is to provide a comprehensive empirical analysis of the relationship between bank capital, capital requirements and bank lending in the period 2013-2016 by using a panel dataset of Scandinavian banks. Specifically, we seek to empirically estimate the effect of banks' capital holdings and national capital requirements' effect on the credit supply. The thesis' research objective is of significant interest, when considering credit supply's perceived role in facilitating economic growth and the harshening of the regulatory framework in recent years as a direct outcome of the financial crisis of 2007/2008. We analyse publicly available income statement, balance sheet and capitalisation figures for 137 Scandinavian banks during the period 2011-2016.[2] We restrict our sample to banks whose primary focus is lending. Both publicly listed and non-listed banks are included. Each bank in the dataset has on average 5.2 time observations. The empirical analysis will be carried out through the use of panel data regression methodology. We estimate a two-way fixed effects panel regression with banks' gross loan growth as the dependent variable, banks' capital ratios and national capital requirements as the main explanatory variables and control for other relevant determinants of lending.

The main research question (RQ), which we seek to answer, can be formulated as:

- **RQ**: To what extent has bank capital and Basel III's capital requirements affected bank lending in Scandinavia between 2013-2016?

The main research question can be decomposed into the following sub-research questions (SRQ):

2. We investigate lending growth between 2013-2016, but we include data from 2011 and 2012 in the study, as the one-period lagged loan growth is used as a control variable in the regression model of chapter 7

- **SRQ 1**: To what extent does excess bank capital influence lending behaviour among Scandinavian banks?
- **SRQ 2**: How does the lending behaviour differ between well-capitalised and under-capitalised Scandinavian banks?
- **SRQ 3**: How does bank capital and capital requirements' affect on lending differ depending on bank location, relative size, and whether a bank is publicly listed or not?

1.2 Main Findings

First, we find that an increase in the equity-to-assets ratio leads to a modest increase in lending growth. We thus confirm the findings of previous empirical studies like Berrospide & Edge (2010). Secondly, in contrast to other empirical studies, we find no evidence of a direct significant relationship between capital requirements and lending growth. Neither, do we find evidence of a relationship between excess capital held above capital requirements and bank lending. Further, we find some evidence that under-capitalised banks are associated with significant lower lending growth compared to adequately capitalised banks. Finally, evidence is found that that lending behaviour of listed banks is less negatively affected by an increase in capital ratios compared to non-listed banks. Some evidence is also found in support of differences in lending behaviour across bank size but not across the three Scandinavian countries, Denmark, Norway and Sweden.

1.3 Theory & Methodology

This thesis seeks to support its research design with existing theory. Hence, the bank capital channel provides the theoretical foundation of the thesis. The theory argues for the existence of a channel wherein shocks to a bank's capital (e.g. from capital requirements) can affect the level and composition of assets of the bank. Thus, the theory argues that in some instances, a profit-maximising bank might find it optimal to reduce or alter its assets mix following a shock to its financing. Specifically, we use Francis & Osborne's (2009) 'bank capital channel' model which seek to explain the relationship between bank capital, capital requirements and lending. It rests upon two main assumptions of capital requirements being to some degree uncertain and equity issuance being expensive. Along with Francis & Osborne's (2009) model, traditional capital structure theories will act as a major source of reference for justification of Francis & Osborne's model assumptions and hypothesis and for identifying other bank specific characteristics that affect lending.

Empirical studies on the relationship between bank capital, capital requirements and bank lending will likewise act as major sources of reference. The studies include, but are not limited to, Berrospide & Edge (2010), Mésonnier & Monks (2015), and Kragh & Rangvid (2016). The empirical studies include a mixture of journal articles and industry articles published by various industry actors such as national FSAs, central banks and the IMF. The empirical studies will inform the regression methodology used, and the results of our empirical analysis will be contrasted to the most relevant empirical papers.

1.4 Research Gap and Contribution

Overall, the thesis seeks to add another piece to the puzzle of the effect of bank capital and capital requirements on lending growth. Hence it aims at contributing to the enlargement of the literature within this field, where consensus on capital requirement's effect on banks' lending behaviour is still widely discussed. As evident from the above introduction a substantial amount of empirical literature exists, which all investigate the relationship between capital as well as capital requirements on bank lending in different settings and set-ups. However, little research has been done in the context of the most recent strengthening of capital requirements stemming from Basel III, which has arguably introduced the toughest capital requirements on banks yet. In addition, only little research on Scandinavian countries has been conducted, and there exists no Scandinavian cross-country study to the best of our knowledge. Thus, this study contributes to the literature by utilising the most recent data obtainable to provide an insightful investigation of the relationship between capital, capital requirements and bank lending in the implementation period of Basel III covering the years 2013-2016. Moreover, we apply several bank specific segmentations, such as capitalisation degrees, size of bank, and whether banks are publicly listed. The segmentations may reveal interesting results given the theoretical insights of these features.

1.5 Delimitations

The main objective of the thesis is to investigate the effect of bank capital and capital requirements on lending. We limit the focus of the thesis by not considering the welfare effects of credit supply and capital requirements on the economy as a whole. Similarly, the normative discussion of capital regulations will not be considered. As a means of fulfilling the research objective, we rely on traditional capital structure theories to identify components that influence bank lending. Despite the somewhat extensive use of traditional capital structure theories, we do not aim at investigating the optimal capital structure of banks, nor is it the aim to carry out an analysis of banks' adjustment process towards a target capital ratio if one such exists. Further, the focus of the thesis is solely on the capital requirements part of bank regulation. We acknowledge that other bank related regulation may influence the relationship of interest, and that such regulation has emerged in recent years, e.g. Liquidity Coverage Ratio (LCR) Net Stable Funding Ratio (NSFR), Total Loss Absorbing Capacity (TLAC), and Minimum Requirements for own funds and Eligible Liabilities (MREL). However, such regulation and other bank regulation are not investigated in this thesis. Furthermore, the thesis applies econometric methods in the model estimations. While having a strong focus on applying correct and appropriate estimation techniques, it is not at the core of the thesis to provide a comprehensive assessment of econometric theory. Lastly, on the practical side, the thesis contains bank specific data from more than 800 financial statements. A manual inspection of the correctness of the data is therefore not possible. Hence we rely fully on the chosen database to provide accurate data.

1.6 Structure of Thesis

The thesis is divided into nine chapters. The first chapter introduces the research design and framework of the thesis. To provide an understanding of the empirical study, chapters 2, 3, and 4 review the fundamentals of banking, the regulatory environment, theoretical insights of capital's effect on lending and the empirical literature within the field of study. The second chapter reviews the distinct features of banking, and it describes the development of the current regulatory framework surrounding Scandinavian banks. Chapter 3 introduces traditional capital structure theories in the context of banking. It presents a bank-level theoretical model of the link between bank capital, capital requirements and lending. Chapter 4 reviews the methodology and findings of the empirical studies within the research field. Thus, chapters 2, 3 and 4 serve as the foundation for the empirical analysis. Chapters 5, 6, and 7 present the methodology and results of the empirical study. Chapter 5 describes the data selection and implications arising from the data extraction. Chapter 6 describes the research methodology including the model specification, parameter choices, and econometric considerations. Chapter 7 presents the results and robustness of the empirical study. Chapter 8 discusses the broader validity of empirical studies within the field of capital requirements and bank lending by focusing on the theoretical assumptions and methodological issues. Finally, chapter 9 concludes the thesis.

Chapter 2

Institutional Review

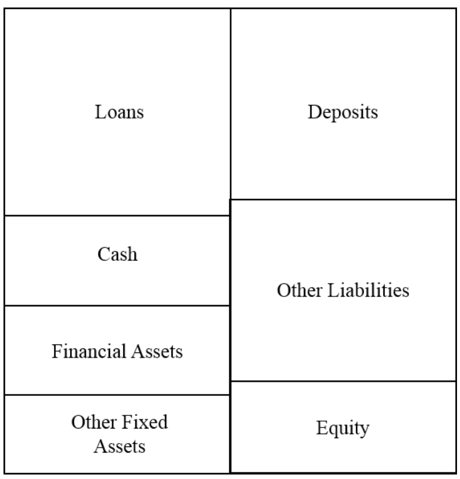
To analyse the effect of bank capital and capital requirements on loan growth, we first need to understand the bank's business model and the corresponding risks that it carries. The bank plays an essential role in the economy by providing liquidity, however the centrality of the banking sector in the economy also imposes risk upon the economy as evident in the financial crisis of 2007-2008. The chapter will explain the fundamental functions of a bank, its risks and the capital requirements its faces.

2.1 Fundamental of Banking

2.1.1 A Bank's Balance Sheet

The bank's balance sheet made up of assets and liabilities and equity as any other firm. The assets constitute the bank's income potential, and it can be divided in the following main types of assets: Loans, cash, financial assets, and other fixed assets. Liabilities and equity finance the assets of a bank. At a simplified level, bank's liabilities can be divided into deposits and other liabilities. Figure 2.1 illustrates a simplified balance sheet of a bank:

Figure 2.1: A Bank's Balance Sheet



Typically, loans account for the largest part of assets of a bank, and it is the primary source of income for a bank. The income is generated by charging borrowers an interest rate on the amount of loan that they lend from the bank. A bank finances its loans through liabilities, which it pays an interest rate on. A large part of its income is thus the difference between the interest it earn on its loans and the interest it pays on its liabilities. A substantial part of a bank's income also comes from the various fees the bank charges for its services (e.g. factoring, cards, transactions, advisory). The bank holds a given part of its assets as cash and deposits with central banks. These types of assets have a limited contribution to the bank's income generation. Cash is held to meet the bank's short-term liquidity needs e.g. when a customer wants to withdraw its deposits. Financial assets include the bank's stock of securities such as bonds and derivatives. They contribute to the income generation as well as the bank's short-term liquidity, as they can be converted to cash in case of an increased demand hereof. Other fixed assets can include properties, inventory and equipment, which are indirectly income generating by supporting the services and functioning of the bank (Hull 2010).

The bank obtains funds by borrowing and issuing liabilities such as deposits. Deposits are the primary source of a bank's liabilities, and they are thus an essential source of financing, which is also relatively stable. Additionally, there is a large market for interbank lending. It allows banks with deposit in excess of what it needs to finance it operations to lend to banks with insufficient amounts of deposits to finance its operations. The interbank lending market contributes to an increased dependency between banks and it connects the industry across national borders (Rangvid 2013).

Finally, the remaining part of the bank's assets is financed through equity. The equity primarily constitutes shareholder capital, retained earnings, and accumulated reserves. Equity is loss-absorbing meaning that the value of the equity decreases one-to-one with a decrease in the value of assets. Hence, the bank's equity is an important determinant of the bank's solidness and its ability to withstand future losses, as a decrease in the value of assets exceeding the total value of equity will make the bank insolvent. The capital to asset ratio is a crucial aspect of ensuring the bank's solvency, an aspect that will be further discussed later in the thesis.

2.1.2 Maturity transformation

An important function of a bank is to create liquidity by offering deposits that are more liquid than the assets it holds (Diamond 2007). The function is often termed "liquidity transformation" or "transforming maturities". By accepting short-term liquid liabilities in the form of deposits and issuing longer-term illiquid loans, the bank effectively transfers funds from savings to investments (Al-Khouri 2012). The transformation can benefit production and growth in society by intermediating between savers and borrowers[1]. Liquidity transformation stems from investors, who are liquid but do not want to consume now (but some time in the future), and

1. The thesis will not focus on the welfare effects of banking, and thus this discussion will not be pursued further.

borrowers, who are illiquid but want to consume now (Al-Khouri 2012). The uncertainty of consumption from investors are transferred into the bank's deposit portfolio, whose actual maturity is highly uncertain, as the investor always expects his deposits to be readily available, unless a fixed maturity has been agreed upon (Al-Khouri 2012). The illiquid borrowers constitute the loan portfolio of the bank. The downside of this model is that the liquidity mismatch between the bank's assets and liabilities may result in a "bank run", when too many depositors attempt to withdraw their funds at the same time (Diamond 2007). The more a bank engages in liquidity transformation the more dependent it is on future financing from deposits or the capital markets. In case of a slowdown in deposits compared to loans, the maturity mismatch may force the bank to liquidate otherwise illiquid assets at a loss (Al-Khouri 2012). Prior to the financial crisis of 2007/2008 many banks had engaged in extensive liquidity transformation widening the maturity mismatch between loans and deposits. It made the need for market financing more urgent. The sudden uncertainty in the industry triggered by the decrease in loan demand caused a sudden drop in available market financing. It resulted in banks becoming insolvent, as they had to liquidate loans at large losses (Rangvid 2013).

2.1.3 Risks

The preceding subsection 2.1.2 shows that a bank is exposed to liquidity risk, if it cannot raise cash fast enough to meet demand from depositors or if the bank, in doing so, incurs large losses due to the "fire sale" of illiquid assets. In the extreme case of a bank run, where (all) depositors withdraw their money simultaneously, the bank also faces the risk of becoming insolvent, as the bank is forced to liquidate illiquid assets at large losses. If the capital holdings are incapable of absorbing the large losses then the bank is insolvent. In addition, the bank is also exposed to other types of risk, which will be discussed in the following paragraphs. Throughout the paragraphs, we define risk as the probability of sustaining losses on a bank's asset portfolio.

Credit Risk

Credit risk is the risk that counterparties in loan transactions will default (Hull 2010). The potential loss to the bank includes lost principal, interest and increased collection costs, however, in some cases, the bank may be able to partially collect the amounts due (Bessis 2010). In some instances, the bank may not face an immediate cost but simply an increase in counterparty credit risk due to a deteriorated credit quality of the counterparty. The loan portfolio is the primary source of income for the bank, and it constitutes the greatest risk exposure. Hence, a bank conducts a credit analysis to evaluate the ability of the counterparty to honour its financial obligations and, thereby, its probability of default (Bessis 2010). At the issuance of a loan, a borrower's probability of default is taken into consideration, when determining the interest rate that the borrower must pay. A bank adjusts its interest rate offered to reflect the borrower's credit quality to ensure a satisfying relationship between risk and return for the bank. There are several ways in which a borrower may improve his credit quality to reduce his interest payments. One common way is to provide collateral in assets such as property or equipment. If the borrower is unable to meet his debt obligations, the bank can seize the collateralised assets to recover potential losses. Collateral will reduce the borrower's credit risk and thereby reduce his interest payments.

Operational and Market Risk

A consensus on a definition of operational risk has not emerged in the literature, yet. Nonetheless, the Basel Committee on Banking Supervision, which will be reviewed later in the chapter, has defined it, as "*the risk of direct or indirect loss resulting from inadequate or failed internal processes, people, and systems or from external events*" (Basel 2006). This includes, but is not limited to, internal and external fraud, system failures, and damage to physical assets due to natural disasters. A focus on reducing operational risk became particularly amplified among banks when regulators imposed capital requirements on it (Hull 2010). Market risk is the probability of a bank to sustain losses due to factors that affect the overall performance of the financial markets in, which the bank is involved (Bessis 2010). Market risk is primarily situated in the bank's trading book and it is the risk of securities declining in value. Market risk factors include interest rates, exchange rates and equity indexes, among others. The magnitude of the risk is dependent on the liquidity of an instrument, where less liquid instruments generally carry a higher market risk (Bessis 2010).

Systemic Risk

As described in section 2.1.1, banks engage in interbank lending which exposes them to a general collapse in the banking industry. This risk is called systemic risk, and it is enhanced by an increasing nominal amount of transactions between banks (Hull 2010). Systemic risk is also addressed by Admati & Hellwig (2013), who describe it as a contagion effect where the failure of one bank imposes losses upon other banks, and the losses may cause them to fail as well, and so on. This risk is increasing with the level of interrelatedness between two banks and the size of the bank. On a bank-level, systemic risk cannot be diversified away but limiting interbank lending and implementing a more conservative lending policy may reduce it (Rangvid 2013). Several banks were bailed out during the financial crisis of 2007/2008 because governments were concerned about the systemic risk of letting them fail. In the time up to the financial crisis the complexity in the industry had increased, while the transparency had decreased, making it increasingly difficult to identify the true creditworthiness of banks. Thus, less creditworthy banks could obtain cheaper and larger loans. When the market crashed, several of these banks became insolvent, which through the interrelatedness of banks ultimately affected the entire industry, and it caused the government to bail out some of the largest banks (Rangvid 2013).

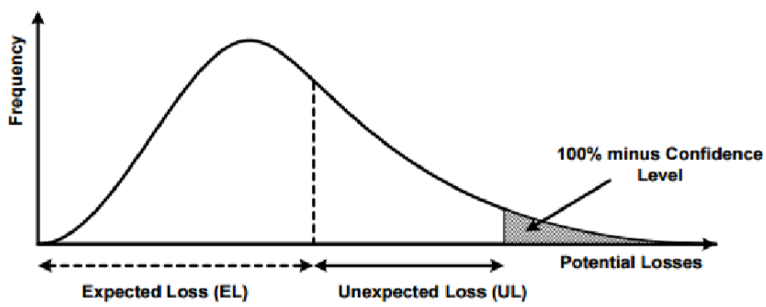
Risk Covering

The preceding section explains the different risks a bank face. Despite being able to mitigate the credit risk of its loan portfolio through sound lending policies, the risk that some customers will not be able to meet their obligations remain. The following paragraphs describe, how a bank ensures coverage of these potential losses through the parameters: Expected and unexpected losses.

Expected loss The expected loss describes the average loss, based on historic data, that a bank expects to incur on borrowers who are not able to meet their future obligations (Bessis 2010). The expected loss considers the historic risk exposure on the loan portfolio, where a larger share of risky borrowers will result in a larger expected loss. The expected loss will be covered through adding a risk premium to the borrower's interest rate (Ibid.). As expected loss describes the average loss on a loan portfolio, then the actual individual losses may vary. When the probability of the borrower not being able to meet his future obligations becomes predominant it is common to take provisions, which will ultimately be reflected in the level of expected loss (Resti et al. 2007).

Unexpected loss The unexpected loss is a measure of the potential loss a bank may incur, exceeding the expected loss, in stressed market situations. The unexpected loss constitutes a significant credit risk for the bank, as it is not covered with any risk premium on the borrower's price. Instead the bank must hold enough loss absorbing capital to ensure itself against future stress scenarios, which could make the bank insolvent. Thus, an adequate capital buffer is essential for the bank to withstand above average losses, which could occur from economic downturn. Figure 2.2 depicts the credit loss distribution and the area for which the bank must hold capital. The y-axis shows the frequency of losses and the x-axis shows the magnitude of loss. A bank's expected loss is the area left of the dashed line, which indicates the historic average loss, and the unexpected loss is the area between the dashed line and the confidence level. It is this area for which the bank must hold a capital buffer. The grey area indicates the magnitude of losses which are highly unlikely to occur, hence the bank is not required to hold a capital buffer for this area.

Figure 2.2: Distribution of Potential Losses



Source: BCBS 2005

Much regulation has been implemented to ensure that banks hold sufficient amounts of capital - a matter which will be discussed in the next section.

This section has given a concise presentation of the fundamentals of banking including a bank's general business model, the risks that a bank faces, and how a bank can mitigate and cover these risks. This general knowledge will allow us to proceed with understanding why and how banks are regulated.

Until now, we have used the words equity and capital interchangeably. This is not uncommon but may be a cause of some confusion when addressing capital regulation. It will become apparent from the following section that capital requirements are based on *regulatory* defined capital and not book equity. Although the two concepts are largely similar, important differences exist. Whereas 'equity' refers to the book value of equity on the balance sheet, 'capital' refers to the regulatory defined loss absorbing capital. Certain subordinated and convertible debt may be included in regulatory capital unlike the book value of equity. To avoid confusion, we use capital when we mean regulatory capital and equity when we mean book equity.

2.2 Bank Regulation

The purpose of bank regulation is to ensure that banks hold enough capital to cover the risk that they take (Hull 2010). One might ask why a bank is not capable of insuring a sufficient level of capital and, like most other firms, maintain a level of capital commensurate with the risks they take. There are two explanations to why this view does not hold. Equity holders have historically allowed banks to take excessive risks, and the introduction of deposit insurance reduced the incentive of depositors to monitor their banks.

2.2.1 Deposit Insurance and Moral Hazard

As discussed in section 2.1, *Fundamentals of Banking*, the bank is largely financed by deposits. This fact makes the bank exposed to liquidity risk should a large portion of the depositors attempt to withdraw their funds simultaneously. It can happen, if depositors fear that the bank is in financial distress and that their funds may therefore suffer a loss (Hull 2010). Whether the bank is actually in financial distress matters little as simply the rumour of financial distress may cause a panic among depositors, who run to withdraw their cash, thus making the rumour self-fulfilling (Admati & Hellwig 2013). Such a situation is depicted very well in the 1964 film classic "Mary Poppins". The situation, called a "bank run", is very costly for the bank, and therefore creates an incentive for the bank to do what it can to avoid it. Failure of the bank may also be harmful to the depositors creating a mutual interest in monitoring the bank. However, history has shown that this mutual interest in monitoring banks has not been enough to avoid costly failures of banks, which has caused governments to step in to insure stability.

To ensure financial stability, protect depositors and generally mitigate bank fragility government regulators in many countries have introduced guarantee programs (Hull 2010). These are often referred to as deposit insurance, insuring depositors against losses up to a certain level. In the EU, the deposit insurance is enacted under the National Deposit Guarantee Scheme (DGS), which ensures that all deposits up to EUR 100,000 are protected (EU 2014). With such a deposit insurance, governments effectively reduces the risk that the depositors hold and thereby significantly reduces their incentive for monitoring the banks. In other words, the risk-return trade-off between depositors and banks is distorted, as the depositors' required return do not increase with increased risk taking by the banks. It thereby creates an incentive for the bank to pursue riskier activities, as it knows that it is less likely to lose depositors (Hull 2010). Such a behaviour is commonly referred to as *moral hazard*. The type of moral hazard just explained occurs from an *explicit* government guarantee scheme. Additionally, large banks are also covered by an *implicit* government guarantee arising from the fact that the overall consequences for society in case of a default are so large that the government will step in to avoid it (Hull 2010). These banks are often referred to as the "too-big-to-fail" banks, for whom the incentive to take on additional risk is increased.

Both the explicit and implicit guarantees create moral hazard incentives to take on additional risk, which is against the intention of the guarantees. The incentives may, however, be reduced through bank regulation such as setting higher requirements to the size of banks loss absorbing capital, as losses will then be covered by the shareholders and not the depositors. Shareholders will, *ceteris paribus*, sanction too risky banks, thus reducing the incentive for banks to take on additional risk.

2.2.2 Regulatory Agencies

In 1974, the Basel Committee of Banking Supervision, BCBS (hereinafter Basel Committee) was established originally by ten countries' central banks but have since expanded its membership base. The Basel Committee has since its formation been the primary global standard setter for the prudential regulation of banks (BIS 2017). Its main purpose is to enhance financial stability through a mandate of strengthening regulation, supervision and general practices of banks (Ibid.). The Basel Committee does not have the authority to implement regulation, thus its recommendations only serve as guidance for national (or EU-wide) laws and regulation. The recommendations have historically been given substantial weight in the legislation among the participating countries, and EU has i continuously implemented the recommendations into EU-directives. National Financial Services Authorities (FSAs), who to some extent can adjust regulation in accordance with national needs, monitor certain guidelines. This option will be discussed in section 2.2.6 where a review of additional regulation in Scandinavia will be presented.

Bank regulation has existed for many years, but the demand hereof has increased substantially in recent years due to increasing creativity and complexity within the industry. Further, banks are increasingly operating across borders, which have added a need for global regulatory standards. The following sections will provide a brief overview of the original Basel accords I to III, including important additions and modifications added during the period. The focus will be on understanding the evolution of capital requirements, thus other aspect such as liquidity and funding requirements will not be addressed.

2.2.3 Basel I

Throughout the 1980s and 1990s, banks went through a period of significant change in market conditions. Globalization and deregulation allowed banks to increase both their domestic and foreign exposures in a race for larger market shares (King & Tarbert 2011). In many cases, these new exposures were not matched by increases in the banks' capital holdings resulting in lower capital to assets levels across the industry. Additionally, deregulation allowed banks to take advantage of differences in national regulation resulting in unhealthy competition and regulatory arbitrage (Ibid.). Specifically, some national standards did not link capital requirements with actual risk levels. Hence, a regulatory consensus began to form around a global set of standards that were to ensure stability and a level playing field in the industry by providing guidance on proper capital levels. The result was the Basel Capital Accord (or Basel I), which was introduced in 1988. The accord presented a standardisation of the minimum regulatory capital ratio for internationally active banks as well as a definition of what was considered regulatory capital and how banks were to calculate it (BCBS 1988).

Introduction to Risk Weighted Assets

A distinct feature of Basel I was the introduction of minimum capital requirements as a ratio of risk weighted assets. "Risk weighting" involves categorising a bank's assets according to credit risk and then weighting each of these categories accordingly (King & Tarbert 2011). Total risk weighted assets includes both on-balance-sheet and off-balance-sheet items, and they are a measure of a bank's total credit exposure (Hull 2010). Basel I used a "bucket" approach that consisted of several major categories of assets and corresponding risk weights. Table 2.1 lists a sample of risk weights and asset categories. Thus, all on-balance-sheet items are assigned

Table 2.1: Examples of risk weights and corresponding asset categories under Basel I

Risk Weight	**Asset Category**
0%	Cash; Claims on OECD governments such as treasury bonds
20%	Claims on OECD banks and OECD public sector entities such as securities issued by US government agencies
50%	Uninsured residential mortgage
100%	Claims on private sector firms such as corporate bonds.; Claims on non-OECD banks

Source: BCBS 1998

a risk weight which reflects its credit risk. The relationship is described as:

$$\textit{Risk Weighted Asset} = \textit{Risk Weight x On-balance-sheet item}$$

When risk weighting off-balance-sheet items, the items are first expressed as a *credit equivalent amount*, which is obtained by multiplying the item by a *credit conversion factor* (CCF). The reasoning behind the method is that off-balance-sheet items, such as a pledged loan, have a probability of becoming an on-balance-sheet item, should the customer take out the loan. The CCF is the estimate of this probability (Hull 2010). The relationship is described as:

Risk Weighted Asset = Risk Weight x (Off-balance-sheet item x CCF)

Table 2.2 lists a sample of credit conversion factors and examples of instruments.

Table 2.2: Examples of credit conversion factors and instrument categories under Basel I

Credit Conversion Factor	**Instrument Category**
0%	Commitments that may be unconditionally cancelled at any time
50%	Credit line with original maturity over one year
100%	Direct credit substitutes, e.g. general guarantees of indebtedness

Source: BCBS 1998

Capital Requirements

Basel I required banks to maintain a total capital to risk weighted assets ratio of a least 8% (BCBS 1988). Items qualifying as regulatory capital were divided into Tier 1 and Tier 2 capital. The requirement is described as:

(Tier 1 capital + Tier 2 capital) / RWA ¿ 8%,

where 50% of the required capital (i.e. 4% of RWA) must be Tier 1 capital. Tier 1 capital represents the highest quality of capital in terms of ability to absorb losses, e.g. equity and disclosed reserves. This type of capital is wholly identifiable from banks' published accounts, which makes it easy to measure and regulate across markets allowing for a high level of transparency (Hull 2010). Tier 2 capital, or supplementary capital, represents lower quality capital in terms of ability to absorb losses. It includes undisclosed reserves, revaluation reserves, general provisions, hybrid debt capital instruments, and subordinated debt.

Critique of Basel I

Basel I was the first attempt to set international risk-based standards for capital adequacy. The achievement, despite its success, was also considered one of the framework's greatest flaws (King & Tarbert 2011). On the bright side, all members of the Basel Committee signed it, and it is said to have fundamentally changed the way banks measure, understand, and manage risk. However, it was widely criticised for creating risk-seeking incentives for banks. Among the greatest criticisms were that Basel I was too simple and allowed for regulatory arbitrage (Hull 2010). Especially, the bucket approach to defining risk weights, where, for example, government bonds from Greece (BBB rating in 1997) received the same zero percent risk weighting for their debt as the United States and the United Kingdom (AAA rating in 1997) meant that banks could take on higher risk without necessarily having to hold more capital. Additionally, the broad definitions of Tier 1 and Tier 2 capital led some countries to allow banks to use instruments of questionable quality as part of their capital holdings (King & Tarbert 2011). The flaws and the accompanying increased risk in the industry led to a revision of the framework in the form of Basel II (Ibid.).

2.2.4 Basel II

The shortcomings of Basel I led to a demand for new and more comprehensive regulation, thus Basel II was implemented in 2004. The overarching goal of Basel II was to further strengthen the soundness and stability of the international banking industry while insuring that capital regulation would not distort competition among banks (BCBS 2005). As a method towards reaching this goal, Basel II introduced more risk-sensitive capital requirements and a greater reliance on banks own assessment of risk in the calculations. To adapt to the increased complexity in the financial industry, the accord sought to provide a range of options for calculating capital requirements which allowed banks and national supervisors to apply the approaches most appropriate for their operations and financial market structure (Ibid.).

Basel II is based on three pillars: (1) Minimum capital requirements, (2) Supervisory review, and (3) Market discipline. The first pillar is the most important, and the most controversial, hence the following sections will be mainly devoted to providing a thorough understanding hereof.

Pillar 1 – Minimum Capital Requirements

Pillar 1 defines the minimum capital requirements under Basel II. The capital requirement ratio was maintained at the 8% level of RWA at the implementation of Basel II. Also, the requirements to the composition of Tier 1 and Tier 2 capital remain identical to Basel I with a minimum requirement of 4% Tier 1 capital. Additionally, new requirements for market risk and operational risk were added.[2] E.g. the capital requirement for an operational risk is calculated by multiplying with 12.5 to convert the risk to a required RWA figure so that the following relationship holds:

Total capital = 0.08 x (Credit risk RWA + Market risk RWA + Operational risk RWA)

One of Basel II's main contributions was its revision of the "bucket" approach to calculating RWAs to better match capital requirements with the riskiness of the bank's assets (King and Tarbert 2011). Basel II provided three methods of assessing credit risk:

- The standardised approach
- The foundation internal rating based (FIRB) approach

2. Market risk was already added in the 1996 amendment to the original Basel Accord (Basel I).

- The advanced internal rating based (AIRB) approach

As only a basic level of understanding of risk weights is needed in this thesis, we will not elaborate further on the specific mechanisms of these approaches. The important point is that the risk weights vary in the degree to which own parameter estimations may be used in the calculations. The standardised approach resembles Basel I in the sense that it is a “bucket” approach to assigning risk weights, while the IRB approaches rely on bank-specific estimates of risk components in the calculation of capital requirements for given exposures (BCBS 2005).

Pillar II – Supervisory Review

An additional feature of Basel II was the enhanced focus on, making the national authorities take on increased responsibility for the solidity in the banking industry. While the first pillar intends to ensure that banks have adequate capital to support the risks in their business, the second pillar aims to complement the first by encouraging better risk management techniques in monitoring and managing risk (BCBS 2005). The second pillar specifies four key principles to ensure appropriate processes for assessing overall capital adequacy in relation to the risk profile of the banks. Further the second pillar specifies that banks must have a strategy for how to maintain adequate capital levels. The processes and strategy should be reviewed by national supervisors, the Financial Supervisory Authorities (FSAs), whom in case of unsatisfactory results should act. If it is assessed that a bank should hold more capital in relation to their specific risk profile, the FSA may add additional capital requirements (BCBS 2005). If the capital level of a bank is close to the minimum capital level, the FSA should act by implementing restrictions and other measures to ensure that the capital level is above the regulatory minimum (ibid.).

Pillar III – Market Discipline

Pillar III focuses on increasing the transparency of banks' actual risk profile and financial situation. This is to be achieved by setting disclosure requirements for banks allowing market participant to assess the risk assessment procedures and capital adequacy of individual banks (BCBS 2005). Thus, Pillar III promotes market discipline to allow the industry to self-regulate to a larger extent, e.g. the implementation of Pillar III makes it easier for banks to assess the risks associated with the interbank lending markets. The extent, to which regulators can force banks to increase disclosures to the market, varies from jurisdiction to jurisdiction. However, historically banks have adhered to recommendations from their local FSAs, due to the potential difficulties the FSA may impose on the banks (Hull 2010). Moreover, local FSA may set increased disclosure requirements as a prerequisite for allowing the use of more advanced capital calculation methods (Ibid.)

Critique of Basel II

The implementation of the IRB methods under Basel II allowed the risk weights to a higher extent to be based on asset specific characteristics. Among other additions, it was made possible to account for exposure guarantees in the calculation ultimately making a more accurate calculation of the risk weight possible. The IRB methods, especially the AIRB method, allowed for risk weights that to a higher extent reflected the 'actual' asset risk. It thereby reduced the incentives to issue risky loans that had emerged under Basel I. Additionally, the implementation of pillar II and III allowed the local FSAs to assess the extent to which individual banks complied with the increased regulation and act if necessary. The disclosure requirements further promoted the transparency of the financial industry positively influencing the potential of reducing overall systemic risk.

Despite improving some of the major flaws inherent in Basel I, the Basel II framework carried limitations of its own which abruptly became apparent in the global financial crisis of 2007/2008. One of the first things to be showcased was the fact that Basel II had failed to deal with the broad definitions of Tier 1 and Tier 2 capital that were left largely intact from Basel I (King & Tarbert 2011). It allowed banks to use capital of questionable quality. Banks learned to creatively structure financial products in ways that allowed them to comply technically with Basel II, while holding much lower equity levels. Some banks were found to hold as little as 1% common equity to total assets (King & Tarbert 2011). Secondly, the shift from standardised to bank-specific assessments of risk de facto lowered capital requirements in nominal terms (Rangvid 2013). In other words, the banks were given the opportunity to increase their leverage (debt to equity), which many chose to do. Especially the use of the AIRB method allowed for much lower risk weights, which meant that banks nominal capital holdings could serve as loss absorbing for a greater amount of lending. It ultimately lowered the overall solvency of the industry (Rangvid 2013). In conclusion, the implementation of Basel II made it increasingly possible for banks to issue loans in inappropriate cyclical times, which ultimately resulted in a financial crisis that was more extensive and prolonged than would have otherwise been the case (Ibid.).

2.2.5 Basel III

One of the main reasons behind the extensiveness of the financial crisis of 2007/2008 was the built up of higher debt-to-asset ratios in the banking industry while reducing both the level and quality of their capital base. Thus, the banking industry was therefore unable to absorb the large losses stemming from credit, trading and other exposures during the crisis (BCBS 2010). Basel I and II's missing robustness in terms of loss absorbing capital contributed to the extensiveness of the crisis (BCBS 2010). At the same time, many banks were found to hold insufficient liquidity buffers when liquidity rapidly contracted due to the overall loss of confidence in the industry. All this occurred despite the implementation of Basel I and II, which had attempted to avoid exactly this type of situation. Thus, the main objective of Basel III was to significantly improve the banking industry's ability to resist shocks. It sought to do so by strengthening both the quality and quantity of capital and liquidity in the industry.

The allocation of risk weights under Basel III is done using the same methods as under Basel II with some minor adjustments, e.g. the addition of a correlation effect to the IRB approaches (BCBS 2010). Where Basel II sought mainly to implement a more risk based allocation of capital, Basel III sought to increase both the amount and quality of capital in banks. The basic capital requirement of 8% from Basel I and II remains in Basel III however with additional capital buffers (reviewed later), while the allocation of capital is changed to enhance the robustness of the industry (BCBS 2010).

Allocation of Capital

Before the implementation of Basel III there was a limited focus on the most loss absorbing type of capital, tier 1 capital. Additionally, the financial crisis showcased large differences in which type of capital and capital instruments were accepted as being Tier 1 capital by national FSAs. Thus, the quality of capital varied across countries (BCBS 2010).

The implementation of Basel III sought to increase the loss absorbing ability in the banking industry and to improve the similarity across countries. The Tier 1 Capital requirement was increased from 4% of RWA to 6% of RWA. Furthermore, Basel III breaks down Tier 1 into two categories, Common Equity Tier 1 (CET1) capital and additional Tier 1 capital. With the implementation of Basel III the minimum requirement to CET1 (when fully implemented in 2019) is 4.5% of RWA and the minimum requirement to Additional Tier 1 capital is 1.5% of RWA (BCBS 2010). The stricter requirements in terms of CET1 along with more precise definitions of CET1 and Additional Tier 1 capital make capital holdings more similar across countries and they improve the loss absorbing ability of the banking industry. Increased quality of capital is an objective of Basel III, as it reduces the impact of innovative and complicated capital instruments increasing the weight on actual loss absorbing capital from a "going concern" perspective (Tarbert & King 2011).

Capital Buffers

The objective in Basel III to increase the capital base of banks is not reflected in the minimum capital requirement of 8%, as it is identical to previous regulation. Instead, Basel III implemented adjustable capital buffers intended to serve as further defense against future losses. The common principle behind these buffers is that they build up during "good times", so that they can be drawn on during "bad times", i.e. when unexpected losses occur.

Capital Conservation Buffer

The capital conservation buffer requires banks to hold 2.5 % CET1 capital outside periods of stress in addition to the 4.5% CET capital mentioned above. This effectively brings the CET1 ratio to 7% of RWA. Banks' capital may fall below the 7% ratio in stressed periods, but it must be rebuild through a reduction in discretionary distribution, such as dividends and share buy-backs. Regulators may impose constraints on discretionary distributions until the buffer is re-established. These constraints vary according to the extent to which the capital conservation buffer of 2.5% has been eroded. Table 2.3 depicts the relation between the buffer and capital conservation ratio.

Table 2.3: Individual bank minimum capital conservation standards

Common equity tier 1 ratio	Minimum Capital Conservation Ratios (expressed as a percentage of earnings)
4.5%-5.125%	100%
5.125%-5.75%	80%
5.75%-6.375 %	60%
6.375%-7.0%	40%
>7.0%	0%

Source: BCBS 2006

Countercyclical Buffer

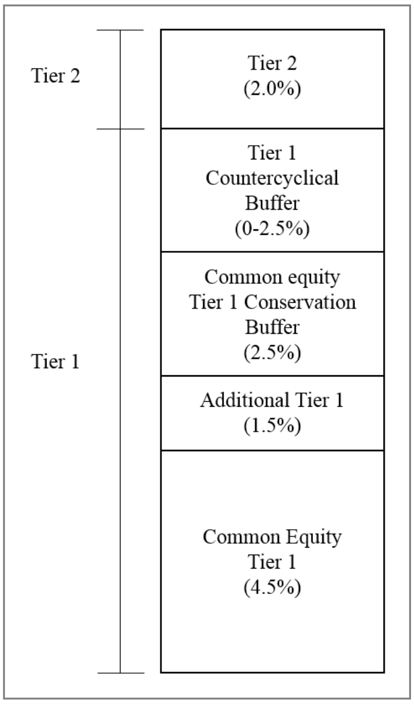
Basel II was criticised for not considering actual market economic conditions. Basel III does not incorporate market economic conditions in the calculation of risk weight, but instead it introduces a countercyclical buffer (Tarbert & King 2011). The buffer is to be set by the national FSAs through Pillar 2 adjustments, and the buffer may range from 0% to 2.5% CET1 capital depending on the market conditions in each jurisdiction. Once a countercyclical buffer is announced there is an implementation face of 12 months during which banks must build up the buffer. If a bank fails to build up the buffer it shall face restrictions on discretionary distributions similar to those of the capital conservation buffer. A full implementation of the countercyclical buffer would bring the CET1 ratio to 9.5% of RWA. Importantly, the countercyclical buffer is calculated as a weighted average of the national buffers in effect in the jurisdictions in which a bank has credit exposures. As an example, Danske Bank had a countercyclical buffer rate of 0.4% at the end of 2016, primarily due to the countercyclical buffer rates in Norway and Sweden (both set at 1.5%), as Denmark has not yet activated the buffer.

The implementation of the countercyclical buffer provides an opportunity for the national FSAs to counteract economic fluctuations to prevent bubbles in times of market upswing and credit crunches in economic downturns (Tarbert & King 2011). In other words, national FSAs may include market economic conditions when imposing capital requirements on banks, and hereby either stimulate credit availability during a downturn or restrict the availability during periods of high credit growth. The countercyclical buffer ultimately provides an additional opportunity for national FSAs to influence the capital holdings in their jurisdiction. Figure 2.3 illustrates the capital requirements under Basel III.

Leverage Ratio

An important aspect of Basel III is the rejection of the notion that capital requirements should only be in terms of RWA. Preceding the financial crisis many banks had built up excessive

Figure 2.3: Capital requirements under Basel III



Source: Own contribution based on King & Tarbert (2011)

leverage while complying with the capital to RWA requirements. To prevent similar situations going forward Basel III introduced a "leverage ratio" of Tier 1 capital to "total exposure", i.e. no reference to RWA. The target leverage ratio is 3%[3]

SIFI Buffer

[4] Following the implementation of Basel III in 2010, the Basel Committee introduced additional requirements to Systemically Important Financial Institutions (SIFI) in 2011 (BCBS 2011). The financial crisis showcased the systemic risk inherent in the financial industry, where uncertainty around large banks affects other banks and thereby spreads to the entire financial market and national economies. In section 2.2.1, it was described how large banks (too-big-to-fail) have a significant impact on the stability of society, and how they thereby are covered by an implicit guarantee in the form of a government bailout. The characterisation of SIFI banks is important from both a national and a global perspective, as it allows national FSAs to increase capital requirements for these banks through the SIFI buffer. SIFIs may be required to hold up to 3% additional CET1 capital to RWA depending on how systemic they are perceived to be (BCBS 2011). The implementation of the SIFI buffer further enhances the overall solidity of the banking industry.

3. The leverage ratio including the calculation hereof was not finalized in the original Basel III document, but was tested and revised in the subsequent years. The final leverage ratio was finalized in 2016. (BCBS 2014, 2016)

4. To be correct then the SIFI buffer was introduced as an addition to Basel III and therefore not part of the original Basel III

Conclusion of Basel III

Basel III has improved the solidity of the industry by increasing CET1 capital requirements to enhance the loss absorbing ability of banks during periods of stressed market conditions. The amount of required CET1 capital was increased through Pillar I requirements, the capital conservation buffer and countercyclical buffer. The countercyclical buffer gives national FSAs the opportunity to react to increased risk among banks or in the market. The implementation of the SIFI buffer further reduces the systemic risk in the industry, and thereby also the moral hazard issue associated with large banks' implicit guarantees. Lastly, the introduction of a leverage ratio contributes to the overall objective of Basel III to increase both the quantitative and qualitative requirements to banks' capital base, which is positive for the overall solidity of the industry.

2.2.6 Scandinavian Requirements

From the review of the Basel Accords, we learned that national FSAs have some degree of power over the implementation of the Basel Committees regulatory recommendations. The Basel Committee's recommendations have historically been included into EU law in the form of Credit Requirements Directives (CRDs). The latest directive, CRD IV, introduces Basel III into law (BCBS 2010). Denmark, Norway and Sweden have in turn introduced the CRD IV into national law. The minimum requirements and the phasing in of these, introduced in CRD IV may be implemented faster or slower than the directive suggests.

The Danish national FSA has implemented the CRD IV exactly as it was introduced in EU law with similar requirements and phasing period (Finanstilsynet 2013). Six banks were appointed SIFI status, and they have therefore been imposed with SIFI buffer requirements to be implemented in the period 2015-2019. [5] The Danish FSA has not made use of the countercyclical buffer as of the beginning of 2017. The Norwegian FSA has generally implemented much stricter requirements than suggested by the Basel Committee (Winje & Turtveit 2014). By July 2013, the minimum requirements and suggested capital conservation buffer (8.5% CET1 capital to RWA) were implemented with no phasing period. Further, a nationwide systemic buffer was introduced for all banks (Winje & Turtveit 2014). In 2016, three Norwegian Banks have been appointed SIFI status, and they have hence been imposed with additional CET1 requirement of 2.0% of RWA. [6] The Norwegian FSA has made use of the countercyclical buffer, which became effective in 2015 at a 1.0% CET1 to RWA level. The countercyclical buffer CET1 requirement was subsequently raised to 1.50% of RWA in 2016, and it has been announced that it will be 2.0% of RWA in 2018 (Norges Bank 2017). Lastly, the Swedish FSA has implemented a speedier implementation of the CRD IV with fully phased in requirements in 2015. Four Swedish

5. Danish SIFIs: Danske Bank A/S, Nykredit Realkredit A/S, Nordea Bank Danmark A/S, Jyske Bank A/S, Sydbank A/S and DLR Kredit A/S

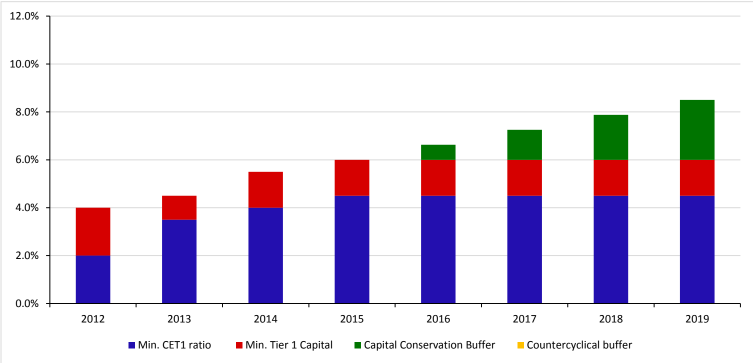
6. Norwegian SIFIs: DNB Bank AS, Nordea Bank Norway AS and Kommunalbanken AS

banks were appointed status as SIFI, and they have been imposed with a 3.0% additional CET1 requirement to RWA that became effective in 2015.[7] The Swedish FSA has made use of the countercyclical buffer, which became effective in 2015 at a 1% CET1 to RWA level. The buffer requirement was subsequently raised to 1.50% in 2016 and 2.0% in 2017 (Finansinspektionen 2016). The Scandinavian implementation phase of national capital requirements are shown in figures 2.4, 2.5, and 2.6.

In summary, contrary to the Danish FSA, which has not deemed it necessary to introduce a speedier implementation, both the Swedish and Norwegian FSAs have introduced faster implementation and higher requirements. The phasing period was significantly shortened in Sweden and Norway exposing the financial institutions operating in the countries to a larger regulatory shock compared to Denmark. Additionally, the nationwide capital requirements are generally higher in both Sweden and Norway compared to Denmark due to the use of the countercyclical buffer.

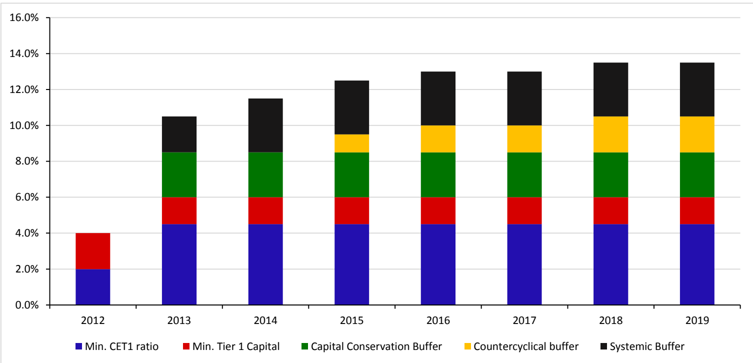
7. Swedish SIFIs: Nordea Bank AB, Svenska Handelsbanken, Swedbank and SEB

Figure 2.4: Capital Requirements Denmark



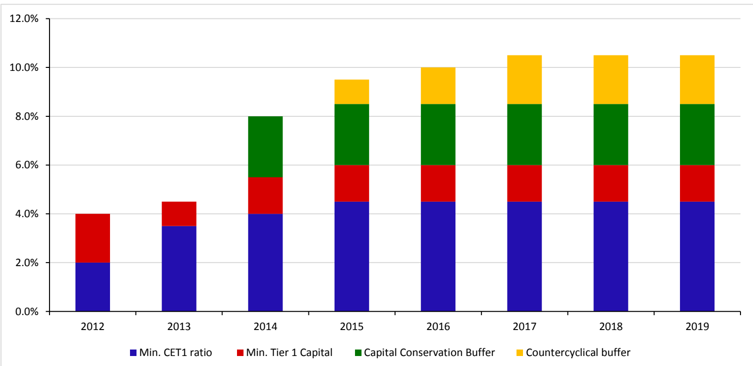
Source: Finanstilsynet Danmark

Figure 2.5: Capital Requirements Norway



Source: Finanstilsynet Norge

Figure 2.6: Capital Requirements Sweden



Source: Finansinspektionen Sverige

Chapter 3

Theoretical Review

The chapter presents the theoretical underpinnings of the empirical model of the thesis. The main goal of the chapter will be to present a simplified model of how a bank's capital holdings and capital requirements might impact its lending. That is, the theory and model presented in this chapter should be able to explain how the financing of the bank might impact the asset side of the bank in the wake of capital requirements. To achieve this, the chapter will firstly outline the various traditional capital structure theories starting with the seminal work of Modigliani & Miller (1958), and it continues with the trade-off theory and contract theory approaches to capital structure. The aim of reviewing the traditional capital structure theory is to build a theoretical understanding of how the financing of a firm might relate to the value of a firm through market imperfections. Secondly, the chapter will outline capital structure in the context of banking as a bank in important ways differs from a non-financial firm in relation to its financing strategy. Lastly, a theoretical model within the literature stream of bank capital channel (Van Den Heuvel 2002; Francis & Osborne 2009) will be presented to explain how bank capital and capital requirements under certain assumptions can impact a bank's lending growth.

3.1 Traditional capital structure theory

Capital structure refers to the financing of a firm's activities through various types of debt and equity securities (Berk & DeMarzo 2014; Myers 2001). The choice between debt and equity to finance a firm's investments is one of the fundamental questions in corporate finance theory. It is of particular interest due to the question of whether the firm's value depends on its financing choice. Yet no one theory has emerged to comprehensively explain the financing strategy of firms today (Myers 2001). The section will firstly outline the various traditional capital structure theories of non-financial firms starting with the work of Modigliani & Miller (1958), and it continues with the trade-off theory. Secondly, contract theory approaches to capital structure will be reviewed before the empirical evidence of both the trade-off theory and contract theory will be discussed. However, before we turn to the work of Modigliani & Miller (1958), the following paragraphs will explain the key features of debt and equity in a simplified illustration to get a basic understanding of capital structure.

An investment project can be financed either through debt or equity.[1] Equity and debt are usually defined in terms of their potential payoffs and risk. Equity is the money the investor / shareholder uses to finance a project. Equity has the claim to all future earnings (after servicing its debt, i.e. paying interest) from the project. However, in a liquidation scenario, equity holders will receive their claim on the assets last. Thus, equity holders will receive what is left, if any, after the debt holders have fully recovered their loans, however the equity can only lose their initial investment (i.e. they cannot lose more than they have invested) regardless of the debt holders fully recover their amount outstanding. Debt has a fixed promised payoff on its investment, interest income. If the project goes well, the debt holders do however not share any of the upside above its interest income.[2] In a liquidation scenario, debt holders receive their claim on the assets first. Depending on the distress of the company, debt holders can receive anything between their entire outstanding amounts to nothing back.

To illustrate the above features of equity and debt, imagine a one-period investment opportunity costing 100 in $t = 0$, financed with 50% debt and 50% equity with 5% interest rate on debt, tax rate of 30%, two scenarios, boom or distress, in $t = 1$, and liquidation of the project after $t = 1$ with no shut down costs. In the boom scenario, assume that the project earns EBIT 100 then net income is 68.25 and the equity value of the opportunity is 118.25 in $t = 1$. Debt holders will earn 2.5 on their debt value of 50, which is unchanged. In the distress scenario, assume that the project generates EBIT of -100 then net income is -71.25 and the equity value of the opportunity is -21.75 $t = 1$. Thus, equity holders lose their investment. Debt holders will in the distressed scenario earn their interest of 2.5 but their initial investment is only 28.25 worth. Figure 3.1 illustrates the investment opportunity. The example assumes in the distressed scenario that the tax asset from negative earnings can be used to generate positive earnings from tax in the same period. In the real world, the tax assets will be pushed forward in time however. Two further insights from the example are worth noting. Firstly, interest expenses are tax deductible, which creates a tax shield on debt. This is a major pillar in the trade-off theory that will be discussed in the next section. Secondly, the debt-to-equity ratio impacts the return on equity. Using debt magnifies the return on equity. In our example the return on equity in the boom scenario is 136.5% compared to the unlevered (fully equity financed) return of 70.0%. In the distress scenario the levered return on equity is -100.0% compared to the unlevered return on equity of -70.0%. Thus, leverage can increase the return on equity in boom scenarios while decrease the return on equity in distress scenarios compared to an unlevered financing structure. However, the financial risk of the company is also increased with leverage. Thus, the example has illustrated the key features of debt and equity and the overall financing strategy, which was needed to fully understand the literature on capital structure theory.

1. The statement is simplified as multiple hybrid capital forms exists in the market (e.g. preferred stocks, convertible bonds and mezzanine debt).

2. Again not considering other hybrid forms of capital such as convertible bonds.

Figure 3.1: Illustration of the Implications of a Firm's Financing Strategy

Balance sheet at t=0	
Assets	100
Liabilities (debt)	50
Equity	50

Income statement at t=1		
Scenario	Boom	Distress
EBIT	100	-100
Int exp.	-2.5	-2.5
EBT	97.5	-102.5
Tax	-29.25	30.75
NI	68.25	-71.75

Balance sheet at t=1		
Scenario	Boom	Distress
Assets	168.25	28.25
Liabilities (debt)	50	28.25
Equity	118.25	0
Levered return on equity	136.5%	-100.0%
Unlevered return on equity	70.0%	-70.0%

3.1.1 Modigliani & Miller's Propositions

Modigliani & Miller (1958) through a market value maximisation approach proposed that the financing of a company did not impact the value of the firm. M&M's proposition I states that the value of a company is independent of the choice of equity and debt (ibid.). The proposition has come to be known as the *capital structure irrelevance theorem.*

M&M Proposition I: The value of a firm is independent of the choice of equity and debt:

$$V_L = V_U$$

Proposition II states that cost of equity increases with the market value debt-equity ratio (Berk & DeMarzo 2014; Modigliani & Miller 1958).

M&M Proposition II: The cost of equity increases with the market value debt-equity ratio:

$$r_E = r_U + \frac{D}{E}(r_u - r_D)$$

This a consequence of levered equity becoming more expensive as the financial risk increases with higher proportions of debt. So, substituting more "expensive" equity with "cheaper" debt will not change the cost of capital of the company, as the equity becomes marginally more expensive offsetting the lower cost of debt. Their argumentation is built on the assumptions of (1) perfect capital markets understood as competitive markets with no frictions such as transaction costs; (2) equal access to capital markets in that any security is priced based on characteristics of its payoff streams and not on the type of issuer; and (3) complete capital markets in the sense that no asymmetric information exists, and each security can be replicated from other securities (Fama 1978; Modigliani & Miller 1958; Myers 2001). Stiglitz (1974) shows that the irrelevance theorem under the above assumptions must be true through an arbitrage argumentation. The capital markets are however not perfect, and the M&M propositions are in direct conflict with the simple example presented in table 3.1. Thus, the relevance of M&M's propositions can be questioned, however, in the words of Miller (1989, 100): *"...Showing what doesn't matter can also show, by implication, what does"*.

3.1.2 Trade-off Theory

Trade-off theory argues for companies to hold moderate debt-to-equity levels, as companies try to balance the benefits and cost of leverage (Myers 2001). Trade-off theory relates to a string of theoretical papers, which focus on the optimal leverage (debt-to-equity mix) of a company through the balancing of tax advantage of debt and the cost of bankruptcy with an optimum where the marginal cost equals marginal benefit. Trade-off theory was established as a response to M&M's irrelevance of debt theorem and perfect capital market assumption. Firstly Modgliani & Miller (1963) themselves added the tax advantage of debt to argue for substantial leverage levels and later, Kraus & Litzenberger (1973) added bankruptcy cost. Following Frank & Goyal (2007), the literature review distinguishes between static and dynamic trade-off theory. Literature within the static trade-off theory explains a firm's optimal capital structure, as the outcome of balancing the single period tax benefit of debt against the cost of bankruptcy (Frank & Goyal 2007). The dynamic trade off theory literature explains a firm's leverage as an outcome of the firm estimating the optimal level of leverage across periods based on the expected tax benefit of debt and cost of bankruptcy and then adjusting gradually over time towards the target level of leverage (Frank & Goyal 2007). The following two paragraphs will explore static and dynamic trade-off theory and afterwards consider contract theory approaches to capital structure.

Static trade-off theory explains firm leverage in a single period, as a trade-off between the benefits of debt against the costs of bankruptcy. It argues that the firm will borrow up to a point where the marginal value of tax shield on additional debt exactly equals the present value of financial distress. The deductible of interest payments from taxable corporate income increases the value of the firm. However, the additional leverage decreases the creditworthiness of the firm, increasing the probability of default and thus the probability of sustaining direct and indirect costs (e.g. agency costs) of bankruptcy (Myers 2001). Following Modigliani & Miller (1963) and Kraus & Litzenberger (1973), Bradley et al. (1984) present a standard single period model of capital structure. The model incorporates corporate and personal taxes, distress costs and non-debt tax shields (following DeAngelo & Masulis (1980)).[3] It is built upon risk-neutral

3. DeAngelo & Masulis (1980) develop the notion of non-debt tax shields, specifically depreciation, investment tax credit and deferred tax losses, which function as traditional debt tax shields, however the non-debt tax shields are found in their paper to be negatively related with level of firm leverage by working as a substitute for debt.

investors. The model shows that financial distress cost and leverage (debt-to-equity ratio) are negatively related, non-debt tax shields and leverage are negatively related, and taxes are positively related with leverage (Bradley et al. 1984; Frank & Goyal 2007). The key weakness of the static trade-off theory and the model by Bradley et al. (1984) is the absence of retained earnings and mean reversion of the leverage ratio. By construction, both retained earnings and mean reversion are not part of a static model, which can be a criticism in itself, however a theoretical model will always be based on simplifications. Retained earnings are equity, and thus more profitable companies will become less levered over time, all else equal. Mean reversion and any deviation from optimal capital structure cannot be explained in the static trade-off model. These two inadequacies of the static trade-off theory spurred both the research in agency theory explanations to capital structure and later dynamic trade-off models (Frank & Goyal 2007).

Dynamic trade-off theory explains a firm's choice of leverage as an adjustment process between the firm's observed debt-equity ratio and the firm's optimal debt-equity-ratio based on the trade-off between the marginal benefits of debt and present value cost of financial distress across time (Frank & Goyal 2007). The key features of dynamic trade-off theory as oppose to the static trade of theory revolves around the importance of expectations and adjustment costs as a result of the model being time dependent. Before Fischer et al. (1989), transaction costs were assumed away, thus leading to instant rebalancing towards the optimum and thus predictions of high debt-to-equity ratios as rebalancing in case of adverse shocks is costless, so firms will maintain high levels of debt to increase firm value (e.g. Kane et al 1984). With the inclusion of transaction costs, the leverage ratio can drift away. Profitable companies would then pay down debt until a boundary is reached and then recapitalise, while unprofitable companies will issue equity when the upper-boundary is reached. Goldstein et al. (2001) further advances the literature by considering the option value of deferring leverage decisions, thus leading to lower leverage today. The models of Fisher et al. (1989) and Goldstein et al. (2001) thus help to resolve the problem of high debt level predictions of earlier models aligning the trade-off theory more closely with empirical findings. A vast amount of literature within dynamic trade-off theory exists that will not be covered here given the focus of bank capital and lending.

3.1.3 Contract Theory Approaches

In part due to the inadequacies of static trade-off theory, contract theory approaches to capital structure arose in the 1970s and 1980s with perhaps the most prominent being the pecking order theory presented by Myers & Majluf (1984). The pecking order theory argues that a firm (1) prefer internal to external financing and (2) if external funding is necessary then the firm prefer safer to riskier assets, issuing first debt, then hybrid forms of financing (e.g. preference shares, convertible bonds and subordinated securities) and lastly equity (Myers 2001). Thus, the debt ratio represents the cumulative requirement for external funding. Myers & Majluf's (1984) theory is based on asymmetric information between managers and investors in that investors do not know the value of the existing assets of the firm and its new investment opportunities.

Further, their pecking order argument is built on the assumptions of management acting in the interest of existing shareholders and existing share being passive (i.e. they do not buy new shares in a stock issuance). Other assumptions of managerial and shareholder behaviour could also be justified, however the assumptions of the pecking order theory helps to explain the fact that stock prices on average decreases on the announcement of a stock issuance. On those grounds the assumptions might be reasonable compared to other assumptions of managerial and shareholder behaviour.

In the pecking order theory, managers acting in the interest of the existing shareholders translate to the maximisation of the existing value of equity. A firm will consider a stock issuance whenever they have a NPV positive growth project that they need funding for. Thus, the stock issuance conveys good news to new investors in the form of a positive NPV project. However, the stocks issued can be either over- or undervalued at any point in time. Issuing overvalued stocks will transfer value from new investors to existing investors while issuing undervalued stocks will transfer value from existing shareholders to new shareholders. Since managers are assumed to act in the interest of existing shareholders, and only managers can observe the actual value of the assets-in-place and the growth opportunity at hand then an equilibrium is created where issuing of new shares will result in a drop in the stock price as any attempt by managers to issue stocks will be perceived by new investors as overvalued shares.[4] Thus, managers will choose to finance a growth opportunity with debt before equity. Equity will only be issued if debt is unavailable / too costly, e.g. in the case of financial distress. Further, firms will prefer internal to external financing as asymmetric information is only assumed to be relevant for external financing (Myers & Majluf 1984; Myers 2001). Compared to trade-off theory then the pecking order theory does not stipulate a target debt ratio. The leverage ratio is merely a reflection of the cumulative needs for external financing to date. Further, more profitable companies will in the case of the pecking order theory hold less debt due to larger internal funding and vice versa.

Jensen & Meckling (1976) and Jensen (1986) offer other contract theory approaches to capital structure. These should not be seen as capital structure theories, however they do offer some further insights into the choice between equity and debt in the financing of the firm. Jensen & Meckling (1976) and Myers (1977) highlight the cost associated with conflicts between debt and equity holders. They identify two primary sources of cost to debt holders from managers acting in the interest of shareholders: (1) Asset substitution and (2) debt overhang. *Asset substitution* refers to the investing in risky projects (even NPV negative projects), as it increases the expected payoff to equity holders, as debt holders do not gain any "upside" but shares the "downside" with equity holders. Thus, equity holders have a call option like feature with high potential upside and limited or no downside if equity is already "out-of-the-money". This agency cost,

4. In the (special) case where the net present value of the growth opportunity more than offsets the transfer of value from existing to new shareholders from issuing undervalued stocks then the managers will issue undervalued stocks.

debt overhang, refers to a situation where equity holders will not invest in positive NPV projects, which will increase the market value of the firm, due to high levels of risky debt. The risky debt, increasing the default risk, reduces the incentive to take on positive NPV projects, as part of the value of the future growth opportunity will flow to debt holders. Thus, in certain states the option to invest will be abandoned if the NPV is less than the combined investment cost and payment to debt holders (Myers 1977). As the market value of the firm depends on its future growth options and positive NPV projects are foregone (i.e. suboptimal investment strategy is undertaken) then the market value of the firm decreases. Both *debt overhang* and *asset substitution* stress moderate leverage ratios to optimise the market value of the firm and these and other agency costs are typically arguments used in trade-off theory as the balancing factor against the tax benefit of debt along with direct bankruptcy cost.

3.1.4 Empirical Evidence of The Trade-off Theory and Pecking Order Theory

Empirically, neither trade-off theory nor pecking order theory provides compelling evidence in explaining firm behaviour. Both theories can explain some empirical observations while failing to explain others.[5] On an aggregated level, Frank & Goyal (2007) show that the leverage ratio of non-financial, non-farming US companies has been quite stable across time and Rajan & Zingales (1995) suggest that leverage ratios across the G7 countries are fairly similar. A stable leverage ratio might be explained by the trade-off theory. However, the leverage ratio has actually been too stable to adequately be explained by the trade-off theory when considering the significant fluctuations in the corporate tax rate (Frank & Goyal 2007; Myers 1984). Further, the usage of debt in the US by companies has existed far longer than the corporate income tax has been in place. The pecking order theory suffers from three fundamental limitations with regards to empirical observations: (1) Firms issue debt even when they have cash on hand, (2) financing deficit[6] is better tracked by net equity issues compared to net debt issues, and (3) firms issue equity at times when the pecking order theory would suggest that they should not (Fama & French 2005; Leary & Roberts 2010). Overall, it seems that the capital structure theory lacks a unifying theory to explain the financing strategies of firms.

However, the two theories, trade-off theory and pecking order theory, do seem to explain certain leverage determinants, i.e. market imperfections that are relevant for the development of the bank lending channel view and bank capital channel view, discussed later. Capital structure theory has identified multiple cross sectional variables that potentially explain leverage with Frank & Goyal (2007) identifying the six most robust and significant correlations with leverage in their literature review: Growth, firm size, tangibility of assets, profitability, industry mean debt ratio and expected inflation. This short review of the factors will focus on firm size and

5. E.g. pecking order theory explains declining share prices (on average) when issuing seasonal equity. Trade-off theory explains why growth companies on average has less leverage due to higher distress costs compared to other types of companies.

6. Financing deficit is defined by Myers & Shyam-Sunder (1999) in their regression test of the pecking order theory as investments plus change in working capital plus dividends less internal cash flow.

profitability as these two factors are also commonly used as determinants of bank lending, and they are therefore also included in the regression analysis in chapter 7.

Firm size is predicted to have a positive relationship with leverage in the trade-off theory. Larger companies compared to smaller companies have an overall lower volatility in performance and thereby lower probability of default. Further, agency costs of debt might be smaller due to a longer history and reputation of the company in the capital markets. Thus, leading to higher leverage in the trade-off theory literature. The pecking order theory is interpreted as implying a negative relationship between leverage and firm size. This is argued based on the assumption that larger firms will have lower adverse selection / asymmetric information costs from having a longer history and reputation in capital markets. This is essentially the same argument used by the trade-off theory to argue for higher debt levels from lower agency costs of debt, however in the pecking order theory less asymmetric information implies lower cost to issue equity all else equal. The empirical literature finds a robust positive correlation between firm size and leverage (Frank & Goyal 2007), implying that trade-off theory has higher explanatory power compared to pecking order theory on this metric.

Empirical studies have found a negative relationship between leverage and *profitability* (Frank & Goyal 2007). Static trade-off theory predicts that more profitable companies will have a higher level of debt, as the probability of distress is lower and the interest tax shield in absolute value is higher for a more profitable firm compared to a less profitable firm. Pecking order theory predicts the opposite, a positive relationship between profitability and leverage. As no target-debt ratio is evident and internal financing is preferred to external financing in the pecking order theory then more profitable companies will have lower leverage as retained earnings is used to finance the company. It would imply that pecking order theory explains leverage on this metric better. However, static trade-off and dynamic trade-off theory differs in their prediction of leverage based on profitability. A dynamic trade-off model can model retained earnings and multiple papers have modelled a negative relationship between profitability and leverage. Fisher et al. (1989) emphasises transactions costs causing drifts away from target debt ratio. Thus, higher profitability draws down the leverage ratio due to adjustment costs, as the costs cause the company to postpone re-leveraging. Tserlukevich (2008) develops a dynamic model with investments endogenously determined and real frictions existing. The model shows that in the event of a positive demand shock (profitability increase), real frictions will delay investments, and thus debt issues, but equity value will increase instantaneously from the positive shock leading to a lower leverage ratio. Thus, dynamic trade-off theory seems to be able to explain the negative relationship between profitability and leverage however from different model assumptions.

3.1.5 Summary of Traditional Capital Structure Theories

The literature reviewed has displayed multiple market imperfections, which can cause the assets of a firm to be affected by its financing (i.e. deviations from the Modigliani & Miller

(1958) world). Trade-off theory, in its most simple form, argues that the capital structure is determined by the balancing of the tax advantages of debt against the distress and agency cost of debt. Pecking order theory, on the contrary, argues not for an optimal debt-to-equity structure but for an optimal choice of financing with the firm choosing internal funds over external funds and debt over equity to fund capital expenditures due to asymmetric information. Neither theory has convincingly been able to explain all aspects of empirical evidence in the capital structure literature. But each theory has to some extent explained parts of the empirical observations on capital structure. Thus, both theories should be perceived to offer only part of the explanations to the firm's choice of capital structure. Regarding the thesis' focus on financial institutions further caution needs to be taken, as financial institutions are inherently different from non-financial institutions. The theoretical literature reviewed so far has focused on capital structure of non-financial institutions while the next subsection will focus on the theoretical literature on financial institutions before concluding the theoretical literature altogether.

3.2 The Capital Structure of Financial Institutions: Bank Capital, Requirements and Lending

The following two subsections will elaborate on the role of capital structure in financial institutions, and how it can affect the lending growth of banks. Firstly, the Modigliani & Miller (1958) propositions in the context of banking will be discussed and tentative arguments of how credit growth can be affected dependent on whether the propositions hold will be outlined. The second subsection will outline the bank capital channel and bank lending channel views. Both theories concern how market imperfections create channels through which monetary policies can affect the asset-side of the bank. Afterwards, Francis & Osborne's (2009) 'bank capital channel' model will be outlined to explain how bank capital and capital requirements can affect the loan growth of a bank.

3.2.1 Modigliani & Miller in the Context of Banking

The section elaborates on the key differences between non-financial and financial institutions in relation to their capital structure, and how, the differences relate to the Modigliani & Miller propositions and the lending capacity of banks. Financial institutions differ from non-financial institutions with respect to capital structure theory in that firstly banks engage in liquidity production as explained in section 2.1, *Fundamentals of Banking*, by maturity transformation of long-term loans and short-term deposits. Deposits are thus an operating liability, which banks earn a premium on, the net interest margin. In banking, part of the bank's financing is thus NPV positive compared to non-financial firms. Secondly, as explained in section 2.2.1, banks main liabilities, deposits, are insured both explicitly and implicitly by the government in the form of deposit insurance and "the too-big-to-fail" doctrine, respectively. It makes the risk premium paid by the bank on its financing (deposits) constant regardless of the debt-to-equity level. These two aspects of banking are interesting in the context of Modigliani & Miller's (1958) propositions

I and II. Recall from 3.1.1, Modigliani & Miller's (1958) propositions state that the value of the company does not depend on the financing of the company (proposition I), and equity cost rises with leverage (proposition II). If the M&M propositions hold in the context of banks then it does not seem plausible that bank capital and capital requirements (i.e. the funding mix of the bank) can alter credit growth (i.e. the operations of the bank). The failure of one or both propositions might however entail that bank capital and capital requirements can impact credit growth.

The previous paragraph explained that the net interest margin between loans and deposits makes the financing (deposits) NPV positive. That is, banks will by increasing leverage expand their asset side (assuming it is used to finance loans), and thus the net interest margin conflicts with M&M's proposition I. The previous section highlighted other imperfections that also would imply the failure of the capital structure irrelevance theorem: Tax advantages of debt, distress costs and agency costs. Banking in itself is a product of an imperfect market in the form of asymmetric information between borrowers and lenders. It therefore seems reasonable to suggest that M&M's proposition I fails in the context of banking. A constant risk premium due to government guarantees (both explicit and implicit) implies the failure of M&M's proposition II, as increasing leverage will thus not increase the cost of equity. The bank will therefore increase the amount of leverage as to benefit from tax advantages of debt. If both propositions fail then it would imply that credit growth can be negatively affected by both increases in capital ratios and capital regulations, as it would entail a switch from cheaper financing to more expensive financing with the result of a diminishing asset side.

However, caution must be taken. If M&M's proposition II does not fail (in that equity cost increases with higher leverage), then it would not necessarily be that capital ratios are negatively related with lower growth. Labonne & Lamé (2014) argues that if M&M's proposition II holds but M&M's proposition I fails then it would be that capital requirements could negatively impact credit growth but capital ratios can be positively associated with credit growth. The argument is that capital requirements will cause the bank to hold more capital beyond, what the bank deems optimal and thereby increases the financing cost of the bank leading to lower credit supply. Capital ratios in so far that they reflect changes in *economic capital* (desired capital) can increase the credit growth. That is, increases in capital ratios holding the capital requirement constant (equivalent to increases in capital buffer) could reflect decreases in the financial riskiness of the bank (proposition II) and lead to credit growth. Thus, depending on whether M&M proposition II holds (assuming proposition I fails) then bank capital and capital requirements can have different effects on lending.

Admati et al. (2013) would argue that the risk premium is not constant and that M&M's proposition II actually holds (the equity cost rises with leverage). In their argument, loans and deposits are inherently operating activities of the bank. The bank incurs real costs on deposits beyond the interest rate given e.g. in the form of ATMs, transaction services and branches while sustaining losses on its loans. Further, banks hold significant amount of traditional market debt. Thus, at the margin when deposits are constant, increasing leverage would imply a higher cost of equity. To see this then it is necessary to adjust the bank balance sheet into an analytical balance sheet that distinguish between operating and financing activities. Figure 3.2 illustrates this.

Figure 3.2: Adjustment of Bank Balance Sheet

The bank balance sheet

Loans + Securities	Deposits + Market debt + Equity
= Assets	= Liabilities + equity

The adjusted bank balance sheet

Loans - Deposits	Market debt - securities
= Net operating assets	= Net interest bearing debt
	Equity

The preceding discussion of the relation between M&M's propositions and credit growth have been fruitful in illustrating that in capital markets with some type of frictions it might be possible to imagine a scenario where credit growth (the asset side of a bank) can be affected by the financing (bank capital and capital requirements). In particular, it seems possible that capital requirements can be negatively associated with credit growth and capital ratios can be positively associated with credit growth. The subsequent subsections will develop a theoretical model of how and under what assumptions credit growth can be affected by bank capital and capital requirements. The theoretical model will be consistent with the bank capital channel view, which the following subsection will elaborate on before explaining the theoretical model.

3.2.2 Bank Capital and Bank Lending Channel Views

Within in the academic field of monetary policy transmission research, two particular views, the bank capital channel and the bank lending channel views, have gained interest as to how monetary policy can affect the real economy besides and on top of the usual interest rate / "money" view mechanism of standard IS/LM text book models (Kashayp & Stein 1994). The thesis will not discuss the traditional interest rate / money view but instead focus solely on the bank capital channel and bank lending channel view. The bank lending channel refers to the effect on credit growth from the transmission of monetary policy through market imperfections in banks' reserves (Kashayp & Stein 1994). The bank capital channel view relates monetary policy to bank's credit growth through imperfections in the market for equity (Van den Heuvel 2002). Thus, both approaches rely on imperfections in capital markets, the bank lending channel on imperfections in the market for debt and the bank capital channel on imperfections in the market for equity, to explain how monetary policies can have effects on credit growth for banks beyond the traditional central bank mechanisms. Fundamental to the bank capital channel is that it explicitly states a role for capital requirements and its potential impact on lending growth. The theoretical underpinnings of the thesis will thus be rooted in the bank capital channel view to explain how credit growth can be affected by bank capital and capital requirements. However, both channels will be outline first before we turn to Francis & Osborne's (2009) model.

The bank lending channel view argues that monetary policy can have a direct impact on the loan growth of a bank through the assumption of an imperfect market for uninsured debt independently of the monetary policy on the central bank lending rate (Gambacorta & Mistrulli 2004; Kaspyap & Stein 1994; Kaspyap & Stein 1994). The market for uninsured debt is assumed to be imperfect in that it suffers from asymmetric information between the borrower (the bank) and the issuer following Myers & Maljuf's (1984) pecking order argumentation as explained in section 3.1.3. To illustrate the lending channel, consider two banks, which are identical in all respects except that one of the banks has a larger share of liquid assets to total assets compared to the other bank. Imagine a negative shock to insured deposits of both banks due to monetary policy. A shock to deposits works as a shock to the bank's financing. The assumption of asymmetric information in the market for uninsured debt would make the marginal cost of external funding an increasing function of the amount raised.[7] Increasing marginal costs will lead to less than a one-to-one offset between insured deposits and uninsured external financing transmitting to decreases in the asset side of the balance sheet of the two banks. The more liquid bank will (compared to the less liquid bank) be able to 'protect' its loan portfolio better by decreasing its stock of liquid assets to accommodate the shock in deposits from monetary policy.

The bank lending channel has been criticised by Romer & Romer (1990) who present a M&M consistent argument in which banks can frictionless offset the shortfall in deposit financing. To see this, recall that the M&M theorem states that the financing of a company should not have an impact on its operational activities. In the context of the example of the previous paragraph, the M&M theorem would propose that the two banks could secure uninsured external funding to completely offset the decrease in insured deposits. Thus, the contractionary monetary policy would not affect the loan supply through a 'lending channel'. Furthermore, disentangling the lending channel effect on lending from standard demand effects from monetary policies have also been challenged. The bank lending channel will not be the theoretical support of the thesis. We will however control for bank liquidity in the regression models to make sure that the bank lending channel view does not affect the results.

The bank capital channel view argues that financial shocks to bank capital can affect the lending capacity of banks through an imperfect market for equity (Van den Heuvel 2002; Gambacorta & Mistrulli 2004; Francis & Osborne 2009). The financial shocks can be monetary policy, shock to asset value or regulations where the model of the next section will focus on the latter. The general bank capital channel view rests upon three assumptions: (i) Equity issuance is expensive due to asymmetric information (Myers & Maljuf 1984) limiting the possibilities of banks to raise equity; (ii) Banks are subject to interest rate risk from the maturity transformation activity; And (iii) banks are subject to regulatory capital requirements which imposes costs

7. Kashayp & Stein (1994) also present other arguments for the increasing marginal cost of external financing, which will not be discussed here.

to the bank if breached (Gambacorta & Mistrulli 2004). In the later model, only the first and third assumption will be needed to explain how bank capital and capital requirements can affect lending. However, in the general model of monetary policy the second assumption is important. Imagine an increase in market interest rates. Only a small proportion of a bank's loans compared to deposits will be renegotiated (as loans are long-term and deposits are short-term) causing the interest rate on banks' loans to more slowly adjust compared to banks' deposits. Therefore, banks bear a loss (and subsequently capital decreases) due to the maturity mismatch between assets and liabilities when market interest rates increase. Given that capital requirements are binding, and equity is sufficiently low and too expensive to be raised then banks will reduce lending to meet requirements (Gambacorta & Mistrulli 2004). Further, even if capital exceeds current capital requirements then the costs of breaching requirements in the future can cause a bank to forego growth opportunities today (Van den Heuvel 2002). The model presented in the next section will rely on some of the same logic as the more general bank channel view presented in this paragraph.

3.3 A Theoretical Model Relating Bank Capital and Regulations to Lending

The section outlines Francis & Osborne's (2009) 'bank capital channel' model explaining the relationship between bank capital, capital regulations and lending. The overall goal of the section is to show that a theoretical argument linking capital, requirements and lending is present in the literature. It is not the aim of the thesis to produce a new theoretical model of the relationship, and therefore we use Francis & Osborne's (2009) existing model to support and inform our empirical study. Rather, we will elaborate and be critical of the main assumptions of the model in relation to our empirical study. We link the results of the model directly to the research design of the empirical study in chapter 6. Firstly, the assumptions of the model are outline, and secondly, the results of the model are presented.

The objective of the model presented in the following paragraphs is to provide some basic theoretical insights into a bank's portfolio behaviour. The model rests on market imperfections at the bank level to explain how capital requirements can impact the lending behaviour of a bank. Hence, it is a bank-level model based on market values. Banks are assumed to be profit maxisimising.

3.3.1 Model Assumptions

The model has three time periods ($t = 0, 1, 2$). In each period, the bank's asset side consists of loans *(L)* and government securities *(G)*. Banks' loans (L) have a maturity of two years, and banks only issue loans at $t = 0$. That is, the loans cannot be liquidated until $t = 2$. Loans earn a return denoted r_L. Banks can also invest an amount in government securities *(G)* at time $t = 0$. The return on government securities is, r_G. Unlike loans, government securities can be liquidated at no cost at $t = 1$. Loans are assumed to be riskier than government securities (due to higher probability of default), and thus loans offer a higher rate of return. That is, $r_L > r_G$. Banks are assumed to have some power over the rate on loans that they charge, and the demand for loans is assumed to be inversely related to the rate on loans that the bank sets (i.e. downward-sloping demand curve). That is, $L = L(r_L)$ and $L'(r_L) < 0$. Therefore, a bank's loan amount (L) in period $t = 0$ is based on the rate on loans that it chooses to charge, and the loans cannot be liquidated until $t = 2$. The last assumption is fairly strong in that in the "real world", a bank's loan portfolio has various maturities, and loans can be liquidated early. However, the assumption captures two important features of banks while keeping the model simple. Firstly, banks face uncertainty about future capital requirements when negotiating loans, and secondly, banks face liquidity risk. Government securities carry a lower risk weight than loans. For simplicity, we will assume that the risk weight is zero, and thus that the capital requirements (presented later) on government securities is zero as well. A bank's capital requirements will thus only depend on the loan amount (L).

$$L = L(r_L)\, and\, L'(r_L) < 0 \tag{3.1}$$

$$r_L > r_G \tag{3.2}$$

The assets of the bank are financed through two sources: Deposits, D, and equity capital, K. Deposits are exogenously determined by central banks' monetary policy. The interest rate paid on demand deposits is r_D, which is less than the return on loans and government securities, $r_D < r_G < r_L$. Demand deposits carry reserve requirements equal to gD where g is a fraction ($\in (0, 1)$) of the deposit balance. Only government securities can count towards the requirement. That is, $G \geq gD$. We will assume like Francis & Osborne (2009) that deposit withdrawals are deterministic. The bank's reserve requirement, gD, is thus sufficient to meet any shock to its demand deposits. The assumption is quite strong. Further, the deposit base could have been assumed to evolve stochastically to produce indirectly shocks to capital (e.g. from uncertainty of deposit supply and external funding at a higher cost). However, the primary objective of the model is to show, how direct shocks to capital through capital requirements can affect loan growth, and thus it would add unnecessary complexity to have a stochastically determined deposit base in the model.

Banks are endowed with an initial level of capital of K_0^B at time $t = 0$ where K_t^B denotes the end of each period's capital on the balance sheet. Capital evolves over time with the addition of profits, π_t, for $t = (1, 2)$, and issuance (redemption) of new (existing) capital K_t^E for $t = (0, 1)$. Profit is the sum of earnings received on loans and government securities less the cost of deposits, $\pi_t = r_L L_t + r_G G_t - r_D D_t$. K_t^E is the change in capital from transactions with investors. Banks are subject to adjustment costs if they change capital (described below). Dividends are assumed to be zero for all time periods. At time $t = 2$, banks are liquidated at no cost, and shareholders receive the amount of equity on the balance sheet and earnings for period 2. Thus, bank i's balance sheet, which must balance in each period, is given by:

$$Bank\, i's\, balance\, sheet\, at\, time = t : L_t + G_t = D_t + K_t^B \tag{3.3}$$

From the paragraph above, it is evident that the capital accumulation equation is:

$$Capital\, accumulation : K_t^B = K_{t-1}^B + \pi_t + K_t^E \tag{3.4}$$

Where, profit is given by:

$$Profit : \pi_t = r_L L_t + r_G G_t - r_D D_t \tag{3.5}$$

Issuance of equity is assumed to be expensive due to asymmetric information on the level of the bank between the managers and shareholders of the bank. Francis & Osborne (2009) therefore assumes that the marginal cost of external equity funding is an increasing function of the amount raised. The assumption is rooted in the work by Myers & Majluf (1984) on asymmetric information in equity issuance. In an otherwise perfect capital market, a firm would invest in all positive NPV projects regardless of the cash on hand, as equity can be raised in the capital market at a NPV of zero. However, imagine that managers are assumed to hold superior knowledge compared to outside investors, managers act in the interest of the old shareholders (equivalent to maximising the existing equity value), and old shareholders are assumed to be passive (i.e. they do not invest in new equity issuance). If a given investment opportunity is NPV positive then the management wants to invest, however if they are financially constrained (i.e. no cash at hand) then they need to raise equity in the capital market. At any point in time, a company shares can be over- or undervalued, and only the managers know. With managers acting in the interest of old shareholders, and old shareholders are passive then in some situations the managers will choose not to issue shares and thereby not to invest, as it is not in the interest of old shareholders. That is, the cost to old shareholders of issuing shares at a bargain price may outweigh the investment opportunity's NPV. Outside investors knows this. Thus, a company's choice to issue equity will be seen as conveying "bad / less good" news and investors will demand a lower price for the issued shares. This will again affect the issue / investment decision. Thus, the company will in some instances choose not to invest in positive NPV projects, and the cost of issuing equity will increase with the size of the required equity issuance (Myers & Majluf 1984). In the model it is thus assumed that the adjustment costs of equity is quadratic:

$$Adjustment\, cost\, of\, capital = \frac{\beta_1 (K_1^E)^2}{2} \tag{3.6}$$

Where β_1 represents per unit cost of capital and K_1^E, as stated earlier, represents amount of equity issued.

The adverse selection argumentation of costly equity issuance is well-documented with stock prices on average falling with a stock issuance announcement. However, some general points are worth noting before continuing with the model. Firstly, as discussed in section 3.1.3, managers acting in the interest of current shareholders and existing shareholders being passive can be contested. Secondly and related, rights offerings to existing shareholders would effectively resolve the conflict between existing and new shareholders. However, it requires that existing shareholders have the liquidity to participate in the rights issuance. Lastly, the specific functional form for adjustment cost of equity can alter the magnitude of the model results on lending. However, the functional form is not critical for the direction of the results as long as the adjustment costs are exhibiting increasing marginal costs of equity.

The model assumes the existence of capital requirements similar in spirit to the Basel Capital Accords. The capital requirements in the model consist of a non-discretionary minimum capital requirement ratio (capital-to-risk-weighted-assets) and a bank-specific capital requirement ratio (capital-to-risk-weighted-assets) set by regulators based on the bank's loan portfolio risk at time t. In mathematical notation, the required capital amount is $K_t^R = k_{R,t}L = (k_t^{min} + k_t^{disc})L$ for $t = (0, 1)$, where K_t^R is the required *amount* of regulatory capital at time t, $k_{R,t}$ is the *total* capital requirement ratio in percentage ($\in (0, 100)$), k_t^{min} is the *minimum* national capital requirement ratio in percentage ($\in (0, 100)$), and k_t^{disc} is the bank-specific *discretionary* capital requirement ratio in percentage ($\in (0, 100)$). The bank-specific proportion of the total capital requirement ratio can vary over time, and it is not fully known to the bank. The minimum national requirement ratio is known to the bank at all times. Further, breaching the capital requirements imposes real costs to the bank in form of equity adjustment costs. The main objective of the model is to show the effect of change in regulatory requirement at $t = 1$. The effect will be dependent on whether the capital holdings at $t = 1$, K_1^B, exceeds the capital requirement at $t = 1$, K_t^R, and the above-mentioned cost of adjusting equity if additional equity is needed. Equation 3.7 summarises the capital requirements assumed in the model.

$$K_t^R = k_{R,t}L = (k_t^{min} + k_t^{disc})L, for\, t = (0, 1) \tag{3.7}$$

3.3.2 The Model Mechanics

The main driver of the model is that a bank faces uncertainty of future requirements in t=1 when setting the loan rate in the period before (t=0) combined with the adjustment costs of capital. From the assumptions outlined in the preceding paragraphs, we can work backwards to solve the bank's portfolio choices at $t = 0$ and $t = 1$ and investigate the effect of capital requirements on lending growth. At $t = 2$, the bank enters with loans of L, securities of G, and a capital cushion from period 0 of $K_0^E (= K_0^B - k_{R,0}L)$ already on the balance sheet. The capital requirements of period $t = 1$ are unknown to the bank, and thus the adjustment costs of equity is possible, when the bank sets its loan supply in $t = 0$. It is this uncertainty that drives the bank to hold a capital cushion in $t = 0$. The capital level in period $t = 1$ before adjusting equity is given by $K_1^B = k_{R,0}L + K_0^E + \pi_1$. It can be either in surplus or shortfall compared to the requirement set in period $t = 1$.:

Surplus: $K_1^B = k_{R,0}L + K_0^E + \pi_1 > K_1^R = k_{R,1}L$
In this case, the bank has a capital surplus in period $t = 1$ compared to the capital requirement set by regulators in period $t = 1$. The bank can continue to support its asset side without raising additional equity.

Shortfall: $K_1^B = k_{R,0}L + K_0^E + \pi_1 < K_1^R = k_{R,1}L$
In this case, the bank has a capital shortfall in period $t = 1$ compared to the capital requirement set by regulators in period $t = 1$. The bank must raise additional equity at a cost to support its asset side.
Considering both scenarios together, the capital needed to be raised in the event of a shortfall can be expressed as:

$$K_1^E = Max[0, k_{R,1}L - (k_{R,0}L + K_0^E + \pi_1)] \tag{3.8}$$

The cost of adjusting K_1^E is given by $\beta_1(K_1^E)^2/2$. K_1^E is thus the amount of shortfall in period $t = 1$ that must be offset by an equal amount of capital raised in the capital markets. The costs of not complying with regulatory requirements in $t = 1$ is dependent on the probability of actually being in a capital shortfall (contrary to capital surplus). The probability of being in a shortfall can be expressed as:

$$Pr[K_1^B = k_{R,0}L + K_0^E + \pi_1 < K_1^R = (k_1^{min} + k_1^{disc})L] \tag{3.9}$$

And the expected capital adjustment costs is thus the probability multiplied with the shortfall, all squared, and then multiplied with β_1, and divided by 2. Expressed mathematically, the expected capital adjustment costs are given by:

$$E[\frac{\beta_1(K_1^E)^2}{2}] = \frac{\beta_1 P_s[(k_{R,0}L + K_0^E + \pi_1) - (k_1^{min} + k_1^{disc})L]^2}{2} \tag{3.10}$$

Where P_s denotes the probability of being in a shortfall.

From the above, we can now set up the optimisation problem in $t = 0$. At $t = 0$, the bank chooses r_L (and implicitly $K_0^E = K_0^B - k_{R,0}L$ and $G_0 = D_0 + K_0^B - L$)[8][9] to optimise the value of the firm which lives for two periods:

$$\max_{r_L} E[V] = r_L L + r_G G + \beta_1(E[K_1^E])^2/2 \tag{3.11}$$

8. By choosing r_L then implicitly the bank also chooses the initial capital cushion K_0^E as the initial capital endowment of the bank, K_0^B, is exogenously determined, the capital requirement in period t=0, $k_{R,0}$, is also exogenously determined and L is given by r_L.

9. To see this, recall that demand deposits and initial capital endowment are exogenously determined and lending is given by the chosen loan rate.

Notice from equation 3.11 that the value of the firm depends on the profit generated by the bank in the two time periods and the expected adjustment cost of equity in the event of a capital shortfall.

Substituting equation 3.10 into equation 3.11 yields:

$$\max_{r_L} E[V] = r_L L + r_G G + \frac{\beta_1 P_s [k_{R,0} L + K_0^E + \pi_1 - (k_{R,1}^{min} + k_{R,1}^{disc}) L]^2}{2} \quad (3.12)$$

The last term in equation 3.12 provides a measure of the expected total costs of adjusting capital to meet new capital requirements set at time 1. Taking the first order condition of the firm value maximisation problem of equation 3.12 with respect to the bank's decision variable, loan rate, yields:

$$\frac{dV}{dr_L} = L + r_L L' - r_G L' + \beta_1 P_s K_1^E [L'(k_{R,0} - k_{R,1}) + L + r_L L' - r_G L'] = 0 \quad (3.13)$$

Where $L' = dL/dr_L < 0$. We assume that the second-order condition for maximisation is satisfied, i.e., $d^2V/dr_L^2 < 0$ at the optimal solution, r_L^*.

Rearranging equation 3.13 yields the optimising condition:

$$L + r_L L' - r_G L' = -\beta_1 P_s K_1^E [L'(k_{R,0} - k_{R,1}) + L + r_L L' - r_G L'] \quad (3.14)$$

The left-hand side of equation 3.14 is the marginal profit from a change in the loan rate. The right-hand side of equation 3.14 is the expected capital adjustment cost multiplied by the impact of a change in the lending rate on the capital constraint at time 1. The bank thus sets its loan rate such that the marginal revenue from its loans and government securities equals the marginal adjustment costs from any capital shortfall.

To investigate the effect of capital requirements on lending, we investigate the comparative statics effect of a change in capital requirements on the loan rate. Using equation 3.13 and the implicit function theorem, the effect of a change in capital requirements on the loan rate can be formally evaluated:

$$\frac{dr_L}{dk_{R,1}} = -\frac{\frac{\partial}{\partial k_{R,1}}\{L + r_L L' - r_G L' + \beta_1 P_s K_1^E [L'(k_{R,0} - k_{R,1}) + L + r_L L' + r_G L']\}}{\frac{\partial}{\partial kr_L}\{L + r_L L' - r_G L' + \beta_1 P_s K_1^E [L'(k_{R,0} - k_{R,1}) + L + r_L L' + r_G L']\}} > 0 \quad (3.15)$$

The expression is positive since the denominator is negative due to the second-order condition[10] and the numerator is positive[11]. Higher expected capital requirements in time 1 must be offset by an increase in the loan rate leading to a lower level of loans to equate marginal revenue and marginal cost. Thus, the model implies that an increase in (expected) capital requirements

10. Second-order condition: $d^2V/dr_L^2 < 0$.

11. The positive sign can be seen by looking in more detail at the components and sign of the denominator: $\frac{\partial}{\partial kr_L}\{L + r_L L' - r_G L' + \beta_1 P_s K_1^E [L'(k_{R,0} - k_{R,1}) + L + r_L L' + r_G L']\} = -\beta_1 P_s K_1^E [L' k_{R,1}]$

will lead to lower loan growth.

Similarly, the effect of a change in the per unit capital adjustment cost is interesting to investigate. The comparative statics effect of a change in the per unit capital adjustment cost on the loan rate is:

$$\frac{dr_L}{d\beta_1} = -\frac{\frac{\partial}{\partial \beta_1}\{L + r_L L' - r_G L' + \beta_1 P_s K_1^E [L'(k_{R,0} - k_{R,1}) + L + r_L L' + r_G L']\}}{\frac{\partial}{\partial k r_L}\{L + r_L L' - r_G L' + \beta_1 P_s K_1^E [L'(k_{R,0} - k_{R,1}) + L + r_L L' + r_G L']\}} > 0 \tag{3.16}$$

Equation 3.16 is positive, since the numerator is positive, and the denominator is negative (by the second-order condition). Thus, an increase in per unit cost of adjusting capital decreases the loan level of bank i.

We can further extend the findings from the comparative statics effects of equation 3.15 by considering the effects of capital requirements on initial capital buffers and the holdings of government securities. Recall that initial capital buffer is a function of the initial capital endowment and the capital requirement on loans at time 0. Since the level of loans are a function of the loan rate then the optimal capital buffer at time 0 can be expressed as:

$$K_0^{E^*} = K_0^B - k_{R,0} L(r_L^*) \tag{3.17}$$

Taking the partial derivate of $K_0^{E^*}$ with respect to time 1 capital requirements:

$$\frac{\partial K_0^{E^*}}{\partial k_{R,1}} = -k_{R,0} \frac{dL}{dr_L^*} \frac{dr_L^*}{dk_{R,1}} > 0 \tag{3.18}$$

The term $\frac{dL}{dr_L^*}$ is negative and the term $\frac{dr_L^*}{dk_{R,1}}$ is positive making the overall expression positive. Equation 3.18 shows that the optimal capital buffer held at time 0 increases as expected time 1 capital requirements increase. The result is similar if taking the partial derivative $K_0^{E^*}$ with respect to the per unit cost of adjusting capital, β_1. That is, the optimal capital buffer in time 0 increases as the per unit cost of adjusting capital increases.

Similarly, using the balance sheet identity together with the comparative statics in equation 3.15, we can consider how the optimal government securities holdings are affected by time 1 capital requirements. Expressed mathematically,

$$\frac{\partial G_0^*}{\partial k_{R,1}} = -\frac{dL}{dr_L^*} \frac{dr_L^*}{dk_{R,1}} > 0 \tag{3.19}$$

Again the term $\frac{dL}{dr_L^*}$ is negative and the term $\frac{dr_L^*}{dk_{R,1}}$ is positive making the overall expression positive. The result is similar when replacing time 1 capital requirement with per unit cost of adjusting capital. The result shows that a bank will choose to hold higher government securities holdings, as expected time 1 capital requirements increase or per unit capital adjustment costs rise, since the capital requirement of government securities are lower than the capital requirement on loans.

3.3.3 Model Results

From the comparative statics effects shown, we can summarise the model results and relate them to loan growth. The results will inform the research design of the empirical study of the thesis.

Model results:

(i) An increase in expected capital requirements leads to lower loan growth

(ii) An increase in per unit adjustment cost of capital leads to lower loan growth

(iii) An increase in capital buffer leads to higher loan growth

(iv) An increase in the capital requirement or adjustment cost of capital leads to a higher government securities position

(i) Higher expected capital requirement leads to larger expected capital shortfall (i.e. adjustment cost of equity increases) and thus the loan rate is set higher to increase the profit and decrease the realised capital shortfall. Higher expected capital requirements therefore leads to lower loan growth in Francis & Osborne's (2009) model. The negative relationship between capital requirements and loan growth will be tested in chapter 7 after outlining the data and methodology of the empirical study in chapter 5 and 6, respectively.

(ii) An increase in the per unit capital adjustment cost, β, (or an increase in the probability of sustaining a capital shortfall) increases the cost of the potential shortfall of capital and thus must be offset by an increase in loan rates implying a decrease in loan growth. The adjustment cost of equity cannot be directly observed in our empirical study and thus not directly studied. However, multiple proxies for the adjustment cost of equity can be thought of. Firstly, listed banks may have lower cost of raising equity, as they compared to non-listed banks have higher disclosure requirements to outside investors and likely a larger investor-base available (i.e. implying a lower search cost of finding investors). Thus, listed banks are likely to experience lower adjustment cost of capital. Secondly, larger banks might also be argued to have lower cost of raising equity from being more well-known in the equity markets and availability of information to investors being larger for larger banks compared to smaller banks. It would suggest a positive relationship between size and loan growth. Arguments against a positive relationship between listed banks and loan growth and size and loan growth will be presented in later chapters.

(iii) An increase in the capital buffer (from a higher initial capital endowment or lower initial capital requirements) leads to a lower optimal loan rate and thus a higher optimal loan growth. Thus, the model predicts that capital surplus should be positively associated with loan growth.

Further, it might also suggest that more capitalised banks compared to less capitalised banks should be less affected by adjustment costs of equity or probability of capital shortfall and thus they reduce lending comparably less. The positive relationship between capital surplus and lending, and the relationship between the degree of capitalisation and lending will be tested in the empirical study in the later chapters.

(iv) An increase in the per unit cost of adjusting capital or higher expected capital requirements leads the bank to hold a higher government securities position (liquidity position). This is due to the higher liquidity and lower risk weight of government securities, which effectively work to offset increases in adjustment costs or capital requirements. Thus, the model suggests that the government securities should be positively associated with loan growth. The positive relationship will be tested in the empirical study.

The results are dependent on the assumptions of (1) increasing marginal cost of adjusting capital (imperfect market for equity), (2) uncertainty about future bank-specific capital requirements, and (3) an inverse demand curve between loan rate and loan stock with the individual bank having some price-setting power. The first assumption has been extensively discussed and it seems reasonable. If, however Modigliani & Miller's propositions holds then it is equivalent to $\beta = 0$ in the model, and then it is clear that capital requirements cannot impact loan growth. We regard this assumption as unrealistic and proceed with the assumption of imperfect market for equity. The second assumption of uncertainty about future bank-specific capital requirements seems reasonable. Especially the larger reliance on national FSAs to adjust capital requirements when and where it seems fit with a relatively short notice period supports the model assumption of uncertainty. The extent of the uncertainty and the time horizon is of course up for debate. The third assumption seems reasonable, too. An inverse demand curve is a very common feature assumed in loan markets (i.e. the aggregated demand for loans will decrease with an increase in price. The relationship might be tested, if instead of bank-specific requirements, national requirements shock the bank's position. This is discussed in chapter **??**, *Discussion.* A price-setting bank, compatible with an oligopolistic market, could be supported as well, as top 20 banks in Scandinavia accounts for 93% of loans in our sample, suggesting that the bank may have power to differentiate and set prices on their loans regardless of the market.

3.4 Summary

The main purpose of the chapter was to investigate Francis & Osborne's (2009) 'bank capital channel' model to establish a theoretical grounded relationship between bank capital, capital requirements and lending. The model has produced four overall results, which will inform the research design of the empirical study. Further, theoretical literature has been reviewed to give a comprehensive account of how capital structure through market imperfections can potentially impact the asset side of a firm or bank.

Chapter 4

Review of Empirical Studies

The theoretical literature and model reviewed in the preceding chapter generally highlight positive effects of holding additional capital and negative effects of capital requirements on credit growth. The magnitude of the effects of bank capital and capital requirements on lending growth is an empirical question, which will be elaborated on in this chapter. The empirical literature on credit growth is plentiful and diverse in the sense that the studies vary depending on their research scope, estimation approach and type of data. We limit the empirical literature review to studies that investigate the impact of bank capital or capital requirements on lending growth. We further divide the literature into three branches according to the specification of the main explanatory variable and focus of study: (i) Capital ratio and capital surplus / shortfall to a target capital ratio; (ii) Capital requirement and capital surplus / shortfall to capital requirement; And (iii) welfare cost studies. The following literature review will present and discuss the data, estimation technique and main findings of each of the three branches within the literature. We will give particular attention to some studies during the review, as our research design draws inspiration from these particular studies. Within the first branch of literature, we begin by introducing two early studies by Bernanke & Lown (1991) and Hancock & Wilcox (1993), which serve as the foundation for many later studies. Later, we review the more recent studies within the same branch. Secondly, we investigate the second branch of literature on capital requirements and capital surplus / shortfall to capital requirements. Finally, we review the third stream of literature that focus on the welfare cost of capital regulation. Table 4.1 summarises the most important empirical studies on the effect of bank capital and capital requirements on lending. The literature will be discussed in the following sections.

4.1 Capital Ratios and Capital Surplus / Shortfall to Target Capital Ratio

4.1.1 Early Studies

Much of the literature on the effect of capital constraints on bank lending emerged after the 1990s. It was inspired by the question of whether the US recession in the early 1990s was worsened by capital constrained banks which cut back lending at an inconvenient time - a ques-

Table 4.1: Overview of Selected Empirical Studies

			Dependent variable	**Main Explanatory Variables**			**Control variables**						**Data**			
Year	*Author(s)*	*Fixed Effect Study*	*Lending growth*	*Capital Ratios*	*Capital requirements & capital surplus / shortfall to requirement*	*Surplus / shortfall of actual capital ratio to target capital ratio*	*Lagged lending growth*	*Size*	*Profita-bility*	*Risk*	*Liquidity*	*Other Variables**	*Country / Area*	*Time period*	*Time observation*	*Listed / non-listed banks*
2012	Aiyar et al.	One-way	✓	✓	✓	(✓)	✕	✓	✕	✓	✕	✓	UK	1998-2007	Quarterly	n.a.
2010	Berrospide & Edge	One-way	✓	✓	✕	✓	✓	(✓)	(✓)	✓	✓	✓	US	1992-2009	Quarterly	n.a.
1993/94	Hancock & Wilcox	n.a.	✓	✕	✕	✓	✕	(✓)	✕	✓	✕	✕	US	1991	Quarterly	n.a.
1991	Bernanke & Lown	n.a.	✓	✓	✕	✕	✕	✕	✕	✕	✕	✕	US	1990	Quarterly	n.a.
2016	Deli & Hasan	Two-way	✓	✕	✓	✕	✓	✓	✕	✓	✓	✓	Global	1998-2011	Annually	Listed
2015	Bridges et al.	Two-way	✓	✕	✓	✕	✓	(✓)	✕	✕	✕	✓	UK	1990-2011	Quarterly	Both
2015	Mésonnier & Monks	One-way	✓	✓	✓	✕	✓	✓	✕	✕	✓	✓	EU	2011-2012	Monthly	n.a.
2015	De Nicoló	Two-way	✓	✕	✕	✓	✓	✓	✓	✓	✕	(✓)	Global	1982-2013	Annually	Listed
2014	Labonne & Lame	Two-way	✓	✓	✓	✕	✓	✕	✕	✓	✕	✓	FR	2003-2011	Quarterly	n.a.
2009	Francis & Osborne	One-way	✓	✕	✕	✓	✕	(✓)	(✓)	✓	✕	(✓)	UK	1996-2007	Quarterly	Both
2016	Kragh & Rangvid	Two-way	✓	✕	✓	✕	✕	✓	✓	✓	✕	✕	DK	2007-2014	Quarterly	Both

*Not including variables that are captured with fixed effects.
Note: In studies where a target capital ratio is calibrated first and subsequently used to estimate lending growth parentheses '()' indicates that a variable is used in the first calibration and thus indirectly in the final estimation of lending growth.

tion often referred to as the "capital crunch hypothesis" (Bridges et al. 2015). Bernanke and Lown (1991) found using a cross sectional US state-level dataset that in some regions of the US, capital constrained banks, because of losses on real estate lending, reduced their lending subsequently. On another cross sectional dataset of 111 banks in the state of New Jersey, Bernanke & Lown (1991) finds a significant positive relationship between capital ratios and lending. In the study on New Jersey banks, a 1% increase in the equity-to-asset ratio leads to +2.0-2.5%. In his review of the empirical findings concerning the credit crunch hypothesis, Sharpe (1995) however concludes that the research generally failed to convincingly link the reduced bank lending to changes in capital ratios. He does, however, find the link between loan growth and bank profitability to be robust, an insight, which will be applied to our analysis.

Despite the missing consensus on whether a credit crunch in bank contributed to the US recession in 1990, other researchers also provide evidence of capital constrained banks reducing lending. Using a US bank dataset in 1991 and a partial adjustment process model, in which banks adjust to capital requirements over time, Hancock & Wilcox (1993, 1994) find that banks, which are in capital shortfall to an internal calibrated target capital to asset ratio, have reduced lending growth compared to banks that are in capital surplus. Additionally, they find that banks with capital shortfall to risk weighted assets (RWA) compared to an internal calibrated target capital to RWA did not reduce lending (Hancock & Wilcox 1994). In fact, they find that banks with capital shortfall measured on a RWA ratio shifted away from assets with low risk weights, such as securities, and towards assets with higher risk weights, such as commercial real estate and business loans however without reducing lending significantly. Hence, the early research around concluded that the effect of bank capital on the US recession of 1990-1991 was ambiguous.

The studies of Bernanke & Lown (1991) and Hancox & Wilcox (1993, 1994) were some of the first studies on the effect of bank capital and capital requirements effect on lending. While both studies have inspired later studies, then they also suffer from some limitation. Firstly, both studies are cross-sectional studies and thus they do not study the effect on lending of changes in capital ratios of banks over time. Later studies have almost exclusively focused on panel datasets to improve the inference from the models estimated. Secondly, the regression models estimated suffer from limitations. Bernanke & Lown's (1991) regression model do not include controls variables while Hancox & Wilcox's dependent variable, bank credit, includes securities, which in most later studies are excluded to solely focus on loans.

4.1.2 Recent Studies

In their study of the effect of bank capital on lending, Berrospide & Edge (2010) draw on some of the earlier literature just outlined, and they find that a 1%-point increase in capital ratios leads to a +0.7-1.2%-points in lending, while a 1%-point increase in capital surplus to an internal calibrated target capital to asset ratio increases lending growth with 0.25%-points. That is, lending growth is larger for banks with higher capital ratios and higher levels of excess capital. They use quarterly balance-sheet data for large US bank holding companies (BHC) in the period 1992-2009, and they specifically rely on the approaches developed by Bernanke & Lown (1991) and Hancock & Wilcox (1993, 1994) in the development of their empirical models. Berrospide & Edge (2010) point out an important possible bias in the empirical literature, namely survivorship bias [1]. While, Berrospide & Edge's (2010) study also suffers from survivorship bias like most other empirical studies as they include only BHCs that remained in operation by the end of their sample period (2009). They seek to address this issue by taking a different estimation approach than panel regression to test the robustness of the results. Through a variant of Lown and Morgan's (2006) vector autoregressive (VAR) bank capital model, they test the dynamic and general-equilibrium effects of exogenous change to a bank's capital ratio (Ibid.). Despite the application of this different approach the results remain largely similar, i.e. the errors that potentially occur from survivorship bias are found to be limited.

Berrospide & Edge (2010) specify two models to test the effect of bank capital and capital requirements on lending growth. The first model uses capital ratios as the main explanatory variable similar to Bernanke & Lown's (1991) study. The second model uses capital surplus / shortfall (deviations of actual capital levels relative to an internal calibrated target capital level) following Hancock & Wilcox (1993). We will elaborate on the first model below. The model test multiple different capital ratios as explanatory variable in separate specifications[2]. We will focus on the ratio, $K_{i,t-1}/A_{i,t-1}$ as specified in equation 4.1 below.

$$\begin{aligned}\Delta\%LOAN_{I,t} = &\sum_{s=1}^{4}\alpha_s\Delta\%LOAN_{I,t-s} + \sum_{s=1}^{4}\gamma_s\Delta\%GDP_{I,t-s} + \sum_{s=1}^{4}\delta_s INF_{I,t-s} + \sum_{s=1}^{4}\beta_s\Delta RFF_{I,t-s}\\ &+ \sum_{s=1}^{4}\zeta_s STD_{I,t-s} + \psi LIQU_{I,t-1} + \chi CHG_{I,t-1} + \psi(K_{I,t-1}/A_{I,t-1}) + \epsilon_{I,t}\end{aligned} \tag{4.1}$$

In their specification GDP and inflation (INF) is used to control for demand-side effects, while changes in federal funds rate control for monetary policy changes (i.e. aggregated supply effects). At the firm level, controls for bank liquidity (measured by liquid assets to total assets) and risk (measured by the ratio of net charge-offs to total assets) are included. They estimate the model using a one-way fixed effect estimation (bank fixed effect) to capture any additional omitted firm-specific factors that are constant over time. All panel data studies reviewed uses a bank fixed effect, however several papers have used a two-way fixed effects estimation, including time fixed effects to control for aggregated demand and supply factors which are constant across firms but vary across time. This is thereby a different approach compared to Berrospide & Edge

1. Survivorship bias is the error of focusing on subjects that have made it through some selection process. In this case it refers to only including banks that have survived over the entire time period of the empirical study.

2. The model is estimated using several different capital ratios separately. The capital ratios are: The equity-to-assets ratio, the total capital to RWA ratio, the tier 1 capital to RWA ratio, and the tangible common equity ratio.

(2010). In the regression model of this thesis, a two-way fixed effects estimation will be used, however we drop the time fixed effects and include aggregated demand and supply factors to test the robustness of our results. Berrospide & Edge (2010) finds that a 1%-point increase in the equity-to-asset ratio is associated with a +0.8% in lending. The result is significant on the 1%-level. Francis and Osborne (2009) estimate a model similar to the second model of Berrospide & Edge (2010) on a quarterly dataset of U.K. banks from 1996 to 2007. They also find a modest but significant effect of bank capital surplus (to a internal target capital level) on lending. Specifically, they find that a 1%-point increase in capital surplus is associated with a 0.06%-point increase in lending growth.

4.1.3 Capital Requirements and Shortfall to Requirements

Some of the most recent studies in the stream of 'natural experiments' also seem to confirm the consensus that capital requirements reduce bank lending in the short-run. Aiyar et al. (2012) find that UK banks from 1998 to 2007 responded significantly to changes in regulatory capital requirements by reducing their loan supply. Investigating the capital exercise of 2011/2012 initiated by the European Banking Authority (EBA), where European banking groups were (unexpectedly) required to increase their core equity tier 1 (CET1) ratio to 9%, Mésonnier & Monks (2015) find that the banks which needed to increase their CET1 ratio grew credit less than non-effected banks. Kragh & Rangvid (2016) use a unique and confidential Danish dataset of 118 banks in the period 2007-2014 to analyse the effect of changes in disclosure requirements and bank-specific time-varying capital requirements on banks' lending growth. They find that lending growth is reduced when capital requirements are increased, and the effect is larger for publicly listed banks. Interestingly, they find that large banks reduce lending less than small banks. Finally, Bridges et al. (2015) on a U.K. dataset between 1990-2011 provide a holistic study of how banks react to changes in capital requirements by focusing how banks adjust their capital ratios and over what time horizon banks do so. They find that following an increase in regulatory capital requirements, banks gradually rebuild the buffers they held above their capital ratios while reducing lending. In their study, loan growth decreases most severely in the commercial real estate sector, followed by other corporate lending and household secured lending.

Mésonnier & Monks (2015) specify a cross-sectional event-study model of lending growth using European banks' capital shortfall to the EBA requirement as the main explanatory variable. Their model is presented in equation 4.2:

$$Y_{i,j,k} = \alpha + \beta_1 Shortfall_j + \beta_2 X_{i,j,k} + S_k \epsilon_{i,j,k} \tag{4.2}$$

$Y_{i,j,k}$ denote the annualised lending growth during the EBA capital exercise of bank i belonging to banking group j and located in country k. $Shortfall_j$ is the ratio of capital shortfall (the capital of bank i less the EBA capital requirement) to risk-weighted assets. X_i represents a range of bank specific characteristics including *size* and *liquidity* and S_k is a control for demand-side effects at the country level (ibid.). They find that a 1%-point increase in capital shortfall is associated with a reduction in lending growth of 1.48%-points.

Kragh & Rangvid (2016) specify a panel regression model to test the effect of bank-specific capital requirements on lending growth. Their model is specified in equation 4.3.

$$\Delta Log(L_{i,t}) = \sum_{k=0}^{K} \beta_k \Delta CR_{i,t-k} + \gamma X + a_i + \eta_t + \epsilon_{i,t} \tag{4.3}$$

$Log(L_{i,t})$ is the percentage change in lending of bank i. $\Delta CR_{i,t}$ is the %-point change in in the bank-specific capital requirements, and X represents a range of bank-specific controls including *risk*, *size* and *profitability*. Finally, they use bank and time fixed effects to control for unobserved and time-invariant heterogeneity at the bank level and aggregated demand and supply effects that are common to all banks (Ibid.). They find that a 1%-point increase in capital requirements reduce lending by 1%.

Despite their general similarity the two studies just presented contain two important differences. Firstly, the use Δ explanatory variable, i.e. changes to the main explanatory variable, as in Kragh & Rangvid (2016) rather than the explanatory variable at a point in time as in Mésonnier & Monks (2015) highlights an important distinction to the interpretation of β. The use of static explanatory variable is the most common in the literature, and (Aiyar 2014) argues that the interpretation of *beta* reflect differences across banks in a study whereas the use of Δ explanatory variables reflect changes in the explanatory variable within each bank. Moreover, it is important to take the type of study into account when interpreting β, e.g. in event-type studies like the one by Mésonnier & Monks (2015) the estimated effects reflect changes in capital requirements *between* banks rather than *within* individual banks. Secondly, the use of time fixed effects, as a substitution for aggregated demand and supply control variables has become increasingly popular in the most recent literature in the field. Bridges et al. (2015) use a two-way fixed effect estimation but in a robustness check they drop the time fixed effects and include macroeconomic and demand-side control variables instead. They find that their results are broadly robust to such a substitution (Ibid.). Such a robustness check is common among the stream of literature that uses two-way fixed effects, and it is the general conclusion that results are robust.

Finally, among the most recent studies, we find two studies by De Nicolo (2015) and Deli & Hasan (2016) who to our knowledge are the first to provide global studies of the effect of capital requirements on lending growth and real activity. In his model, De Nicolo (2015) uses bank data for c. 1,400 publicly traded banks across 43 advanced and emerging markets economies for the 1982-2013, and he finds evidence that support a negative impact of capital requirements on bank lending. His result suggest that the impact may be larger than previously thought, although he calls for more research in support of his findings as well as robustness test of them. Deli & Hasan (2016) also provide a global study, but instead of simply using capital requirements as the explanatory variable, they use a variable denoted capital stringency. The variable capital stringency, introduced by Barth et al. (2013), combines ten different regulatory laws into one single index. Using this approach, Deli & Hasan (2016) find only a weak negative effect of capital stringency on loan growth. In fact, banks with a modestly high level of capital to total assets of 11% do not experience any negative effect of increasing requirements on lending. Instead, they find that the way banks finance its assets can have a negative effect on lending growth depending on the regulatory requirements to equity. Specifically, banks that are only allowed by regulation to use cash or government securities as eligible equity (towards capital requirements) to finance its assets reduce lending significantly when capital stringency increases (ibid.)

Table 4.2 presents a subsample of the quantitative results found in the empirical literature (note that comparison between the estimates should be done with caution as both estimation methods and scope of study vary)[3].

Table 4.2: Subsample of Estimation of Lending Growth Impact

Year	Author	Effect of a 1%-point increase to:	Dependent variable	Impact (%-points)
1991	Bernanke & Lown	Equity to assets ratio	Bank lending growth (US)	+2.00 to +2.50
2010	Berrospide & Edge	Equity to assets ratio	BHC lending growth (US)	+0.72
2014	Labonne & Lame	Tier 1 equity to assets ratio	Lending growth (FR)	+1.00
2012	Aiyar et al.	Total capital requirement ratio	Lending growth (UK)	-6.50 to -7.20
2015	Bridges et al.	Total capital requirement ratio	Household lending growth (UK)	-4.04 to -8.07
2016	Kragh & Rangvid	Total capital requirement ratio	Bank lending growth (DK)	-1.00
2015	Mésonnier & Monks	Surplus capital ratio (to req.)	Bank lending growth (EU)	+1.48
1993	Hancock & Wilcox	Surplus capital ratio (target)	Bank lending growth (US)	n.a.
2009	Francis & Osborne	Surplus capital ratio (target)	Bank lending growth (UK)	+0.06
2010	Berrospide & Edge	Surplus capital ratio (target)	Bank lending growth (UK)	+0.23

4.1.4 Welfare Effects

In a different stream of the more recent literature several authors have attempted to analyse the welfare effects of capital regulation and thereby assess the optimal capital ratio. Van den Heuvel (2008) introduces a quantitative general equilibrium model to estimate the impact of capital requirements on real activity and welfare. He applies the model to US banking data, and he finds that the welfare cost of Basel II capital requirements is equivalent to a permanent reduction in consumption of 0.1% to 1%. He concludes that the Basel II capital requirements are too high. De Nicolo et al. (2012, 2014) studies the impact of capital regulation on bank lending, efficiency and welfare in a dynamic setup and he find an inverted U-shaped relationship between capital regulation and the aforementioned variables with the benefits of regulation turning into costs at a certain requirement threshold. Christiano and Ikeda (2013) use a dynamic stochastic general equilibrium (DSGE) model on US data, and they find that when the capital ratio rises

3. The studies by De Nicolo (2015) and Deli & Hasan (2016) have been excluded from the table as their studies are not comparable to the rest of the studies due to different methodology. Further, the effect on loan growth estimated by Hancock & Wilcox (1993, 1994) is estimated in nominal amounts and thus not applicable.

from 5 to 6 percent, consumption increases by 1.19% leading to a permanently higher steady state welfare equilibrium although bank lending declines significantly. This result contradicts the finding of Van den Heuvel (2008). These papers, among others, provide a relatively consistent picture of the long-run impact of capital requirements on lending and welfare with the consensus that there exists an inverted U-shaped relationship between regulations and welfare effects. However, the assessment of the regulatory threshold at which welfare begins to decline differs markedly. In Van den Heuvel (2008) and Nicolo et al (2012, 2014) the threshold is found to be relatively low (below Basel II ratios), whereas in Christiano and Ikeda (2013) the threshold was found to be higher (above Basel III ratios).

Summing up, the broad range of literature that has evolved since the early 1990s suggests that capital ratios (i.e. bank capital) have a positive (moderate to strong) effect on lending growth and capital requirements have a negative (moderate to strong) effect on lending growth. Various capital ratios, requirements and calibrated variables (capital surplus and shortfall to requirements or internal capital ratio target) have been used as explanatory variables to test the effect on lending. The later literature has generally relied on panel datasets and fixed effect estimations to model the relationship. It seems that a two-fixed effect estimation is generally preferred. Most literature has also relied on capital ratios and capital requirements at points in time compared to changes in capital ratio and capital requirements as explanatory variable. We will use these insights from the empirical literature to guide our research design in chapter 6 and further compared the results of our study to the results of the previous literature in chapter 7.

Chapter 5

Data

The chapter provides a comprehensive account of the data used in the empirical study of the subsequent chapters. The objective of the chapter is to explain the main features of the data used, the data steps taken and data limitation. Firstly, the data sample used is outlined. Secondly, we discuss the characteristics of the optimal data sample and how the actual data collected deviates. Lastly, data mining steps and the quality of the data are discussed.

5.1 Data Sample

We collect publicly available data on active Scandinavian banks from the period 2011 to 2016 from the database Bank Focus by Bureau van Dijk (BvD). The data is consolidated annual income statement, balance sheet and capitalisation figures on group level for each bank. Banks included in the study are commercial banks, cooperative banks, savings banks, bank holding companies, finance companies and real estate & mortgage banks. Both publicly listed and non-listed banks are included. The sample covers 137 banks with an average of 5.2 years of data. National tier 1 capital requirements have been collected from each country's financial authorities, GDP and inflation figures have been collected from the WorldBank and we have collected each country's central bank lending rate.

5.1.1 The Optimal Sample

The following paragraphs will elaborate on the characteristics of the optimal sample if we had unlimited data availability and how the optimal sample differs from the actual data sample collected. The desired optimal data, given the objective to study the effect of bank capital and capital regulation on real lending in Scandinavia, contains the entire population of Scandinavian banks operating in at least one of the three countries. The optimal time period is from 2010 to 2016 with a complete (balanced) dataset of our variables of interest (cf. chapter 6, Methodology) over the desired time period. Below we list three overall objectives of our data sample.

Objective 1: The overall population includes consolidated group level data of both listed and non-listed banks

The objective is to include all banks for which capital structure and capital requirements may have an impact on lending in the real economy. This includes both listed (LB) and non-listed (NLB) banks as both carry equal societal cost in case of distress or default and are thus encompassed by the same regulation designed by the Basel Committee (Koehler 2012). Also, the aim of the analysis is to provide as general conclusions as possible, thus only including LBs (like some previous literature e.g. (Deli & Hasan 2016; Nicoló 2015) may bias our conclusions. LBs only account for 1/5 of all banks, and 9 of 20 of the largest banks, in Scandinavia, while having a 74% share of total gross loans in our sample (BvD2016). Further, there might be significant differences between listed and non-listed banks, which may not be observable and thereby controlled for. Finally, the objective is to include data on a consolidated group level only, given that the group level legal entity is a bank so that it is affected by capital requirements. Consolidated entities is preferred to unconsolidated entities, as it seems more plausible that capital decisions relating to banks activities are often taken on a group level rather than a subsidiary by subsidiary basis. This is supported by the research design of Berrospide & Edge (2010) and Bridges et al. (2015).

Objective 2: The sample contain quarterly data from 2010 to 2016

Our focus is to analyse the effects following the implementation of Basel III capital requirements which are announced in 2012 and implemented from 2013 to 2019 (BCBS 2010). The optimal period is thus from 2010 to 2016 (the most recent year available) to observe the full effects of the first part of the implementation. Data from 2010 and 2011 is desirable to account for banks anticipating the regulation and thus making preemptive capital decisions. Additionally, there are other benefits of focusing on the Basel III capital requirement implantation in relation to the time horizon. The implementation of Basel III has led to large variations in tier 1 capital requirements (positive increases) both across firms and time with the tier 1 capital requirement variable having a mean of 9.4%, standard deviation of 3.0%, maximum value of 13.0% and minimum value of 4.5% across the sample (cf. table 7.1 in chapter 7. The variation allows for more valid results, as variation in the explanatory variable is a key criterion for robust econometrical results (Wooldridge 2010). We will elaborate further on the robustness of our results in section 7.4 of chapter 7. Quarterly data is preferred to annual data in our sample to more closely match capital ratio and capital requirement changes with lending growth changes. Further, quarterly data allows for more observations.

We acknowledge that the choice of time period could bias our sample since it does not cover a full market cycle, i.e. it does not include an economic downturn such as the financial crisis of 2007/2008 and the subsequent years of sluggish growth. The variation of the sample's dependent and independent variables are mainly related to positive increases over the time period (cf. figures 2.4, 2.5, and 2.6 in chapter 2 and figure 7.1 in chapter 7). Thus, inferences of the findings of the paper to an economic downturn might not be valid. Inclusion of data from 2007 and forward is however not possible nor optimal either. Firstly, the Bank Focus database only has data from 2011-2016 (discussed in detail further below). Secondly, even if data from 2007 and onwards were available then governmental capital injections might have biased the sample as evidenced in US data (Berrospide & Edge 2010). Third, the definition of tier 1 common equity capital ratio has been altered from Basel II and Basel III (King & Tarbert 2011). This is also a potential bias in our study as we include data from 2011 and 2012 however it is unavoidable and deemed to be of less importance.

Objective 3: The data contains bank specific capital requirements

Our goal is to analyse the effect of capital requirements on bank lending. Capital requirements ideally include both the national minimum capital requirements and firm specific capital requirements.

5.1.2 Achievement of the Three Objectives

As stated above the first objective of including consolidated group level data of both LBs and NLBs was achieved successfully. The second objective of achieving data from 2010 to 2016 was not achieved. Firstly, data from 2010 is not available in the Bank Focus database as it only covers the period from 2011 and onwards. Secondly, many smaller banks have missing observations in the most recent year, 2016, as they at the time of the data extraction had not released their annual report for the year 2016. Further, some banks also have skewed financial reporting years which can result in less time observations. Additionally, several smaller banks have missing observations for the financial years of 2012 and 2013, which is most likely due to the more limited historical coverage of Bank Focus after the main data provider, Fitch, terminated its contract with BvD (Research financial 2016). We will discuss this further in section 5.2.3, *Data Criticism*. The third objective of data segmentation was not achieved, as it was not possible to obtain data on firm specific capital requirements, as these data are not publicly available across the Scandinavian countries.

5.2 Data Extraction and Data Mining

5.2.1 Obtaining Data from Orbis Bank Focus

As previously mentioned the Bank Focus (formerly BankScope) database, which is developed by Bureau Van Dijk (BvD), has been the preferred choice of database. Bank Focus collects all financial data of all banks into one comprehensive database. Data has been extracted in a Universal Bank Data format to ensure that the data is comparable across countries despite differences in accounting standards and rules, even though these are arguably not very different across Scandinavia. The financial data is extracted on a consolidated group level. Two data extraction methods are possible. The first and preferred method accounts for survivorship bias while the second method does not account for survivorship bias. The two approaches are listed below:

1. Identifying all banks in Scandinavia, while taking into account survivorship bias. This can be achieved by rolling data throughout the years allowing for easy identification of structural changes including bank defaults, mergers, acquisitions, and new banks.
2. Identifying all active banks in Scandinavia in existence by the end of the period, thus not taking into account survivorship bias. Mergers and acquisitions may be accounted for manually.

Unfortunately, the preferred choice of data extraction is not available since Bank Focus deletes information on defaulted, merged and acquired banks, thus only including active banks in the database. As a suboptimal solution, we could potentially have accessed archived releases of the Bank Focus database like in Gropp & Heider (2010) but we do not have access to downloaded data at each time observation. Further, given the recent change to the financial format (and name) of the database, it would be unreasonable to combine old data releases with new data releases even if we had had access to downloaded data from each time observation (BvD 2017). Thus, the second (suboptimal) approach of data extraction has been applied, and a full list of 362 active Scandinavian banks were extracted and subsequently reduced using the following data criteria:

(i) From the overall sample of all active banks in Scandinavia, we exclude the following bank types: Investment banks, private banking / asset management companies, securities firms, investment and trust corporations and other non-banking credit institutions. The banks have been excluded, as their primary activities are not lending. Further, capital requirements for these types of banks differ compared to more traditional banking institutions. Specialised governmental credit institutions have also been excluded from the sample, as their business model and lending activity are significantly different from traditional banking institutions. Central banks have also been excluded, as they lend to the banks that we investigate, but they are not engaged in lending to the 'real' economy directly. Thus, the bank types included in the sample are: Commercial banks, cooperative banks, savings banks, bank holding companies, finance companies and real estate & mortgage banks. The excluded bank types account for a total of 15 banks.

(ii) We include consolidated data at the bank group level as capitalisation and lending decisions are in our view taken at the consolidated group level and not at the individual banking entities within a group as discussed earlier. Thus, from our extract of active banks in Scandinavia we exclude subsidiaries of group entities as to not double count their lending activities. DNB Boligkreditt AS, the mortgage lending institution of the DNB group, is an example of an excluded subsidiary, as its mortgage lending activities is included in the DNB group. For observations where consolidated data is available both on a bank group level and a bank holding level we include the holding level only. Subsidiaries of non-Scandinavian banks have also been excluded. A total of 60 subsidiaries have been excluded from the sample.

(iii) Banks with gross loans to total assets of less than 25% in all the available years have been excluded from the data set to further focus on traditional banking entities with lending to the real economy. This data step and subsequent threshold follows the research design of Kragh & Rangvid (2016). Five banks are excluded due to gross loan constituting less than 25% of total assets in all available years.

(iv) Banks with less than four years of balance sheet figures have been excluded from the sample. This is due the regression model's dependent variable being the growth rate in gross loans over the year, and the model including the lagged dependent variable as independent variable in the regression. The model specification thus requires at least three years of balance sheet figures to produce one observation across the variables included in the regression model. Panel data regression subsequently requires a minimum of two time observations for each variable to run. Thus, four years of balance sheet figures are needed for a bank to be included in the study. Further, it is quite common in the literature to exclude banks with few time observations, e.g. Kragh & Rangvid (2016), Bridges et al. (2015) and Berrospide & Edge (2010). A total of 138 banks are excluded due to less than four years of balance sheet figures.

(v) The data set has manually been corrected for mergers and acquisitions as to focus solely on the organic growth in lending and not include inorganic growth in balance sheet variables used in the regression model. Mergers and acquisitions were corrected for by excluding all observations for all the variables in the event year for the continuing bank. That is, if two banks merge at date T, we exclude the observations at date T for the surviving bank and continue with the surviving bank as of period T+1. In the case of a merger or acquisition, the acquired bank entity can either become absorbed by the acquiring bank entity or continue as a wholly-owned subsidiary. If the bank entity is absorbed, Bank Focus deletes the acquired bank, thus the dataset at time periods before T only includes the surviving bank. If the acquired bank entity becomes a wholly owned subsidiary instead then historical data is available in Bank Focus, and the bank at time periods before T is included. This method of adjusting for mergers and acquisitions creates an unbalanced panel data sample, as observations are excluded. The method is however fairly common practice in the empirical literature on lending (Kragh & Rangvid 2016; DeNicolo 2015; Bridges et al. 2010). A contrasting method of adjusting for mergers and acquisitions is to create an aggregated synthetic merged entity for the entire time period (Aiyar et al. 2012). Even though this method will create a more balanced panel data set compared to the chosen method, we deem the synthetic merger method to be inferior. It rests on the assumption of an aggregated synthetic entity that makes similar capitalisation and lending decisions as two independent entities regardless of e.g. bank culture, business model and size which seems to be unjustifiable. Further, any aggregation of data is prone to subjectivity and method opaqueness making the study more difficult to replicate. 25 time observations for the 137 banks in the sample have been excluded due to mergers, acquisitions and divestments.

(vi) Observations with a gross loan growth in the top and bottom 1-2 percentile has been excluded, as we do not wish for our results to be driven by unnaturally high or low growth rates. In some instances, removing an outlier observation means that the individual bank will no longer contain enough time observations to be included in the model. Again, this is common practice in the literature (e.g. Bridges et al. 2015; Berrospide & Edge 2010). A total of 6 banks were excluded on the grounds of having outlier observations.

(vii) Lastly, data for small Swedish banks for 2013 has been manually collected from the banks' annual reports. Reporting practices of regulatory capital ratios and risk weights for small Swedish banks changed in 2013. This change led to either misstated or missing data in the Bank Focus database. Thus, the observations were manually collected from annual reports and included in the sample.

5.2.2 Other Data

In addition to the data retrieved from Bank Focus additional data on macroeconomic variables have been collected. Real GDP, inflation (GDP deflator) and national central bank lending rates were collected from the World Bank (WB) and Scandinavian Central Banks (CBs), and domestic capital requirements were collected from national FSAs, respectively. Capital requirements are reviewed with a different frequency in the three countries. The Swedish FSA is the most structured with quarterly reviews whereas the Danish and Norwegian FSAs have less frequent reviews. All official publications on capital requirements in the period of analysis have been reviewed and included in the dataset with both the time of announcement and enforcement dates.

5.2.3 Data Criticism

The subsequent analyses and results are highly dependent on the quality of the data used, thus this subsection outlines some critical issues. First, it should be noted that Bank Focus is a highly recommended database, and it has been applied in several academic papers within a similar field of research, e.g. Deli & Hasan (2016), Koehler (2012), and Gropp & Heider (2010), who also note that it is the most comprehensive bank database available. Despite its high regard, the database has some critical limitations and flaws in relation to obtaining the desired dataset. It has already been mentioned that the database suffers from survivorship bias, which we cannot adjust for. Gropp & Heider (2010) estimate the survivorship bias to be 12% in their sample of 200 of the largest publicly traded banks in the US and Europe between 1994 and 2004.[1] Given that Gropp & Heider (2010) covers a significant larger time span then it could be that the survivorship bias in our dataset is smaller even though our sample covers smaller banks which might be more likely to default, merge and be acquired. Multiple other

1. 12% of the banks present at the beginning of their dataset in 1994 do not appear at the end of their data set in 2004.

factors (e.g. the business cycle) affects the comparison to Gropp & Heider's (2010) sample, and it is thus not possible to give a reliable estimate of the size of the survivorship bias in our sample.

Hesse and Cihak (2007) point out some other general issues relating to Bank Focus data. First, it is non-exhaustive and coverage varies from country to country. Especially cooperative banks are known to have less coverage than other bank types, e.g. commercial banks. Secondly, Bank Focus gives the specialization (type) of bank at the latest year available, thus potentially biasing results if banks in the sample have changed type during the period of analysis.

In relation to the thesis, further data criticism exists. Firstly, as of January 1st 2017, Bureau Van Dijk's BankScope database was replaced with the database Bank Focus after the main data provider, Fitch, terminated its contract with Bureau Van Dijk (Research financial 2016). This had led to limited historical coverage on smaller bank entities and a maximum of six years of financial account data. This limits the size of our sample and inference of our regressions. Secondly, quarterly data is not available on the Bank Focus database thus limiting the time observations of each bank. Less time observations make the inference from the regression less precise. Further, very short-run effects would be visible in quarterly data while it might not be possible to identify very short-run effects in annual data. Finally, the Tier 1 capital ratio shows poor coverage in the data sample even in years where data is available for the remaining variables of interest for a given bank entity.

Chapter 6

Research Methodology

The chapter outlines the research methodology of the regression model estimated in the thesis. Firstly, the chapter outlines the main model specifications used to analyse the effect of bank capital and capital regulations on lending. Secondly, the parameter choices of the model, the explanatory and control variables, are explained. This is followed by an elaboration of the predicted effects of the parameters used. Both the choice and predicted effects of the parameters will be closely linked with the theoretical and empirical review in chapter 2 and 3, respectively. Thirdly, the econometric methodology is explained and discussed. The chapter concludes with a discussion of the key limitations of the research design.

6.1 Model Specifications

6.1.1 Baseline Specifications

To investigate the effect of bank capital and capital regulations on lending in the real economy, we focus on estimating three main panel equations. Firstly, we estimate the panel equation (6.1):

$$\begin{aligned}\Delta\%LOAN_{i,t} = \gamma CR_{t-1} + \beta_1 \Delta\%Loan_{i,t-1} + \beta_2 ROA_{i,t-1} + \beta_3 Liquidity_{i,t-1} \\ + \beta_4 Log(Assets_{i,t-1}) + \beta_5 Reserves_{i,t-1} + f_i + f_t + \epsilon_{i,t}\end{aligned} \tag{6.1}$$

where,

$$CR_{i,t-1}\begin{cases} T1CR_{i,t-1} = \frac{Tier\,1\,Capital_{i,t-1}}{Risk\,Weighted\,Assets_{i,t-1}} \\ TCR_{i,t-1} = \frac{Total\,Capital_{i,t-1}}{Risk\,Weighted\,Assets_{i,t-1}} \\ \frac{E}{A_{i,t-1}} = \frac{Equity_{i,t-1}}{Assets_{i,t-1}} \end{cases}$$

The dependent variable, $\Delta\%loan$, in equation 6.1 denotes the percentage change in gross loan on bank i's balance sheet from period $t-1$ to t. The explanatory variable, $CR_{i,t-1}$, denotes the one-period lagged capital ratio of bank i. Three capital ratios will be used in equation 6.1: The Tier 1 Capital Ratio (T1CR) calculated as the tier 1 capital to risk-weighted assets, the total capital ratio (TCR) calculated as the total regulatory capital (tier 1 + tier 2 capital) to risk-weighted assets and the equity to total assets ratio (E/A). The rest of the variables on the right-hand side of equation 6.1 are control variables. The variable, $\Delta\%loan_{i,t-1}$, is the one-period lagged percentage change in gross loan of bank i. The variable $ROA_{i,t-1}$ denotes the one-period lagged return on assets of bank i, calculated as net income in period $t-1$ divided by total assets in period $t-1$. The definition of ROA follows the definition used by the database Bank Focus. The variable, $Liquidity_{i,t-1}$, denotes the one-period lagged ratio of liquid assets to total assets of bank i following BvD's definition of liquid assets[1]. The variable, $Log(Assets_{i,t-1})$, is defined as the natural logarithm of total assets of bank i at period $t-1$, and the variable, $Reserves_{i,t-1}$, denotes the ratio of loan loss reserves to gross loans of bank i at period $t-1$. f_i and f_t are firm fixed and time fixed effects, respectively. $\epsilon_{i,t}$ is the error term of the regression estimation. Firm fixed effects, time fixed effects and the error term will be discussed in the subsequent subsections. Appendix A.2 summarises all dependent, independent and control variables used in the regressions of the thesis.

Secondly, we estimate panel equation 6.2:

$$\begin{aligned}\Delta\%LOAN_{i,t} = \gamma T1CRR_{t-1} + \beta_1\Delta\%Loan_{i,t-1} + \beta_2 ROA_{i,t-1} + \beta_3 Liquidity_{i,t-1} \\ + \beta_4 Log(Assets_{i,t-1}) + \beta_5 Reserves_{i,t-1} + f_i + f_t + \epsilon_{i,t}\end{aligned} \tag{6.2}$$

where,

$$T1CRR_{i,s}\begin{cases} TC1RR_{i,t-1} \\ TC1RR_{i,t} \\ TC1RR_{i,t+1}\end{cases}$$

$T1CRR$ denotes the tier 1 capital ratio requirement of bank i. Three $TICRR$'s will be used as explanatory variables: $T1CRR_{i,t-1}$, $T1CRR_{i,t}$, $T1CRR_{i,t+1}$. Each variable depends on the national tier 1 requirement as presented in section 2.2.6. We include one-year lagged requirements, current, and requirements one years into the future. We do not include the fully phased in requirements in 2019, as it is a constant and therefore would not contain any explanatory power in the model. The dependent variable and control variables of equation 6.2 are identical to the dependent variable and control variables of equation 6.1

Thirdly, we estimate panel equation 6.3

$$\begin{aligned}\Delta\%LOAN_{i,t} = \gamma SP^s_{t-1} + \beta_1\Delta\%Loan_{i,t-1} + \beta_2 ROA_{i,t-1} + \beta_3 Liquidity_{i,t-1} \\ + \beta_4 Log(Assets_{i,t-1}) + \beta_5 Reserves_{i,t-1} + f_i + f_t + \epsilon_{i,t}\end{aligned} \tag{6.3}$$

where,

$$SP^s_{i,t-1}\begin{cases} SP_{i,t-1} = T1CR_{i,t-1} - T1CRR_{i,t-1} \\ SP^1_{i,t-1} = T1CR_{i,t-1} - T1CRR_{i,t} \\ SP^{`19}_{i,t-1} = T1CR_{i,t-1} - T1CRR_{i,2019}\end{cases}$$

The explanatory variable, $SP^s_{i,t-1}$, in equation (6.3) denotes the lagged capital surplus / shortfall ratio of bank i. It is defined as the T1CR of bank i in period $t-1$ less the national T1CRR

1. $Liquidassets_{i,t} = Cash\,\&\,balances\,with\,central\,banks_{i,t} + financial\,assets_{i,t} + netloans\,and\,advances\,to\,banks_{i,t} + reverse\,repos,\ securities\,borrowed\,\&\,cash\,collateral_{i,t} - mandatory\,reserve\,deposits\,with\,central\,banks_{i,t}$

at a fixed time span compared to the current period or a point in time. Three surplus ratios will be used as explanatory variables: $SP_{i,t-1}, SP^1_{i,t-1}\, and\, SP'^{19}_{i,t-1}$. Each surplus / shortfall ratio differs depending on the time period of the national tier 1 capital ratio requirement. That is, $SP_{i,t-1}$ denotes the difference between the one-period lagged T1R of bank i and the national T1CRR at $t-1$. $SP^1_{i,t-1}$ is the difference between the T1R of bank i at $t-1$ and the national T1CRR in period t. The last surplus variable in equation (6.3), $SP'^{19}_{i,t-1}$, is the difference in the one-period lagged T1CR of bank i and the national T1CRR in 2019 at every time observation. The dependent variable and control variables of equation (6.3) are identical to the dependent variable and control variables of equations (6.1) and (6.2).

6.1.2 Additional Specifications

Of additional specifications, we firstly investigate banks' capitalisation degree's effect on lending by interacting the capital ratios and surplus ratios of equations (6.1) and (6.3) with top and bottom quartile and decile dummies (cf. equation (6.4)). Secondly, we investigate the effects of a bank's headquarter location, stock market participation (listed/non-listed) and size on lending by interacting the capital ratios and surplus ratios of equations (6.1) and (6.3) with country dummies, a listed/non-listed dummy and a large bank dummy (cf. equation (6.5)). Specifically, we estimate the panel equations (6.4) and (6.5):

$$\begin{aligned}\Delta\%LOAN_{i,t} &= \gamma_1 Expl. + \beta_1 \Delta\%Loan_{i,t-1} + \beta_2 ROA_{i,t-1} + \beta_3 Liquidity_{i,t-1} + \beta_4 Log(Assets_{i,t-1}) \\ &+ \beta_5 Reserves_{i,t-1} + \gamma_2 Expl. * \begin{cases} Quartile \\ Decile \end{cases} + f_i + f_t + \epsilon_{i,t}\end{aligned} \tag{6.4}$$

and,

$$\begin{aligned}\Delta\%LOAN_{i,t} &= \gamma_1 Expl. + \beta_1 \Delta\%Loan_{i,t-1} + \beta_2 ROA_{i,t-1} + \beta_3 Liquidity_{i,t-1} + \beta_4 Log(Assets_{i,t-1}) \\ &+ \beta_5 Reserves_{i,t-1} + \gamma_2 Expl. * \begin{cases} Country \\ Listed \\ Large\, bank \end{cases} + f_i + f_t + \epsilon_{i,t}\end{aligned} \tag{6.5}$$

Where,

$$Expl. \begin{cases} T1CR_{i,t-1} \\ TCR_{i,t-1} \\ \frac{E_{I,t-1}}{A_{i,t-1}} \\ SP^s_{i,t-1} \end{cases}$$

The segment variable, *Quartile*, represents two dummy variables, $Q1$ and $Q4$, that take the value 1 if an observation of the main explanatory variable is in either the lower ($Q1$) or upper quartile ($Q4$) of the total sample, hence two interaction terms are included. Similarly, the variable, Decile, represents two dummy variables, $D1$ and $D9$, that takes the value 1 if an observation of the main explanatory variable is in either the lower ($D1$) or upper decile ($D9$) of the total sample. The variable, *Listed bank*, is a dummy variable that takes the value 1, if a bank is publicly listed and 0 otherwise. The variable, Large bank, is a dummy variable that takes the value 1, if a bank is among the 20 largest banks based on average total assets across the time period and 0 otherwise. Finally, *Country* represents two dummy variables indicating whether a bank's headquarter is located in Denmark, Norway or Sweden (only two dummy variables are included to avoid a dummy variable trap).

6.2 Parameter Choice

As presented in the review of empirical studies there exist a fairly large number of studies on the effect of bank capital and capital requirements on lending growth. These studies employ somewhat similar regression methods and estimation equations to test the effect of capital and capital requirements on lending albeit with some differences, especially on the choices of explanatory and control variables. The next section will elaborate on the form and motivation behind the choice of the dependent, independent and control variables used in our estimation equation and compare the choices of parameters to the existing empirical literature.

6.2.1 The Dependent Variable - Loan Growth

The dependent variable across our regressions is the percentage change in gross loans from period $t-1$ to t. We have chosen gross loans as dependent variable as we regard it as the best indicator of lending that is publicly available. Other measures, which could have been used is total assets or net loans. Further, in our measure of gross loans we excluded loans to other financial institutions, as these types of loans are mostly related to short-term liquidity lending, and instead only focus on gross loans to the real economy defined as loans to households, corporations and mortgage loans. Total assets are not of particular interest in this study, as many balance sheet items of a bank does not relate to lending to the real economy, e.g. financial assets, tax assets and goodwill. Further, the balance sheet item, net loans, is prone to different definitions across loan types, and it is thus not an optimal dependent variable. Using gross loans as dependent variable is also very common in the empirical literature with numerous studies focusing on gross loans to the real economy as defined in this paper (e.g. Mésonnier & Monks 2015; Labonne & Lamé 2014; Aiyar et al.2012; Berrospide & Edge 2010).

Gross loans is however not a perfect measure of lending growth in the economy. Both, Bridges et. al. (2015) and Labonne & Lamé (2014) argue that loan growth based on balance sheet figures at points in time is not necessarily equal to 'true' lending flows to the economy. Write-offs, exchange rate adjustments, securitisation and changes in accounting practices can all influence the change in loan stock. This is a common flaw in the methodology of almost all empirical studies on lending with the exception of Bridges et. al. (2015), who through a confidential dataset from the Bank of England, is able to adjust for non-flow changes in the stock of loan. They do however not comment on the magnitude of differences between changes in lending due to lending flows to the real economy and changes in lending due to other factors.

We thus acknowledge this potential bias in our dependent variable, but the results of the thesis will still be comparable to the vast majority of the empirical literature on lending.

6.2.2 Explanatory Variables

Capital ratios Three capital ratios will be used as explanatory variables in panel equation 6.1, Tier 1 capital ratio (T1CR), total capital ratio (TCR) and equity to asset ratio (E/A). Ratios are preferred to the nominal value of capital in the equation, as a unit of capital only has meaning in relation to its operational side, assets. That is, it is only logical to understand a bank's financing in relation to the size of what it is financing. All three capital ratios have been lagged one period so that it is the capital ratio at the beginning of period t (or end of period $t-1$) to explain lending over the length of period t. In other words, to explain lending over the full year of 2016, we look at the capital ratio as of 31st of December 2015. Each capital ratio is relevant on its own, and their effect on lending growth is examined independently. T1CR and TCR are two regulatory capital ratios as its components (tier 1 equity, tier 2 equity and risk-weighted assets) are regulatory defined while the E/A ratio is a balance sheet ratio. Tier 1 equity is the highest 'quality' of equity, and thus it might have a large impact on lending growth however, the ratio does not incorporate all of the regulatory equity, which can reduce its explanatory power. Therefore, TCR is included in the study to capture the full effect of tier 1 and tier 2 equity to risk-weighted assets. Further, both ratios include risk aspects of the loan portfolio composition from the inclusion of risk weights. Equity to assets have been used in several empirical studies e.g. Bernanke & Lown 1991 and Berrospide & Edge 2010. It measures the effect of capitalisation decisions from balance sheet items on loan growth.

All three capital ratios (lagged one period) are predicted to have a positive relationship with growth in lending. That is, a more capitalised bank is expected to be able to grow lending more compared to a less capitalised bank /textitceteris paribus. Intuitively and from the theoretical model result (iii) in section 3.3.3, this makes sense. A one-unit increase in a capital ratio in period $t-1$ is equivalent to holding a higher initial capital endowment in the theoretical model. The probability of breaching the capital requirements and the costs associated with this is thus lower, *ceteris paribus*. An equivalent argument is that a more capitalised bank can better withstand an increase ('shock') in regulatory capital requirements without decreasing its loan stock due to a larger initial capital buffer. Thus, in the event of a positive regulatory shock in period t, a more capitalised bank compared to a less capitalised bank can choose to decrease its loan stock less (or not at all) as to be able to preserve its lending capacity in the next period $t+1$ Repullo & Suarez 2012).

$$H_0 : \beta_{CR_{t-1}} > 0$$

Capital Requirements

Three different capital requirements will be used as explanatory variables in equation 6.2. As already mentioned we are interested in both the past, current and future requirements to explain current lending growth. Each requirement variable is therefore relevant on its own and their effects will be examined independently. First, as in Kragh & Rangvid (2016) we are interested in both the current and past capital requirements as banks may initiate their response either contemporaneously or *ex post*, e.g. by first reducing their buffer at the time of change and then subsequently rebuilding the buffer. Secondly, we are interested in how banks respond to future capital requirements today. Banks may implicitly be required to respond to future capital requirements ahead of time, e.g. due to market pressure.

Capital requirements in all periods are predicted to be negatively correlated with lending growth. That is, banks that face tougher capital requirements are expected to grow lending less than banks that face gentler requirements, *ceteris paribus*. The argumentation is based on the model result (i) of the theoretical section 3.3.3. An increase (shock) in capital requirements leads to a higher probability of capital shortfall and thus an increase in the potential cost of being in shortfall. This will cause the bank to reduce lending due to imperfections in the market for raising equity.

$$H_0 : \beta_{T1CRR_s} < 0$$

Surplus

As explained several surplus variables will be used separately as explanatory variables in panel equation 6.3. In the empirical literature, surplus variables have generally taken two forms. Berrospide & Edge (2010), Francis & Osborne (2009) and Hancock & Wilcox (1994) define surplus as the difference between a target capital ratio and observed capital ratio of bank i. The target capital ratio cannot be observed but it is estimated based on a partial adjustment model with various inputs depending on the paper however with most papers including a proxy for risk, return on assets and size. A second stream of empirical literature (e.g. Méssonier & Monks 2015; Aiyar et al. 2012) use a more simple surplus compared to the first stream of literature. In the second stream of literature, surplus is generally defined as the difference between a capital ratio and its equivalent capital requirement ratio. We define surplus similar to the second stream of empirical literature. The surplus variable used in our models has been calculated as the one-period lagged tier 1 capital ratio (T1R) less the national tier 1 capital requirement (T1CRR) in some future point in time either as a fixed time span (t, t+1) or as a fixed date (2019). The surplus equation employed in in this study has some advantages over the previous literature. Compared to the first stream of empirical literature, it does not depend on target capital ratio, which cannot be verified and may be calculated incorrectly. Further, it is simple and easy to implement and replicate. The second stream of literature is mostly event studies, so the surplus variable employed in this study is quite unique in that it considers surplus to a future capital requirement over a longer time period.

The surplus variable is predicted to be positively correlated with lending growth. Intuitively, the variable should have some explanatory power. It is the surplus in percentage-points of T1CR compared to a T1CRR that a bank holds. Thus, for similar reasons as explained with the capital ratios then a bank holding more surplus compared to a bank holding less surplus compared to a future requirement should be able to have more capital to grow its lending and be less worried about the cost of adjusting capital. This is supported by the theoretical model presented in chapter 3. Another dimension to the surplus variables is the time span or fixed date of the national T1CRR. If any of the surplus variables become more significant than the other surplus variables then it must be that the specific surplus variable better explains lending growth from period t-1 to t. We interpret this as being that a bank adjusts its capital positions through lending in the next period according to the time span or fixed date of the surplus variable. That is, if the surplus variable compared to the national requirement in one year is more significant than the other surplus variables then a bank adjusts its lending based on a one year horizon.

$$H_0 : \beta^s_{SP_{t-1}} > 0$$

6.2.3 Control variables

The empirical studies on bank capital and regulatory requirements' impact on lending growth are fairly aligned on the overall characteristics of the control variables used in the regression. They all control for demand, supply and firm-specific characteristics to isolate the effect of capital and regulatory requirements on lending growth. Smaller differences exist on the choice and number of parameters included as controls. All empirical studies reviewed use a fixed effect regression model. Dependent on the choice of either using a one-way bank fixed effect to control for bank-specific time-invariant effects or two-way bank and time fixed effects to control for both bank-specific time-invariant effects and time-varying non-bank specific effects, the number and choice of controls also varies. Regardless, it seems that a consensus in the empirical literature has developed on just a few control variables (cf. Table 4.1 in chapter 4) that all, if significant, filter away unwanted correlation between the independent and dependent variables. The control variables are: *size, risk (asset quality), and liquidity*, all of which are included in our model with inspiration from Deli & Hasan (2016), Berrospide & Edge (2010) and others. Further, inspiration is included from Kragh & Rangvid (2016) by including a control of profitability. Justification and predicted effects for the use of these control variables are found in the theoretical literature review of chapter 3 and will be elaborated on in the following paragraphs.

Aggregated Demand and Supply-side Effects

Time fixed effects will be used in this study to control for aggregated demand and supply effects. It is necessary to control for demand and supply effects as to convincingly attribute changes in lending to changes in bank capital and regulatory requirements. A time fixed effect creates a dummy for each time observation as to capture effects, which affect all banks at a certain point in time. Several empirical studies have employed time fixed effect (Deli & Hasan 2016; Kragh & Rangvid 2016; Mésonnier & Monks 2015; Bridges et al 2015; Labonne & Lamé 2014) while others have not chosen to use time fixed effect (Berrospide & Edge 2010; Aiyar et al 2012) but instead include control variables to control for changes in demand and aggregated supply. Berrospide & Edge (2010) include GDP and inflation to control for the business cycle and price changes (demand effects) and the central bank lending rate to control for monetary policy (supply effect). Aiyar et al. (2012) also includes GDP and inflation and additional sectoral demand proxies to account for demand effects related to specific sectors as banks' may have different loan portfolios. The sectoral demand proxies are however insignificant suggesting loan demand behaves fairly uniformly across sectors. We choose to use time fixed effects in the thesis instead of manually controlling for aggregated demand and supply effects as time fixed effects will be able to capture other time varying macro effects which might not be observable and uncorrelated with GDP and inflation (e.g. regulatory changes). In section 7.4, we drop the time fixed effect and include GDP, inflation and the central bank lending rate to test the robustness of our regressions.

Size

The effect of bank size on loan growth is predicted to be ambiguous. Two arguments can be made that the effect of bank size is positive. Firstly, in relation to the theoretical model presented in section 3.3, it can be argued that larger banks have lower asymmetric information cost in the equity markets causing a regulatory shock to have a smaller effect on lending for large banks compared to small banks (Kishan & Opiela 2000). Less asymmetric information costs can be justified, as the availability of information to outside investors is generally perceived to be higher for larger companies. The lower asymmetric costs will in the theoretical model of chapter 3 translate to lower adjustment cost in the event of a capital shortfall following a regulatory shock. To equate marginal revenue with marginal costs, the loan rate must be adjusted down increasing the monetary size of loans on the asset side of the bank. Secondly, the implicit government guarantee, "Too Big To Fail", which large banks carry can be seen as reducing the cost of breaching the capital requirements. Large banks will thus reduce lending less in response to capital requirement shocks compared to small banks (i.e. moral hazard behaviour from large banks).

The relationship between bank size and lending growth can also be seen as negative. Small banks tend to lend to small firms, which on average are perceived to be pro-cyclical (Kashayp & Stein 1994). During an economic upturn, small banks may then experience larger lending growth compared to larger banks, which may have a more diversified loan portfolio. Further, small nominal increases in a small bank's loan size can lead to high percentage increases in loan size compared to large banks where even large nominal increases in loan size may only lead to small percentage increases in loan size. Therefore, the effect of bank size on loan is ambiguous. The natural logarithm of total assets is used to measure the size of each bank.

$$H_0 : \beta_{Size_{t-1}} (>=<) 0$$

6.2.4 Risk

Risk is predicted to be negatively correlated with lending growth. A more volatile bank compared to a less volatile bank will be more uncertain of its losses on its loan portfolio. Thus, a riskier bank would need to hold more capital to sustain defaults on its loan portfolio, ceteris paribus. As loan growth requires capital, a risky bank compared to a safe bank would be more cautious to grow, as it needs to hold more capital to one unit of assets compared to a less risky bank. The logic can also be seen from the relationship between capital ratios and lending (Figure 1.1). Holding the capital ratio constant, an increase in the riskiness of the bank observed through an increase in the risk weights on the assets leads to higher risk weighted assets and a lower capital ratio. However, holding the capital ratio constant then the increase in capital ratio must be offset by either an increase in equity or decrease in assets/lending. Therefore, volatility/risk is expected to be negatively correlated with loan growth. Risk can also be viewed as the quality of the bank's assets. In this case, we predict a positive relationship between the asset quality of a bank and its loan growth.

Several proxies for risk can be applied e.g. net charge-offs to total assets as used by Berrospide & Edge (2010), risk weighted assets to total assets as used by Aiyar et. al (2012), non-performing loans to total loans as Labonne & Lame (2014) or loan loss reserves to gross loans as Kragh & Rangvid (2016). We choose to use loan loss reserves to gross loans. This is mainly a data driven choice, as loan loss reserves seem to have the best data coverage in our sample out of the different risk measures. Small differences exist in the proxies for risk. Loan loss reserves and charge-offs are internally defined. Loan loss reserves are forward-looking in that reserves are held for future losses while charge-offs are backward-looking in that the debt is written off only after it has been deemed uncollectible. Risk weights can be both internally or externally set depending on the rating model used, and it reflects risk in the current portfolio. Non-performing loans is externally defined as the sum of debt upon which the debtor has not made his scheduled payments for at least 90 days. It is a backward-looking measure. There seem to be no discussion or consensus in the empirical literature of which risk measure is most fitting to use. Loan loss reserves seem to be at an advantage due to it being a forward-looking measure of risk, however it suffers from subjectivity as it is internally defined.

$$H_0 : \beta_{Reserves_{t-1}} < 0$$

Liquidity

Liquidity, measured as the ratio of liquid assets to total assets, is predicted to be positively correlated with lending growth. Kashayp & Stein (1994, 2000) presents a model within the bank lending channel view to explain the link between liquidity and lending in the setting of a contractionary monetary shock. Consider two banks which are identical in all respects except that one of the banks has a larger share of liquid assets to total assets compared to the other bank. A contractionary monetary shock will lower the money supply in the economy and consequently also lower the insured deposits of both banks working as a shock to its financing. Assuming increasing marginal costs of external debt financing due to asymmetric information then the shock to deposits will lead to a less than a one-to-one offset between insured deposits and uninsured external financing transmitting to decreases in the asset side of the balance sheet of the two banks. The more liquid bank will (compared to the less liquid bank) be able to 'protect' its loan portfolio better by decreasing its stock of liquid assets to accommodate the contractionary monetary shock. The less liquid bank will however be forced to cut back on its lending growth, as it cannot reduce its liquid assets further without increasing the default probability. Therefore, we argue that liquidity is positively correlated with lending growth. Section 3.2.2 offers a more comprehensive review of the bank channel view and the assumptions of the model.

$$H_0 : \beta_{Liquidity_{t-1}} > 0$$

Profitability

The effect of profitability, measured by return on assets, on lending growth is expected to be positive. From the model presented in chapter 3, *theoretical review*, it is clear that profit appears in the capital accumulation equation. Higher profitability leads to higher capital accumulation through retained earnings assuming a constant dividend pay-out ratio. In the model, a bank must adjust its loan rate to equate the marginal revenue from its loan portfolio and the costs from adjusting its equity in case of a capital shortfall. A positive shock to profits will increase the capital buffer and thus lower the probability of breaching the capital requirements. This lowers the overall costs of adjusting capital (due to a lower probability). Therefore, the loan rate must decrease to equate marginal revenue from its loan portfolio with the lower marginal cost from adjusting its equity position in case of a shortfall. As we assume an inverse demand relationship between the loan rate and amount lent by the bank then profitability must be positively associated with loan growth. Return on assets is used as proxy for profitability following Kragh & Rangvid (2016).

$$H_0 : \beta_{ROA_{t-1}} > 0$$

Other bank characteristics

Bank fixed effects is used to control for other unobserved heterogeneity among the banks. Several bank characteristics which is not easily observed or do not have an efficient proxy can also influence the loan growth of banks. A bank's business model might influence its lending policy and growth strategy. Management and board composition might also impact the lending growth of a bank. By inclusion of bank fixed effects, dummies are created for each bank. That is, the dummies will control for all unobserved heterogeneity across the sample of banks, which does not vary across time. Thus, the model used to estimate the panel equations uses both time and bank fixed effects. Fixed effects do however not necessarily control for all omitted variables. Any variable, which is time-varying and bank-specific can bias our estimates.

One-period lagged loan growth

The one-period lagged loan growth variable in the estimation equations has been included to control for autocorrelation in the dependent variable. Autocorrelation is the correlation of an individual variable across time periods. Multiple unobserved effects could cause loan growth to be correlated across time so that the development of loan growth over time experiences a trend. By including the one-period lagged dependent variable, we effectively control for this trend even though we cannot observe the mechanism causing the trend. Table 6.1 summarises the predicted effects of the explanatory and control variables on lending:

Table 6.1: Summary of Predicted Effects on Loan Growth

Explanatory Variable	**Predicted Effect**
Capital Ratios	+
Capital Requirements	-
Surplus	+
Size	(+/-)
Risk	-
Liquidity	+
Profitability	+
Lagged loan growth	(+/-)

6.2.5 Segmentation Variables

In addition to the general model specifications, we add extensions in the form of interaction terms to investigate any nonlinear behaviour in our models. First, we test whether isolating banks with the highest and lowest capital ratios and capital surplus provide any additional explanatory power. Second, we test the effect of certain common characteristics (banks' home country, whether the bank is publicly listed or not, and whether it is a large or small bank) on loan growth. The procedure of isolating banks with lowest and highest capital ratios and capital surpluses is fairly common in the empirical literature on bank capital and regulatory requirements' effect on lending growth. Labonne & Lame (2014), Aiyar et al. (2012) and Kragh & Rangvid (2016), all study the effect of loan growth from banks with the lowest capital buffers. No studies, to the best of our knowledge, study the effect of capital surplus across countries. Most studies study the effect on lending within a single country. Thus, our study on lending across Scandinavia might yield some insight into the differences across countries in Scandinavia. Several studies have focused solely on publicly listed banks (Deli & Hasan 2016; Nicoló 2015) while others have focused on both publicly listed and non-listed banks (e.g. Bridges et al. 2015; Francis & Osborne 2009). However, none of the studies to our knowledge have focused on a different effect on lending between listed and non-listed banks. Each specification, parameter choice and its predicted effect will be discussed below.

Quartiles and Percentiles

It is predicted that banks with small capital surplus ratios are particularly sensitive to changes in in capital requirements. As discussed in the theoretical review, banks prefer to hold more capital than required, i.e. to hold a buffer of capital above the minimum requirement. Banks with low capital surplus levels (i.e. banks that are very capital constrained) have little room to absorb unexpected shocks to its capital, and they are therefore more likely to reduce lending growth in case of such a shock or simply as a means of building a higher capital buffer (Kragh & Rangvid 2016). Banks with surplus ratios in the lowest quartile and lowest decile are thus predicted to be significantly negatively correlated with lending growth and significantly different from less capital constrained banks.

$$H_0 : \beta_{Capital\,Ratio/Surplus*Q1/D1} < 0$$

Country

In general, capital requirements have been toughest in Norway where the national FSA has introduced higher minimum requirements and a more rapid implementation phase compared to Sweden and Denmark. Sweden has likewise introduced a speedier implementation phase but has stuck to the tier 1 ratio levels recommended by the CRD IV. Finally, Denmark has directly followed the implementation phase recommended in the CRD IV. With this in mind, the predicted effect for each country is ambiguous. On the one hand, Norwegian banks' lending may be relatively less negatively affected by increasing capital requirements as the tier 1 capital requirement level was already high (8.5%) in the beginning of the investigation period. Swedish banks experienced the biggest "shock" as they saw an increase 3.5%-point from 2013 to 2014 with a subsequent increase of 1.5%-point from 2014 to 2015. This may indicate that they will be relatively more negatively affected. Danish banks have faced a much softer and smoother implementation of the new capital requirements with a mere 2.6%-point increase in the investigation period indicating that they may be the least affected banks relative to their peers in the other Scandinavian countries. Hence, based on the speed and magnitude of the capital regulations over the investigation period, Danish banks are predicted to be the least negatively affected followed by Norwegian and Swedish banks.

$$H_0 : \beta_{Danish\,Banks} > \beta_{Norwegian\,Banks} > \beta_{Swedish\,Banks}$$

The banking industry in Denmark has developed much slower compared to the Norwegian and Swedish banking industries. In the investigation period (2012-2016) the compounded annual growth rate (CAGR) in assets was 0.2% in Denmark, while it was 4.7% and 4.6% in Sweden and Norway, respectively (Marketline 2017). It could therefore be that there has been a significant different macroeconomic development across the three countries. Looking at the housing prices development of the three countries, Appendix A.1, then it seems evident that the Norwegian and Swedish housing markets have developed quite differently compared to Denmark. During the crisis of 2008-2009, the Danish housing market declined considerably more than the Norwegian and Swedish housing markets. Further, during the following years, 2010-2014 the Danish housing market was very flat while the Norwegian and Swedish housing market continued to increase. It could therefore be that regulators in Norway and Sweden have increased their capital regulations faster and in larger magnitude in expectation of a housing market bubble given the very small reduction in housing prices during the crisis and a very fast recovery. Further, the rising housing prices in Sweden and Norway would lead to higher aggregated loan growth development compared to Denmark. Overall, this would suggest a relationship between capital requirements and lending growth for the three countries that is opposite of the one presented above.

$$H_0 : \beta_{Danish\,Banks} < \beta_{Norwegian\,Banks}\, and\, \beta_{Swedish\,Banks}$$

The effect on lending of the three country interactions is thus ambiguous. The magnitude and implementation speed of capital requirements in Sweden and Norway would suggest that the effect on lending for Swedish and Norwegian banks is more negative compared with Danish banks. However, the housing market may have worked as an omitted variable bias causing regulators in Sweden and Norway to increase capital requirements in anticipation of a housing bobble and with the housing market increasing loan growth in the two countries so that capital requirements and lending growth is significantly more positive in the two countries compared to Denmark.

Large Bank

Our sample is characterised by having few very large banks and many small banks based on asset size. The distribution of bank size is therefore markedly skewed to the right. Assets of the 20 largest banks account for approximately 94% of total assets in the sample. The estimated β for the interaction of large banks with the main explanatory variable is ambiguous. The argumentation partly follows that of the control variable, *size*, which is already included as a control variable in all regressions. We include the additional interaction term that distinguishes between the very large banks in the sample and the remaining smaller banks to test for any nonlinear behaviour potentially inherent in the model estimation. This procedure resembles that of Berrospide & Edge (2010) and Aiyar et al. (2014), who, however, find little difference in the estimated impacts on lending growth.

$$H_0 : \beta_{Large\,Bank}\,(>=<)\,0$$

Listed / non-listed Banks

The use of listed and non-listed banks in the empirical literature varies, in many cases depending on the type of study. In their global studies Deli & Hasan (2016) and De Nicoló (2015) use listed banks whereas Aiyar et al. (2014), Labonne & Lamé (2014) and Kragh & Rangvid (2016) all use both listed and non-listed banks in their national studies. This seems to be explained by the practical fact that the three last-mentioned studies are based on unique and confidential bank level information. Such information is arguably very difficult to collect on a large scale, e.g. global, hence the reliance on listed banks allow for more consistency and higher quality information. Disregarding the practical implication of collecting information on listed and non-listed banks, there exist arguments as to why effects of changes in capital ratios and requirements may or may not differ between the two groups. Koehler (2012) show that non-listed banks are usually smaller than listed banks and have more traditional business models with a greater focus on lending activities than listed banks. However, Koehler (2012) finds that listed banks are not more risky than non-listed banks'. This indicates that lending growth of non-listed banks may not be any differently affected than listed banks. This is supported by the finding that non-listed banks pose the same cost to society in case of default as listed banks, why regulatory measures encompass both listed and non-listed banks equally (ibid.). However, listed banks are more exposed to measures of market discipline imposed by investors, which may expect banks to raise capital levels prematurely to demonstrate strength compared to peer banks. Finally, an argument can be made that listed banks generally have easier access to new equity through equity offerings, indicating that listed banks may be less affected by changing requirements. The effect of being a listed bank compared to non-listed is therefore ambiguous.

$$H_0 : \beta_{Listed\,banks} \, (>=<) \, 0$$

6.3 Econometric Method

This section introduces the econometric method applied in the model estimation and discusses possible errors and limitations of the considered estimation approaches.

6.3.1 Panel Data

As previously mentioned, we use panel data in our model estimation. That is, the dataset has both a cross-sectional dimension and a time-series dimension, i.e. multiple banks at different points in time. The panel data approach is popular within the research field of capital structure, capital requirements and lending, and understandably so, as it allows researchers to investigate groups of banks over time, which is not possible with just cross-sectional or time series-approaches. However, a dataset with two dimensions is more complex than a dataset with only one dimension with respect to the econometric analysis. One immediate problem is that we can no longer assume that observations are independently distributed across time (Wooldridge 2012). That is, a panel dataset's cross sections suffer from unobserved factors across time, e.g. the culture of bank i is an unobserved factor that affects bank i in both 2013 and 2015. This is generally known as individual heterogeneity or *unobserved heterogeneity.* If a dataset is not independently distributed across time (i.e. suffers from unobserved heterogeneity) then the results of the econometrical analysis will be biased in that the observed relationship may not be 'true'. The inclusion of bank fixed effect in our model will however control for unobserved heterogeneity, i.e. variables that differ across banks but are constant across time. Further, time fixed effects control for variables that change over time but not across banks (e.g. GDP and inflation). Equation 6.6 specifies a general panel data model:

$$y_{i,t} = \beta_1 x_{i,t} + \alpha_i + \nu_t + \mu_{i,t} \tag{6.6}$$

The general regression model specified in equation(6.6) includes a parameter ν_t which represent all unspecified time-specific variables but bank invariant variables and a parameter α_i, which represents all unspecified bank-specific but time invariant variables. Alongside the usual idiosyncratic error term, ϵ_{it}, ν_t and α_i can be interpreted as error terms in the model. Estimating this model using OLS, which would be a common approach with cross-sectional or time-series data, has certain issues. For OLS to be consistent and unbiased the covariance between the error term and the explanatory variables must be 0 (Wooldridge 2012). This is however not the case as the unobserved variables captured in the error term α_i, such as a bank's business model, are likely to be correlated with the bank's capital ratio. Also, the α_i is correlated with itself over time. This means that both the usual OLS estimates and pooled OLS estimates will be biased. Consequently, we must estimate our model using an approach that can account for the unobserved effect inherent in the correlation of the error term over time.

6.3.2 Estimation Techniques

Accounting for the error term ν_t is usually straightforward as simply including time dummy variables will capture any time dependent variation. Accounting for unobserved heterogeneity is not as simple but still possible, nonetheless. Econometric literature present three common estimation techniques to account for unobserved heterogeneity: First Differencing (FD), Fixed Effects (FE), and Random Effects (RE). All three estimates are capable of controlling for the unobserved heterogeneity in the cross sections. The difference between the estimation techniques lie with how they treat those unobserved effects. The FD estimator is rarely applied in the empirical literature of capital requirements and lending, and the FD treatment of the unobservable effect is similar to the FE estimator (ibid.). Additionally, in situations where the strict exogeneity assumption (explained further below) is violated, which is the case in our model as we include lags of the dependent variable, then the FE technique will most likely be less biased than the FD estimator. Hence, the focus of the next paragraph remains solely on the FE and RE estimators.

The main difference between the RE and FE estimation techniques lie with how they treat the unobserved effects. The RE technique posits that the explanatory variables and the unobservable effects are uncorrelated, i.e. they arise from random cause, while the FE estimator posits that they are correlated. As previously mentioned we suspect that the unobserved effect is correlated with the main explanatory variables, capital ratio, capital requirements, and capital surplus, thus the FE estimator will be the most appropriate technique. This is in line with previous empirical literature, and it is generally thought to be the most convincing tool for estimating ceteris paribus effects (Wooldridge 2012). Despite strongly believing the FE is the most appropriate technique for our regression model it is possible to test the efficiency and consistency of the FE and RE estimators. This is done with the Hausman test, which tests whether the FE and RE estimators are consistent. The H_0 in the Hausman test is that both estimators are consistent. If both RE and FE estimators are consistent then the RE estimator is generally preferred as its standard error is lower than the standard error of the FE model due to a higher number of degrees of freedom. If H_0 is rejected then the RE estimator is not consistent in that the RE assumption of no correlation between the estimator and the error term is violated. The FE estimator is then solely consistent. The estimation of the Hausman test for both equation 6.1, 6.2, and 6.3 is shown in appendix A.3. The Hausman test is clearly rejected at the 1% significance level, hence it is verified that FE estimators are indeed the most appropriate estimators for our model.

The FE estimation involves the process of time-demeaning the data meaning that the average of each variable over time is subtracted from each observation:

$$y_{i,t} - \bar{y}_i = \beta_(x_{i,t} - \bar{x}_i) + \alpha_i - \bar{\alpha}_i + \mu_{i,t} - \bar{\mu}_{i,t} \tag{6.7}$$

Using this approach, it is easy to see that the error term, a_i, that do not vary over time will cancel out of the equation leaving only the errors that do vary across time and across banks. This transformation is also called the within transformation, and the important outcome is that we can now apply pooled OLS estimation to obtain the fixed effects estimator (also referred to as the within estimator). The time-demeaned equation can be written like this:

$$\ddot{y}_{i,t} = \beta_1 \ddot{x}_{i,t} + \ddot{\mu}_{i,t} \tag{6.8}$$

Having determined that the FE estimation is the more appropriate way to eliminate unobserved heterogeneity, α_i, we turn now to testing the remaining assumptions for using FE estimation. In order for FE estimators to be consistent and unbiased four main assumptions must hold. These are listed in table 6.2 below.

Table 6.2: Random and Fixed Effects Assumptions

Estimation Method	**Notation**
General Model Specification	$y_{i,t} = \beta_1 x_{i,t} + \alpha_i + u_{i,t}$
A.1. Strict exogeneity	$E[u_{i,t}, x_s] = 0 \forall s$
A.2. Idiosyncratic error is uncorrelated with explanatory variables at all time periods	$Cov[\alpha_i, x_{i,t}] = 0$
A.3. Errors are homoscedastic	
A.4. Errors are serially uncorrelated across time	$Cov[u_{i,t}, u_{i,s}] = 0$

Own contribution based on (Wooldridge 2012)

We begin by examining assumption 3 and 4. Testing for serial correlation in the idiosyncratic error term after FE estimation is difficult, as it is only possible to estimate the time demeaned errors $\ddot{u}_{i,t}$, but not $u_{i,t}$. By definition, the time-demeaned errors suffer from autocorrelation, as explained above. Although an alternative method may be applied by differencing the errors, $\Delta u_{i,t}$, and testing whether they follow the AR(1) model, we choose not to proceed further as serial correlation under FE generally causes only minor complications (Wooldridge 2012). Inefficiency arising from the absence of homoscedasticity, i.e. heteroscedasticity, is common in panel data regressions. Fortunately, this inefficiency is easily accounted for. A common method is to include heteroscedastic robust standard errors as explained by Wooldridge (2010), a procedure easily done with regression software. This will also correct any incorrectly estimated variances in the error term u_i (ibid.).

Finally, we turn to assumption A.1 of strict exogeneity, which as previously mentioned is obviously violated as we include lags of the dependent variable in our model. The problem is particularly large in a "small T, large N" setting such as ours. Nickell (1981) shows that the problem arises from the demeaning process explained above (section 6.3.2), which creates a correlation between the lagged dependent variable and the error term. The correlation essentially occurs from the fact that $\bar{y}_i$ contains future values of $y_{i,t}$, which are generated by past $y_{i,t}$ which, in turn, are generated by past $\epsilon_{i,t}$, which are contained in $\bar{\epsilon_i}$. The bias is not mitigated by increasing N, and is still significant with T=30 (Francis & Osborne 2009). The direction of the bias depends on the direction of the correlation between the lagged dependent variable and the error term, i.e. if $\rho > 0$ it is negative. Unlike Francis & Osborne (2009) who find that lending growth in their data in most cases was not statistically significant and hence drop the lagged variable and thereby greatly reduce the possible violation of the strict exogeneity assumption, we find that the dependent variable in our model is in fact significantly correlated with its own lags. We therefore keep first lags of the dependent variable in our model, and we note that we are in violation with the assumption of strict exogeneity.

In addition to including the lagged dependent variable any explanatory variable that depends on past values of itself (or on the lagged dependent value), will also violate the strict exogeneity assumption. Finally, omitted variables and measurement errors in the explanatory variables can potentially violate the strict exogeneity assumption, a matter, which will be further elaborated on in the subsection on model limitations. The presence of endogeneity in the model can be accounted for using Instrumental Variables (IV) estimation, such as General Method of Moment (GMM), to which we now turn to.

Under the potential biases inherent in dynamic panel models GMM is the most common procedure used to obtain unbiased estimates. The procedure was initially introduced by Arellano and Bond (1991) and Blundell and Bond (1998), and involves introducing instruments in levels and first differences for the lagged dependent variable. Specifically, ideal instruments are the second and further lags of the dependent variable, loan growth, and of the bank specific characteristics included in each equation (Gambacorta & Mistrulli 2004). Due to the lack of quarterly data available in our sample and the small time period, introducing second and further lags greatly reduces the time series available for investigation, hence applying the GMM procedure is not possible for our data.

Summary of Estimation Techniques

With a dynamic panel data such as the one used in our model, we argue that applying the GMM procedure is the most ideal to account for the violation of the strict exogeneity assumption, which is obvious in our model, as we include lags of the dependent variable in all model specifications. Unfortunately, due to the limitations inherent in our data, applying the GMM procedure is not possible and instead we apply the FE estimation approach. This is not an uncommon limitation as previous literature has, like us, acknowledged the potential bias of applying FE estimation in a dynamic panel data (Aiyar et al. 2014; Berrospide & Edge 2010). We use a two-way FE estimation to control for bank and time fixed effects. Finally, we cluster standard errors by time to obtain results robust to heteroscedasticity in the error terms.

6.3.3 Model Limitations

As mentioned previously, the dataset used is unbalanced in that it has missing observations for some variables in some years. Generally, this does not cause any problems in a fixed effect estimation as the econometrical mechanisms at work are the same as for balanced panel data. The only potential problem lies with why we have missing data and whether the reason is correlated with the idiosyncratic errors. If the missing observations are correlated with the idiosyncratic errors then it could potentially bias our estimators. However, we have no reason to believe that this is the case as most of the missing observations are simply caused by withdrawal of data by providers and by mergers and acquisitions in which all observations for a given period are removed, thus not causing any bias.

As mentioned above measurement errors in the explanatory variables may bias the model estimation. Such errors may occur from the general use of control proxies and from the calculation of the surplus variable. Recall that the surplus variable is calculated as Tier 1 capital ratio minus current or future national minimum tier 1 requirements. The ideal variable would have used the actual firm specific minimum tier 1 requirement instead of the national minimum tier 1 requirement. Hence, we have a measurement error, which causes the proxy estimator to be downward biased. If the variation in the firm specific tier 1 requirements had been very low or the variation in the national tier 1 requirements had been relatively larger, then the bias would have been reduced (Wooldridge 2012). However, we find it fair to assume that this is not the case as firm specific tier 1 requirements have indeed been increasing throughout the period of investigation

The final limitation is the variation in the main explanatory variables. As just explained relative variation in the main explanatory variable, surplus, is important in order for measurement errors not to cause too large biases. Generally, when there is little variation in the explanatory variable across time so that $x_{i,t}$ and $\bar{x}_i$ are highly correlated the estimator $\hat{\beta}_{FE}$ will contain higher variation thus making it more difficult to predict the true β_{FE}. Fortunately, both the Tier 1 capital ratio and the Tier 1 surplus variables experience quite large variation throughout the sample period, e.g. the average yearly change in Tier 1 surplus with one-year horizon is 0.25 %-point with a standard deviation of 2.5%-point. Having stated the specifications of the estimated model, the regression techniques used and model limitations, the following chapter presents the results from the estimated model.

Chapter 7

Empirical Results

This chapter will present the main findings of the thesis from the estimation equations presented in the preceding chapter. Firstly, descriptive statistics will be presented to display the main features of the data. Secondly, we present the main findings of the regression of lending growth on capital ratios and its additional specifications (panel equations 6.1, 6.4 and 6.5). The findings will be related to the theoretical and empirical literature presented in chapters 3 and 4, respectively. The results will offer evidence on to what extent bank capital can affect the lending growth of banks. Thirdly, the findings of the regression of lending growth on tier 1 capital requirement ratios (T1CRR) will be presented and discussed (panel equation 6.2). Unlike the first regression with capital ratios, the second regression will shed light on the impact of Basel III requirements on lending growth. Fourthly, the regression of loan growth on capital surpluses and its additional specifications will be presented and discussed (panel equations 6.3, 6.4 and 6.5). Unlike, the second regression, the third regression with surpluses estimates the impact of Basel III T1CRRs while accounting for the existing level of capital of the bank. Lastly, we consider the robustness of our results.

7.1 Descriptive Statistics

This section serves as a preliminary review of the data sample including various descriptive statistics and presentation of development and distribution of key variables. The overall descriptive statistics are presented in table 7.1 below.

Table 7.1: Descriptive Statistics

Variable	Units	Mean	Median	SD	Min	Max	Q1	Q4	Obs
ΔGross loans	%	5.43	5.31	7.10	-14.16	33.53	1.40	9.28	602
T1CR	%	18.46	17.90	4.27	5.90	48.20	15.70	20.66	744
TCR	%	19.35	18.74	4.37	10.50	51.60	16.70	21.20	746
E/A	%	11.45	10.61	4.48	0.79	33.28	8.67	13.42	750
Capital req.$_{t-1}$	%	8.31	9.00	3.03	4.00	12.50	5.50	10.50	821
Capital req.$_{t}$	%	9.35	10.50	2.97	4.50	13.00	6.63	11.50	821
Capital req$_{t+1}$	%	10.21	11.50	2.65	5.50	13.00	7.25	12.50	821
SP$_{t-1}$	%	9.44	8.62	5.15	0.30	42.20	5.79	12.40	651
SP$_{t}$	%	8.39	7.60	5.08	-0.60	41.58	4.74	11.40	651
SP$_{'19}$	%	6.70	6.00	4.95	-2.60	39.70	3.27	9.19	651
Return on assets	%	0.81	0.80	0.62	-3.71	6.90	0.59	1.08	750
Reserves / gross loans	%	2.88	0.80	5.15	0.00	49.37	0.48	2.80	750
Log(Assets)	Log	15.66	15.27	1.79	12.05	21.97	14.67	16.39	750
Liquid assets / total assets	%	16.92	13.16	12.98	0.18	65.81	6.76	24.09	750

7.1.1 Capital Ratios

Table 7.1 shows that the average tier 1 capital ratio (T1CR) and the average total capital ratio (TCR) are similar and relatively large. The tier 1 ratio is considerably above the country specific minimum tier 1 requirements reported in section 2.2.6, where the largest minimum requirement in 2016 was reported to be 13%. It is important to remember that most banks are faced with additional tier 1 capital requirements as outlined in section 2.2.4, which explains the substantial surplus the average bank holds on top of the minimum requirements. Interestingly, previous literature has found that most banks tend to hold a buffer on top of the total regulatory requirements (Kragh & Rangvid 2016). This is also consistent with what is reported by some of the largest Scandinavian banks who report a target buffer in the range of 0.5 to 1.5%-points in excess of the regulatory requirements (Danske Bank 2016) (Nordea 2016). Figure 7.1 shows the development of average capital ratios and average minimum tier T1CRRs. Important for our empirical analysis there is a large cross-sectional variation in capital holdings. The minimum T1CR is 5.9%, the maximum is 48.2%, and the standard deviation is 4.4%. Given the findings by the previous literature just mentioned this implies that also bank specific T1CRRs contain large cross-sectional variation. To give a visual impression of the variation in capital ratios, we show the distribution of the bank specific T1CRs in 2016, as an example. Finally, we are interested in the changes of T1CRs. Throughout the sample period the average yearly change is 0.76%-points, with a standard deviation of 2,81%-point. Figure 7.3 shows the magnitude of these changes. There is twice the amount of increases (425) as decreases (200), which is expected given the increasing requirements. Finally note that loan growth has been substantial throughout the period with an average annual growth of 5.4%-points, albeit with large variations as the standard deviation is 7.1%-points.

Figure 7.1: Average Capital Ratios and Average Tier 1 Capital Requirements

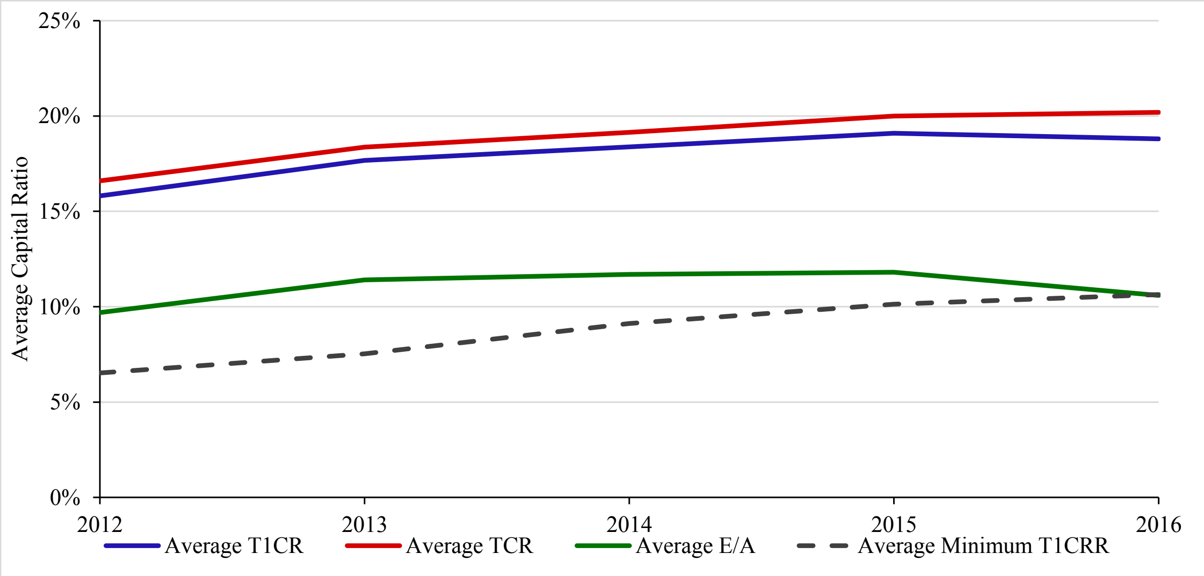


Figure 7.2: Histogram of Tier 1 Capital Ratios, 2016

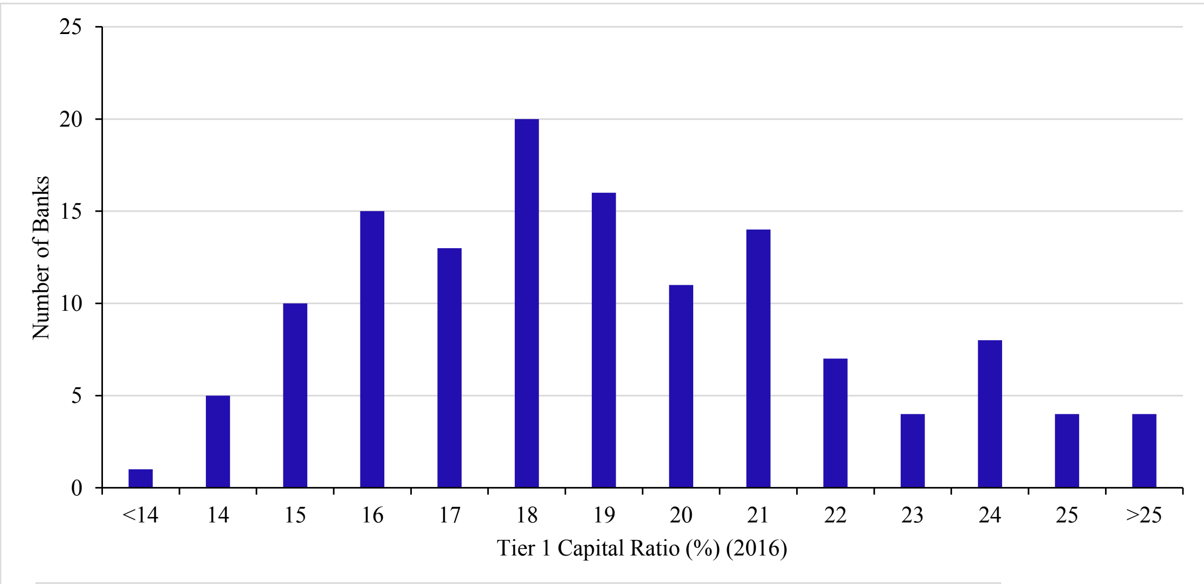
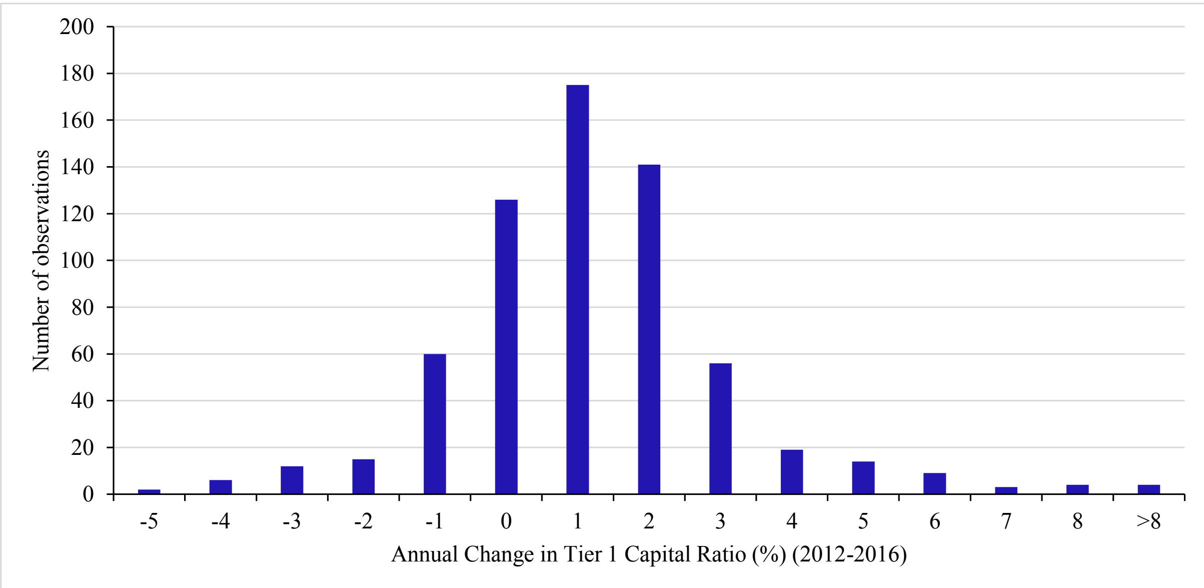


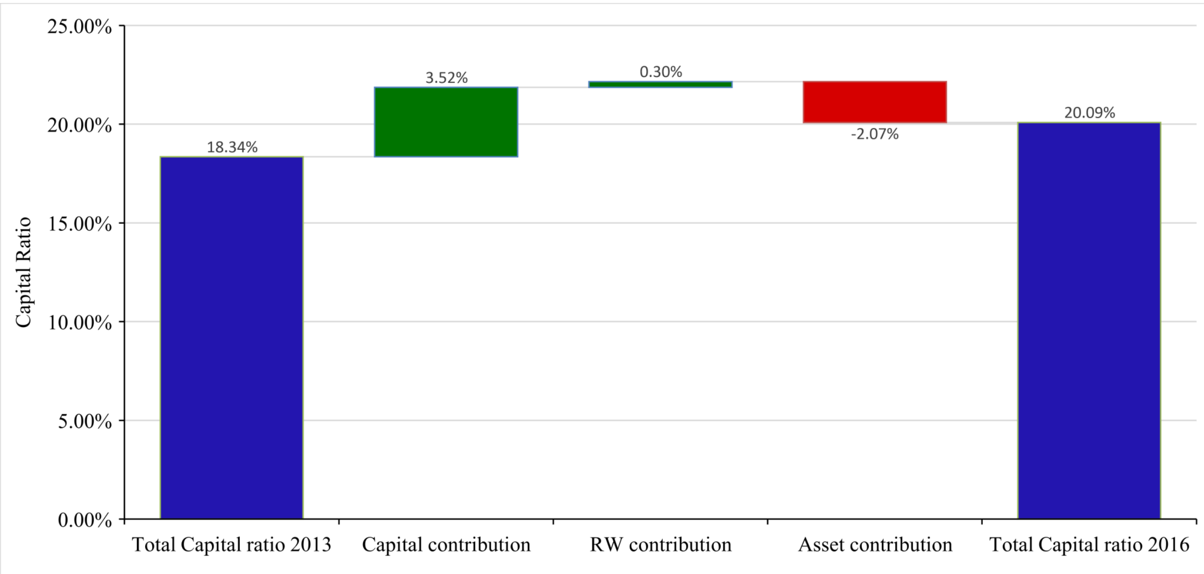
Figure 7.3: Magnitude of Yearly Changes in Tier 1 Capital Ratio



7.1.2 Decomposition of Tier 1 Capital Ratio

The goal of the thesis is to investigate how changes in capital ratios and capital buffers are associated with bank lending. In order to provide further insight into the development of the capital ratios throughout the sample period figure 7.4 decomposes the non-weighted change in TCRs from 2013 to 2016. This sheds light on how banks' balance sheets have adjusted during the sample period. As explained in the introduction of the thesis a change in capital ratios may be driven by several different mechanisms. On an overall level these include changes in nominal capital holdings (e.g. through increased retained earnings or new equity issues) and changes in risk weighted assets which can either be driven by changes in risk weights (RW) (e.g. through replacing risky loans with safer ones) or nominal assets (e.g. through running down the loan portfolio outright), or both. The average capital ratio has increased by 1.7%-points from 2013 to 2016. This increase is attributed to an average increase in nominal capital holdings of 28,4% and a reduction in RW of 7.8%-point, while an average increase in gross loans of 25.3% draw the capital ratio in the opposite direction.

Figure 7.4: Decomposition of total capital ratio



7.1.3 Tier 1 Capital Surplus

As described earlier we construct a surplus variable to investigate the impact of changes hereof on loan growth. Not surprisingly, like the tier 1 ratio the surplus variable also contains large cross-sectional variance. Figure 7.6, shows the distribution of tier 1 capital surpluses with a one-year horizon, as an example. We are interested in knowing when the average bank begins to increase its capital ratio to meet future requirements. For this purpose, we show the development of the surpluses with varying horizons in figure 7.5. The surpluses with short horizons (current and one year) decrease during the sample period, while surplus with fixed 2019 horizon increase during the sample. This may indicate that banks build up capital ratios well ahead of future requirements. Finally, we are interested in the changes in surpluses from year to year. We know that average capital ratios have increased throughout the sample period, but that does not mean that surpluses have increased as well. Some years a bank might build up more capital than what increasing requirements may entail, hence increasing its capital surplus, while in other years it may build up less capital than what increasing requirements may entail, hence shrinking its buffer and reduce surplus. Figure 7.7 shows the magnitude of these changes in tier 1 surplus ratio with one-year horizon, as an example. There is roughly the same amount of increases (303) as decreases (299) increases, which is not surprising given our assumption that banks build up capital well ahead of future requirements, thereby increasing the buffer at an early stage in order to allow it to decrease later.

Figure 7.5: Histogram of Tier 1 Capital Ratio Surplus with One-year Horizon

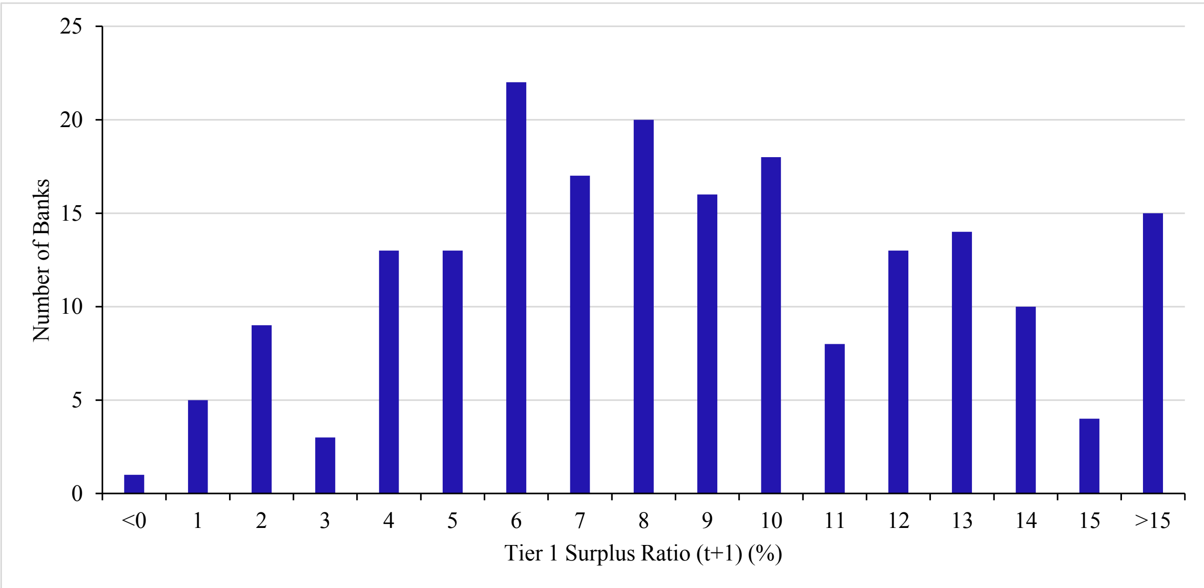


Figure 7.6: Average Surplus with Varying Horizons

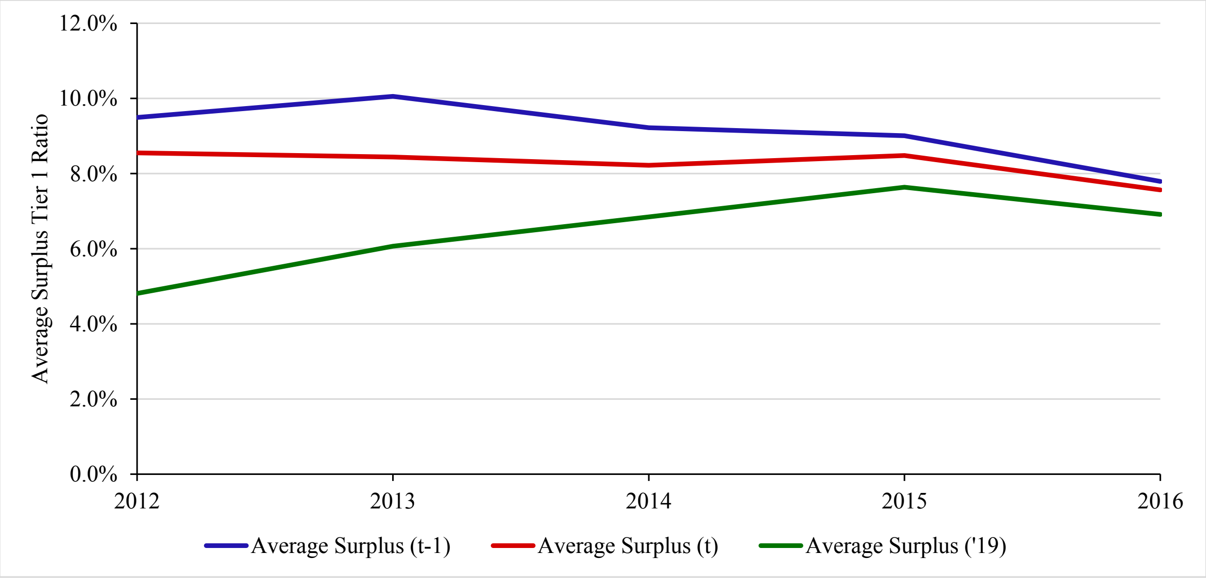
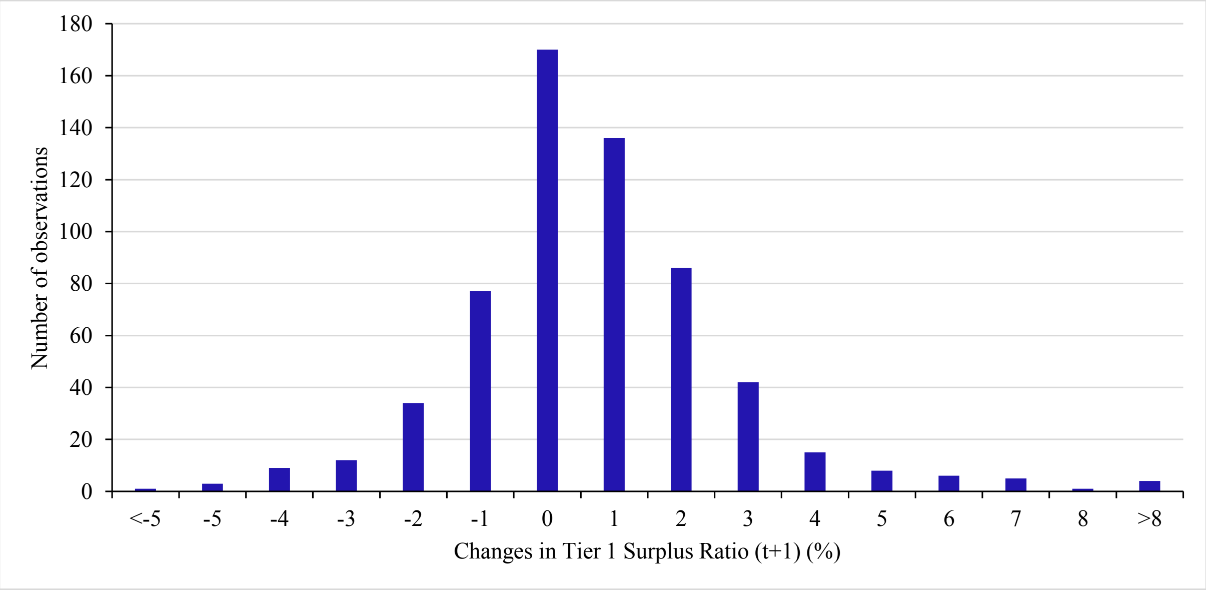


Figure 7.7: Magnitude of Yearly Changes in Tier 1 Capital Ratio Surplus with One-year Horizon



7.1.4 Segmentation of Data

In addition to testing overall effects of changes in capital ratios and capital ratio surpluses on lending we also test possible variations, i.e. non-linear, in the effects depending on bank segmentation. Specifically, we test non-linearity within the following three segments: (1) Large banks, (2) Country, and (3) Listed banks.

In table 7.2 we present reduced summary statistics of the main variables with the segmentation just outlined.

It is evident that our sample contains substantial heterogeneity across segmentations. First, both capital ratios and average lending growth varies between listed and non-listed banks. The is on average 2.6%-points lower for listed banks. This supports the notion that listed banks generally hold lower capital buffers and thereby lower capital ratios. Note, however, that T1CRRs for listed banks are generally lower (by ca. 0.5%-points) than for non-listed banks. Given that we only include national requirements this is however more an indication of the fact that Norway (who has the highest T1CRRs) have more non-listed banks present in the sample. The loan growth is on average 2.8%-points lower for listed banks. This may indicate that listed banks are less exposed to macroeconomic cycles than non-listed banks. Distinguishing between the 20 largest and the remaining "small" banks the difference in loan growth and capital ratios is not as striking, except for the equity-to-assets (E/A) ratio, which varies substantially. Interestingly the average E/A ratio is 7.0% for large banks while it is 12.0% for small banks, a difference of 5%-points. This indicates that the very largest banks are substantially more levered than the average bank in the sample. As noted by Koehler (2012), this is a common feature of large banks compared to small banks, which he attributes to the fact that *"large banks are more likely to be active in volatile and risky trading and off-balance sheet activities such as securitization, which allow them to employ a higher financial leverage."* (ibid., p.4)

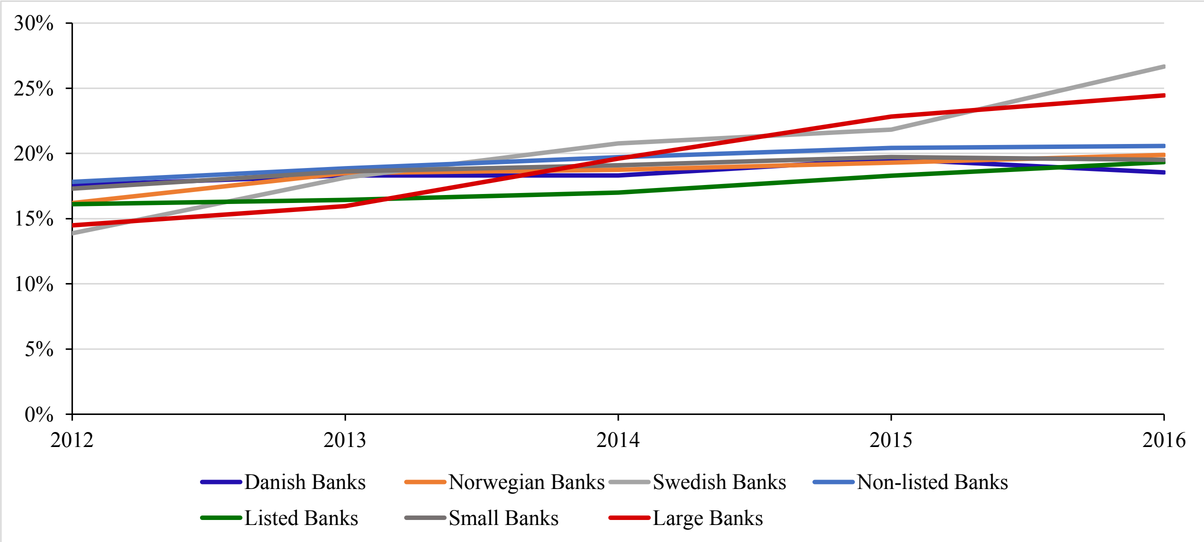
Finally, looking at the country specific statistics it is evident that large variations in especially the loan growth are present. Danish banks in the sample have had an average yearly growth rate of 1.8% while Norwegian and Swedish banks have had growth rates of 6.5% and 7.6%, respectively. This is not surprising given the fact that the banking industry has developed much slower in Denmark compared to Norway and Sweden, as presented in section 6.2.5. It is surprising that capital ratios in Denmark and Norway are almost identical while in Sweden they are nearly 2%-points higher, especially given the fact that national minimum T1CRRs are substantially higher in Norway.

Figure 7.8 below shows the evolution of TCR for the 7 segments. It stands out that Swedish and large banks have evolved from having the lowest capital ratios in 2012 to having the largest in 2016. The latter arguably reflects the fact that SIFI banks (which are all among the 20 largest banks in our sample) have been imposed with additional SIFI requirements, such as the SIFI-buffer.

Table 7.2: Reduced Summary Statistics with Segmentation

		Listed Banks			Non-Listed Banks			Large Banks			Small Banks			Danish Banks			Norwegian Banks			Swedish Banks		
Variable	Units	Mean	SD	Obs	Mean	SD	Obs	Mean	SD	Obs	Mean	SD	Obs	Mean	SD	Obs	Mean	SD	Obs	Mean	SD	Obs
ΔGross loans	%	3.38	6.30	167	6.22	7.24	435	4.34	5.37	70	5.58	7.29	532	1.78	7.43	165	6.51	6.43	317	7.62	6.54	120
T1CR	%	16.42	3.17	166	19.04	4.37	578	18.16	5.82	74	18.49	4.07	670	17.95	4.99	189	18.17	3.00	391	19.72	5.56	164
TCR	%	17.75	3.39	166	19.81	4.51	580	20.62	7.81	75	19.21	3.78	671	18.70	4.64	190	19.07	2.67	391	20.77	6.50	165
E/A	%	9.78	3.33	169	11.93	4.66	581	6.96	2.80	76	11.96	4.36	674	12.42	4.05	190	9.87	2.25	394	14.08	6.81	166
Capital req.$_{\cdot t-1}$	%	7.95	3.10	170	8.41	3.00	651	8.10	3.00	77	8.33	3.03	744	5.00	0.79	206	10.87	1.29	411	6.50	2.32	204
Capital req.$_{\cdot t}$	%	8.85	3.15	170	9.48	2.91	651	9.23	2.89	77	9.36	2.98	744	5.67	0.77	206	11.87	0.96	411	8.00	2.16	204
Capital req$_{t+1}$	%	9.58	3.00	170	10.37	2.52	651	10.19	2.46	77	10.21	2.67	744	6.35	0.66	206	12.50	0.61	411	9.50	0.94	204
SP$_{t-1}$	%	7.69	4.30	153	9.98	5.27	498	8.28	5.94	67	9.57	5.04	584	12.66	5.15	168	6.57	3.21	327	11.98	5.06	156
SP$_{t}$	%	6.78	4.36	153	8.89	5.19	498	7.16	5.98	67	8.54	4.96	584	11.98	5.14	168	5.68	3.19	327	10.22	5.07	156
SP$_{'19}$	%	4.60	4.06	153	7.35	5.02	498	5.13	6.13	67	6.88	4.77	584	9.33	5.20	168	4.38	3.23	327	8.75	5.35	156
Return on assets	%	0.80	0.65	169	0.81	0.62	581	0.71	0.41	76	0.82	0.64	674	0.60	0.97	190	0.81	0.34	394	1.04	0.56	166
Reserves / gross loans	%	3.90	4.90	169	2.59	5.18	581	1.30	2.12	76	3.06	5.35	674	8.44	7.44	190	0.82	0.76	394	1.44	2.76	166
Log(Assets)	Log	17.07	2.17	169	15.25	1.42	581	19.75	1.47	76	15.19	1.10	674	15.30	2.04	190	15.65	1.40	394	16.07	2.18	166
Liquid assets / total assets	%	22.18	11.38	169	15.39	13.03	581	16.42	9.20	76	16.97	13.34	674	33.17	12.25	190	9.31	5.73	394	16.38	8.49	166

Figure 7.8: Evolution of Total Capital Ratio



Following this preliminary view of the data sample, the regression analyses will be carried out in the subsequent sections.

7.2 Regression 1. – Lending Growth on Capital Ratios

Table 7.3 presents the results of regressing lending growth on capital ratios (panel equation 6.1). In column 1, Tier 1 ratio is used as the main explanatory variable. In column 2, TCR is used as the explanatory variable and in column 3, the E/A ratio is used as explanatory variable. The simplest specification, regressing lending growth on one of the three capital ratios excluding all of the control variables, is shown in the columns denoted with an (a) while columns denoted with a (b) includes the control variables. All regressions include both a bank fixed effect and a time fixed effect. Standard errors are reported in parentheses, and they are heteroskedasticity-consistent. For statistical significance, we use the following convention throughout the thesis: *, **, *** denote statistical significance at the 10%, 5% and 1% level, respectively. All figures (except for the logarithm of assets) have been scaled by a factor of 100. For example, an E/A ratio of 0.08 (i.e. 8%) has been scaled to 8. Thus, all figures in the tables should be interpreted as percentages.

7.2.1 The Impact of Capital Ratios on Lending Growth

From column 3(b), we find that the capital ratio E/A is statistically significant (at the 5% level) and positively correlated with lending growth. As predicted, more capitalised banks measured by the E/A ratio in the beginning of a period is associated with higher lending growth over that period. Specifically, a 1%-point increase in the E/A ratio is associated with a 0.9%-point increase in the lending growth when including controls. However, the T1CR and TCR

Table 7.3: The Impact of Capital Ratios on Loan Growth

	Tier 1 capital ratio$_{t-1}$		Total capital ratio$_{t-1}$		Equity/assets$_{t-1}$	
	1(a)	*1(b)*	*2(a)*	*2(b)*	*3(a)*	*3(b)*
Capital ratios$_{t-1}$	0.0645	-0.2677*	-0.02088	-0.2712**	1.0738***	0.8935**
(SE)	*(0.11)*	*(0.16)*	*(0.11)*	*(0.14)*	*(0.38)*	*(0.39)*
Δ%Loan$_{t-1}$		-0.2655***		-0.2677***		-0.2229***
(SE)		*(0.06)*		*(0.06)*		*(0.06)*
Return on assets$_{t-1}$		0.7854*		0.8002*		0.3776
(SE)		*(0.48)*		*(0.48)*		*(0.43)*
Loan loss reserves$_{t-1}$ / gross loan$_{t-1}$		-0.2379		-0.2112		-0.0310
(SE)		*(0.33)*		*(0.32)*		*(0.28)*
Log assets$_{t-1}$		-13.1493**		-12.8314**		-10.4080*
(SE)		*(5.59)*		*(5.57)*		*(5.70)*
Liquid assets$_{t-1}$ / total assets$_{t-1}$		0.1146		0.1207		0.1773
(SE)		*(0.11)*		*(0.11)*		*(0.11)*
R^2	0.66	0.80	0.65	0.80	0.66	0.80
Bank fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Time fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	582	433	586	437	590	439

The table reports the fixed effects regression estimates of panel equation (6.1) for the determinants of gross loan growth on three lagged capital ratios, Tier 1 ratio, total capital ratio, and equity/assets ratio and control variables. The dependent variable is the annual gross loan growth rate. Column (a) reports the regression without controls while column (b) reports the regression with controls. Reported standard errors are given in parentheses. The standard errors are robust (heteroskedasticity-consistent) and clustered by time. For statistical significance, we use the following convention: *, **, and *** denote significance at the 10%, 5% and 1% levels, respectively.

are negatively associated with lending growth at the 10% and 5% significance level, respectively. The negative relationship is quite surprising since both the theoretical and empirical literature would suggest a positive relationship. Two explanations seem probable. Firstly, it could be explained by a combination of banks not focusing on the regulatory defined capital ratios and RW distorting the picture. If RW is used instead of loan loss reserves (cf. section 7.4 and appendix) as a control for risk then both the T1CR and TCR ratios become highly insignificant while the E/A coefficient is robust. It seems likely that banks with higher RW will have lower T1CR and TCR but higher E/A (compared to a similar bank with lower RW) thus explaining a simultaneous negative and positive relationship with lending depending on the capital ratio used. It might suggest that banks are more concerned with the E/A ratio compared to the regulatory ratios, T1CR and TCR, as the regulatory ratios are insignificant in the regression with RW instead of loan loss reserves as the control for risk. The second (alternative) explanation for a negative relationship between the regulatory ratios and lending growth might be due to the aforementioned data and methodology limitations. We will discuss these issues in relation to the results later.

The significant positive relationship between the E/A ratio and lending growth then has some interesting implications. The composition of a bank's financing does matter for the growth of its lending. That is, M&M's proposition does not hold as more capitalised banks are able to grow their asset side more than less capitalised banks. Firstly, the relationship could support that more capitalised banks might experience less adjustment and distress costs in the event of a regulatory shock, as they most likely have a larger buffer of excess capital to the regulatory requirements. This argumentation relies upon imperfection in the market for bank capital (Gambacorta & Mistrulli 2004). If equity issuance is costly due to adverse selection (Myers & Majluf 1984) and banks bind capital regulations, then in the event of a shock to capital requirements the bank will experience costs as it is closer to breaching the regulatory requirements. Thus, in the case of low equity levels, the bank will reduce (or grow less) lending to meet regulatory requirements. Low-capitalised banks might therefore forego growth opportunities while high-capitalised banks will pursue growth opportunities even if both types of banks meet the regulatory requirements (Van den Heuvel 2002). This will be further tested when lending is regressed on surplus capital. Secondly, the positive relationship could also support that low capitalised banks face higher asymmetric information compared to less capitalised banks when raising equity. Bank equity affects the creditworthiness of the bank, which might influence investors to perceive a bank with lower creditworthiness to be riskier than a bank with higher creditworthiness (Kashyap & Stein 1994).

The significant positive relationship between equity to assets and lending confirms and extends on similar studies by Bernanke & Lown (1991) and Berrospide & Edge (2010). Bernanke & Lown (1991) on a cross-sectional regression of a sample of New Jersey banks in 1990 estimate the effect of a one percentage point increase in the E/A ratio on loan growth of +2-2.5%.[1] The regression by Bernanke & Lown (1991) was estimated without any controls. The estimate is considerably larger than our estimate of a one percentage-point increase in the E/A ratio leading to a +1.1% in lending growth (column 3(a)). The difference in estimates could be due to the time period and country differences. Bernanke & Lown's (1991) study is during an economic recession while our study is during an economic upturn. Firstly, in an economic recession, the level of E/A might influence the loan growth more, as under-capitalised banks are severely limited in growing loans due to the recession in the first place. Secondly, several country differences exist among the Scandinavian countries and US that could affect the results. Berrospide & Edge (2010) is probably the most similar study to our specification with similar control variables. They use a one-way fixed effect estimator while we use a two-way fixed effect estimator. They estimate a +0.8% increase in loan growth from a 1%-point increase in the E/A ratio, which is very similar to the effect that we estimate of +0.9%. Thus, our findings on the E/A ratio seem to be broadly aligned with two of the most similar studies in the empirical literature on lending growth.

7.2.2 Capital Ratios and Control Variables

Log assets is negatively associated with loan growth and statistically significant across all three specifications. In section 6.2 of chapter 6, *Methodology*, we predicted that the effect of size on loan growth is ambiguous. The argumentation for a positive relationship between loan growth and size rested mainly on the notion that larger banks would have lower asymmetric

1. On the full sample of 111 banks, Bernanke & Lown (1991) estimate the effect of a 1pp increase in the equity to asset ratio on lending growth to be +2.0%. For a sample of small banks, they estimate the effect to be +2.5%.

information and thereby lower cost of adjusting its equity position through equity issuance in the wake of a shock to capital requirements. The argumentation for a negative relationship rested mainly on the tenet that smaller banks might experience higher loan growth in an economic uptrend as their main borrowers, small firms, might be more pro-cyclical. The negative relationship offers support for the latter view. The negative relationship is also found in Deli & Hasan's (2016) global study on loan growth. However, other empirical studies find a positive relationship between bank size and lending growth (Kragh & Rangvid 2016; De Nicoló 2015).

The other control variables seem to be broadly aligned with the parameter predictions of 6.2 however mostly statistical insignificant. Return on assets, loan loss reserves to gross loans and liquid assets to total assets all have the predicted sign, however with loan loss reserves to gross loans and liquid assets to total asset being insignificant in all three regression specifications and return on assets only being significant at the 10% level in the T1CR and TCR specifications. Return on assets is fairly highly correlated with the E/A ratio (through retained earnings), and that could explain why it is insignificant in the E/A regression specification. It does however confirm a positive relationship between loan growth and return on assets as predicted in 6.2. It could therefore support that more profitable firms are better poised for growth, as they are *ceteris paribus* more resourceful albeit only statistically significant at the 10% level. Kragh & Rangvid (2016) also find a similar positive statistical relationship between return on assets and loan growth in the magnitude of 0.7% however with firm-specific T1CRRs as the main explanatory variable instead of capital ratios.

The variable, loan loss reserves to gross loans, is the proxy for risk used in the study. It is negatively correlated with loan growth as predicted although it is insignificant across all three specifications. It is likely that risk is better captured by size and the lagged dependent variables (discussed below) compared to loan loss reserves. Alternatively, other risk terms, e.g. net charge-offs to gross loans, might be a better than a reserve item, however due to limited data coverage of net charges offs in the database BankFocus then it has not been possible to include. In 7.4, we try to include RWA/A as an alternative risk measure to further test the robustness of our results. Liquid assets to total assets is positively associated with the loan growth across the three specifications but again insignificant. Our findings could present evidence against Kashayp & Stein's (1994, 2000) model of the link between lending growth and liquid assets and confirms similar findings from Mésonnier & Monks (2014) in their event study on lending. This contradicts findings from Berrospide & Edge (2010) and Deli & Hasan (2016) who find a statistically significant positive relationship between lending and liquidity in the magnitude of 0.2-0.3%-point. Given the data issues described earlier and in particular the lack of quarterly data then we do not believe that we offer substantial evidence against Kashyap and Stein's (1994, 2000) model.

The one-period lagged dependent variable, loan growth, included to control for any residual serial correlation, is significant at the 1% level in all three specifications with a negative sign. We would have suspected the coefficient to be positive so that there was a trend in loan growth. The negative correlation can be interpreted in several ways. It could suggest that growth in gross loan exhibits mean reversion from one year to the next year of c. 25%. That is quite surprising as mean reversion in other areas of finance such as stock prices usually experience momentum (positive correlation) on a one-year horizon and mean reversion on three to five-year horizon. Alternatively, it could be that the regression suffers from an omitted variable bias, i.e. the lagged dependent variable, loan growth, must be correlated with the error term. The omitted variable must be correlated with gross loan and its lag to bias the coefficient of the lagged dependent variable. However, given a quite exhaustive empirical literature review, we have included all relevant controls and tested even more controls in unreported regressions. Lastly, the negative correlation could be due to the Nickell bias (cf. section 6.3). The empirical literature on the direction of the one-period lagged dependent variable is mixed however with the most similar studies finding a positive relationship. Deli & Hasan (2016), Bridges et al. (2015) and Berrospide & Edge (2010) finds a positive relationship while Nicoló (2015) and Mesonnier & Monks (2014) finds a negative relationship.

7.2.3 Interactions with Percentile and Quartiles

Table 7.4 reports the results of regressing lending growth on capital ratios and interactions of capital ratios with dummies for upper and lower quartile and upper and lower decile for each of the capital ratios. That is, for bank i at time $t-1$, the quartile and decile dummies will take the value 1 if the capital ratio is within the specific quartile or decile and 0 otherwise. Column (a) reports results including interactions of the capital ratio with the quartile dummies while column (b) reports results including interactions of the capital ratio with the deciles dummies. Standard errors are reported in parentheses and robust.

Capital ratio interacted with quartile and percentile dummies have been included to test whether the relationship between lending growth and capital ratios is significantly different depending on the capitalisation degree of the banks. The results of regressing loan growth on capital ratios and its interactions with the upper and lower quartiles and percentiles are disappointing. All interactions except for the interaction of the E/A ratio with Q1 are insignificant across the three capital ratios. This suggests that there is no evidence that the relationship between capital ratios for under-capitalised and well-capitalised banks should be significantly different (non-linear) from the rest of the sample. Thus, the argumentation that shocks to the capital requirement can affect the capital ratio of under-capitalised banks to significantly reduce or grow lending less is not substantially supported. This is in line with findings of Kragh & Rangvid (2016) on their capital requirement study. The interaction of the E/A ratio with the lower quartile (Q1) is significant on a 5%-level. It suggests that banks with a capital ratio at time t-1 among the 25% lowest in the sample increase their lending significantly less than the

Table 7.4: The Impact of Capital Ratios on Loan Growth – Relative Capitalisation

	Tier 1 capital ratio$_{t-1}$		Total capital ratio$_{t-1}$		Equity/assets$_{t-1}$	
	1(a)	*1(b)*	*2(a)*	*2(b)*	*3(a)*	*3(b)*
Capital ratios$_{t-1}$	-0.3540	-0.2051	-0.2129	-0.4657**	0.5371	0.8977**
(SE)	(0.24)	(0.21)	(0.21)	(0.19)	(0.45)	(0.38)
Δ%Loan$_{t-1}$	-0.2669***	-0.2634***	-0.2670***	-0.2663***	-0.2124***	-0.2260***
(SE)	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)
Return on assets$_{t-1}$	0.8483*	0.9563**	0.8021*	0.6418	0.4092	0.3256
(SE)	(0.52)	(0.49)	(0.45)	(0.51)	(0.44)	(0.44)
Loan loss reserves$_{t-1}$ / gross loan$_{t-1}$	-0.2480	-0.3507	-0.2785	-0.1964	-0.0735	-0.1149
(SE)	(0.33)	(0.34)	(0.31)	(0.32)	(0.28)	(0.28)
Log Assets$_{t-1}$	-13.246**	-12.6581**	-12.5564**	-13.6892**	-11.1388*	-10.7270*
(SE)	(5.55)	(5.63)	(5.42)	(5.52)	(5.78)	(5.84)
Liquid assets$_{t-1}$ / total assets$_{t-1}$	0.1054	0.1318	0.1435	0.1389	0.1792	0.1936*
(SE)	(0.11)	(0.11)	(0.10)	(0.11)	(0.11)	(0.11)
Capital ratios$_{t-1}$ x Q1	0.0074		0.1176		-0.2536**	
(SE)	(0.09)		(0.07)		(0.13)	
Capital ratios$_{t-1}$ x Q4	0.0754		0.0404		0.0836	
(SE)	(0.06)		(0.06)		(0.13)	
Capital ratios$_{t-1}$ x D1		0.1740		-0.1231		0.4145
(SE)		(0.14)		(0.10)		(0.47)
Capital ratios$_{t-1}$ x D9		0.097		0.0864		0.0465
(SE)		(0.07)		(0.06)		(0.21)
R^2	0.81	0.81	0.81	0.80	0.80	0.80
Bank fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Time fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	433	433	437	437	439	439

The table reports the fixed effects regression estimates of equation (6.4) for the determinants of gross loan growth on three lagged capital ratios, Tier 1 ratio, total capital ratio, and equity/assets ratio and control variables. The dependent variable is the annual gross loan growth rate. Column (a) reports the regression with quartile interactions while column (b) reports the regression with decile interactions. Reported standard errors are given in parentheses. The standard errors are robust (heteroskedasticity-consistent) and clustered by time. For statistical significance, we use the following convention: *, **, and *** denote significance at the 10%, 5% and 1% levels, respectively.

rest of the sample (c. 0.25%-point) in response to a 1%-point increase in the capital ratio. Yet, the effect of a 1%-point increase in capital ratio on the overall sample is insignificant, thus blurring the findings. Further, we do not find any significant difference in the lending behaviour of very well-capitalised and very under-capitalised banks measured on the statistically significant E/A ratio of column 3(b).

7.2.4 Segmentation

Table 7.5 reports the results of regressing lending growth on capital ratios and interactions of capital ratios with dummies for the various segments in the sample. Column (a) reports results including interactions of the capital ratio with the *Large bank* dummy, column (b) reports results including interactions of the capital ratio with the *Listed bank* dummy, and column (c) reports results including interactions of the capital ratio with the country dummies. Robust standard errors are reported in parentheses.

Capital ratio interacted with segmentation dummies have been included to test whether the relationship between lending growth and capital ratios is significantly different depending on

Table 7.5: The Impact of Capital Ratios on Loan Growth – Segmentation

	Tier 1 capital ratio$_{t-1}$			Total capital ratio$_{t-1}$			Equity/assets$_{t-1}$		
	1(a)	*1(b)*	*1(c)*	*2(a)*	*2(b)*	*2(c)*	*3(a)*	*3(b)*	*3(c)*
Capital ratios$_{t-1}$	-1.1640***	-1.1247***	-0.2908	-0.7873***	-0.3237	-0.3490	1.2321**	1.0671***	0.6038
(SE)	*(0.18)*	*(0.19)*	*(0.35)*	*(0.26)*	*(0.30)*	*(0.31)*	*(0.51)*	*(0.39)*	*(0.67)*
Δ%Loan$_{t-1}$	-0.2673***	-0.2739***	-0.2782***	-0.2831	-0.2703***	-0.2782***	-0.2211***	-0.2332***	-0.2263***
(SE)	*(0.06)*	*(0.06)*	*(0.06)*	*(0.06)*	*(0.06)*	*(0.06)*	*(0.06)*	*(0.06)*	*(0.06)*
Return on assets$_{t-1}$	0.4215	0.4969	1.1191**	0.9386**	0.8291	0.9886*	0.3296	0.2894	0.2730
(SE)	*(0.44)*	*(0.43)*	*(0.55)*	*(0.46)*	*(0.51)*	*(0.52)*	*(0.46)*	*(0.45)*	*(0.44)*
Loan loss reserves$_{t-1}$ / gross loan$_{t-1}$	-0.2156	-0.2340	-0.1991	-0.1461	-0.2083	-0.1783	-0.01725	-0.0349	-0.0948
(SE)	*(0.34)*	*(0.35)*	*(0.33)*	*(0.30)*	*(0.32)*	*(0.33)*	*(0.28)*	*(0.28)*	*(0.27)*
Log Assets$_{t-1}$	-17.2401***	-17.6159***	-14.4122**	-13.5917**	-12.9201**	-13.0792**	-9.4017*	-9.8579*	-11.1655**
(SE)	*(4.50)*	*(4.98)*	*(5.88)*	*(0.10)*	*(5.57)*	*(5.72)*	*(5.80)*	*(5.76)*	*(5.62)*
Liquid assets$_{t-1}$ / total assets$_{t-1}$	0.1222	0.1217	0.118	0.1309	0.1232	0.1299	0.1743	0.1680	0.1661
(SE)	*(0.10)*	*(0.10)*	*(0.11)*	*(0.10)*	*(0.11)*	*(0.11)*	*(0.11)*	*(0.11)*	*(0.11)*
Capital ratios$_{t-1}$ x Listed Bank	0.3297*			0.6884**			-0.5392		
(SE)	*(0.17)*			*(0.29)*			*(0.62)*		
Capital ratios$_{t-1}$ x Large Bank		0.2125			0.0724			-2.6245***	
(SE)		*(0.17)*			*(0.32)*			*(0.87)*	
Capital ratios$_{t-1}$ x Danish Bank			-0.6212			-0.3206			0.5171
(SE)			*(0.61)*			*(0.54)*			*(0.71)*
Capital ratios$_{t-1}$ x Swedish Bank			0.2004			0.1905			-2.1971
(SE)			*(0.37)*			*(0.32)*			*(1.36)*
R^2	0.82	0.83	0.81	0.80	0.80	0.80	0.80	0.80	0.80
Bank fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	428	428	432	437	437	437	439	439	439

The table reports the fixed effects regression estimates of equation (6.5) for the determinants of gross loan growth on three lagged capital ratios, Tier 1 ratio, total capital ratio, and equity/assets ratio and control variables. The dependent variable is the annual gross loan growth rate. Column (a) reports the regression with listed bank interaction, column (b) reports the regression with large bank interaction while column (c) reports the regression with country interactions. Reported standard errors are given in parentheses. The standard errors are robust (heteroskedasticity-consistent) and clustered by time. For statistical significance, we use the following convention: *, **, and *** denote significance at the 10%, 5% and 1% levels, respectively.

different sample segments. The significance of the results are mixed. The listed banks interactions are significant and positive for the T1CR and TCR ratios while the large bank interaction is significant and negative for the E/A ratio. The country dummies are insignificant across all three capital ratios. Overall, there is some evidence that non-linear relationships exist between listed and non-listed banks and large and small banks.

To our knowledge, we are the first to test whether capital ratios' impact on loan growth is different for publicly listed and non-listed banks. Hence, we do not have any benchmark in the empirical literature. The listed bank interaction is statistically significant at the 10% level and positive correlated with lending growth for the T1CR and statistically significant at the 5% level and positively correlated with lending for the TCR. The results suggests that listed banks behave significantly different that non-listed banks. The positive relationship offers support to the hypothesis that listed banks have easier access to capital markets. The easier access to capital markets will in terms of the theoretical model presented reduce the expected costs of adjusting the capital position in case of a capital shortfall from a regulatory shock. Thus, listed banks will be less likely to change their lending growth compared to non-listed banks. We do however proceed with caution in relation to this hypothesis, as the relationship is not significant for the E/A ratio[2] and the T1CR and TCRs may not be particular robust explanatory variables as mentioned previously in section 7.2.2.

2. The listed bank interaction for the E/A ratio is actually negatively correlated with lending growth however highly insignificant

The interaction of E/A with *large bank* is significant at the 1% level and negatively correlated with lending growth. This suggest nonlinearity does exist as the largest 20 banks in our sample reduce lending by 2.62%-points more than the remaining banks in response to a 1%-point increase in E/A ratio. This is a surprising result like the result for the control variable *size*, which was also found to be negative and significant. Furthermore, it contradicts the results of Berrospide & Edge (2010) and Aiyar et al. (2014) who find no significant difference in the estimated impact on lending growth.

Finally, we test whether the impact of capital ratios on lending growth differ significantly between banks in the three Scandinavian countries. The results are not significant. Hence we cannot conclude that differences between the countries should impact lending growth. However, a careful interpretation of the estimated effects of the country interactions with E/A, despite their insignificance, indicate that the regulatory stringency argument provided in section 6.2.5 could be more appropriate compared to the macroeconomic argument. The regulatory stringency argument stated that Danish banks' lending growth would be least affected of a change in capital ratios followed by Norwegian and Swedish banks based on the speed of implementation of the capital requirements and magnitude of increases in the capital requirements across the three countries.

This ends the discussion of the main findings of regression 1: The impact of capital ratios on lending growth. We now turn to the results of regression 2: The impact of T1CRRs on lending growth. Unlike the first regression with capital ratios, the second regression will shed light on the impact of Basel III requirements on lending growth. Regression 2 with T1CRRs instead of capital ratios will have the same control variables, and hence we do not comment on the results of any control variables unless these show any significant differences compared to the first regression.

7.3 Regression 2. – Lending Growth on Capital Requirements

Table 7.6 reports the results of regressing lending growth on national minimum T1CRRs. The setup follows that of table 7.3 with the regression of T1CRRs on loan growth without control variables in column (a) and with control variables in column (b). We estimate the model three times, each with T1CRRs at different points in time as the main explanatory variables.

The results of regressing loan growth on T1CRRs are modest. While all three specifications of T1CRRs are negatively associated with loan growth, as predicted in section 6.2, then they are mostly insignificant. T1CRRs in the period, *t-1*, and *t*, are found to have a negative and significant (at the 10% and 5% level, respectively) impact on lending growth in period *t* in the

Table 7.6: The Impact of Capital Requirements on Loan Growth

	Capital Req.$_{t-1}$		Capital Req.$_{t}$		Capital Req.$_{t+1}$	
	1(a)	*1(b)*	*2(a)*	*2(b)*	*3(a)*	*3(b)*
Capital requirement$_{t-1}$	-0.5519*	-0.4284	-1.1318**	-0.8467	-0.8182	-1.1663
(SE)	(0.33)	(0.57)	(0.57)	(0.64)	(1.34)	(1.23)
Δ%Loan$_{t-1}$		-0.2470***		-0.2455***		-0.2352***
(SE)		(0.06)		(0.06)		(0.06)
Return on assets$_{t-1}$		0.6657		0.6764		0.7629
(SE)		(0.49)		(0.47)		(0.49)
Loan loss reserves$_{t-1}$ / gross loan$_{t-1}$		-0.1647		-0.1644		-0.1368
(SE)		(0.30)		(0.30)		(0.29)
Log assets$_{t-1}$		-12.3965**		-12.3958**		-12.9135**
(SE)		(5.67)		(5.69)		(5.71)
Liquid assets$_{t-1}$ / total assets$_{t-1}$		0.1192		0.1270		0.1469
(SE)		(0.11)		(0.23)		(0.11)
Adjusted R^2	0.65	0.80	0.65	0.80	0.64	0.80
Bank fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Time fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	602	438	602	438	602	438

The table reports the fixed effects regression estimates of panel equation (6.2) for the determinants of gross loan growth on three capital requirements with varying time spans. The dependent variable is the annual gross loan growth rate. Column (a) reports the regression without controls while column (b) reports the regression with controls. Reported standard errors are given in parentheses. The standard errors are robust (heteroskedasticity-consistent) and clustered by time. For statistical significance, we use the following convention: *, **, and *** denote significance at the 10%, 5% and 1% levels, respectively.

specification without controls. When including controls the regressions are insignificant. Regardless of the insignificance, the magnitude of a 1%-point increase in T1CRRs on loan growth varies between (-)0.4-(-)1.2% depending on the specification. These results are fairly similar to those of Kragh & Rangvid (2016), who find that lending growth is reduced by 1%-point when T1CRRs are increased by 1%-point on sample of Danish banks. These results are however in the lower range of the of estimates found in the empirical literature on the impact of bank capital requirements (see table 4.2. Aiyar et al. (2014) and Bridges et al. (2015) find that UK banks reduce lending by 6.5-7.2%-points and 4.1-8.1%-points, respectively. The insignificance of the results could be related to data and methodology issues which will be discussed in the subsection 7.4.4 further below.

The control variables of regressing loan growth on T1CRRs are very similar in significance and magnitude to the control variables of the regression of loan growth on capital ratios (cf. table 7.3. It suggests that the previous period's loan growth and size of the bank might be the most important factors in determining loan growth in the next period. Loan growth in the previous period is negative correlated with loan growth in the next period in the magnitude of ca. -0.25% for a 1%-point increase. The result is very similar to that obtained in the regression of table 7.3. Size is also negatively correlated with loan growth. Inverting the natural logarithm, then a 1% increase in total assets decreases loan growth with ca. -0.075%.

7.3.1 Regression 3. – Lending growth on Capital Surplus

Table 7.7 reports the results of the third and final regression, lending growth on tier 1 capital surplus to national minimum requirements. Again, regression results without control variables are shown in column (a) and with control variables in column (b). Recall that the surplus variable is calculated as the bank T1CR in period *t-1* less the national tier 1 minimum requirement in period *s*. We estimate the model five times with requirements in three different periods: *t-1, t*, and fixed in 2019.

Table 7.7: The Impact of Capital Surplus on Loan Growth

	Capital surplus$_{t-1}$		**Capital surplus$_t$**		**Capital surplus$_{'19}$**	
	1(a)	*1(b)*	*2(a)*	*2(b)*	*5(a)*	*5(b)*
Capital surplus$_{t-1}$	0.1485	-0.3200*	0.1090	-0.2643	0.0645	-0.2677*
(SE)	(0.12)	(0.19)	(0.12)	(0.17)	(0.11)	(0.16)
Δ%Loan$_{t-1}$		-0.2653***		-0.2644***		-0.26546***
(SE)		(0.60)		(0.06)		(0.06)
Return on assets$_{t-1}$		0.8582*		0.8016*		0.7854*
(SE)		(0.50)		(0.48)		(0.48)
Loan loss reserves$_{t-1}$ / gross loan$_{t-1}$		-0.2080		-0.2236		-0.2379
(SE)		(0.33)		(0.32)		(0.33)
Log assets$_{t-1}$		-13.5813**		-13.2746**		-13.1493**
(SE)		(5.59)		(5.60)		(5.59)
Liquid assets$_{t-1}$ / total assets$_{t-1}$		0.1224		0.1151		0.1146
(SE)		(0.11)		(0.11)		(0.11)
Adjusted R^2	0.66	0.80	0.66	0.80	0.66	0.80
Bank fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Time fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	582	433	582	433	582	433

The table reports the fixed effects regression estimates of equation (6.5) for the determinants of gross loan growth on three one-period lagged capital surpluses and control variables. The dependent variable is the annual gross loan growth rate. Column (a) reports the regression without controls while column (b) reports the regression with controls. Reported standard errors are given in parentheses. The standard errors are robust (heteroskedasticity-consistent) and clustered by time. For statistical significance, we use the following convention: *, **, and *** denote significance at the 10%, 5% and 1% levels, respectively.

Estimating the model without control variables we find a small positive, but insignificant impact of surplus on lending growth. Estimating the model with control variables we find a negative and significant relationship between surplus and lending growth for surplus to requirements in all periods, except period *t*. The magnitude of the impact of a 1%-point increase in surplus on lending growth lies in the range of -0.26 to -0.32%-points depending on the requirement period. This is an unusual result, but not surprising given the already known results of estimating the impact of T1CR and TCR on lending growth in subsection 7.2 above, where the relationship was likewise found to be negative and significant. Recall that banks not focusing on the regulatory defined capital ratios was presented as a possible explanation along with the RWs distorting the picture. The results are likewise surprising when comparing to similar empirical studies. As explained in section 6.2.2 our definition of surplus resembles that of Méssonier & Monks (2015) and Aiyar et al. (2012). In their study of the European Banking Authority's (EBA) capital exercise in 2011/2012 Méssonier & Monks find that a 1%-point larger (smaller) shortfall (surplus) among the participating banks lead to a decrease (increase) in lending growth of 1.48%-points. This effect is large, which is arguably due to the event-like nature of their study, why it is not directly comparable to our results. In two similar studies Francis & Osborne (2009) and Berrospide & Edge (2010) find that an increase in surplus capital ratio (calibrated to a target) of 1%-point leads to an increase in lending growth of 0.06 and 0.23 %-points, respectively. These results are not directly comparable to ours due to fact that their surplus ratios are constructed using a calibrated target, whereas ours is the surplus capital to the national T1CRR. However, it seems fair to conclude that are results, despite the difference in type of study and how we calibrate surplus, contradicts previous empirical studies.

7.3.2 Interactions with Percentile and Quartiles

Table 7.8 reports the results of regressing lending growth on surplus ratios and interactions of surplus ratios with dummies for upper and lower quartiles and deciles for each of the capital ratios. Column (a) reports results including interactions of the capital ratio with the quartile dummies while column (b) reports results including interactions of the capital ratio with the deciles dummies. Standard errors are reported in parentheses and are robust.

Recall that capital surplus interactions with quartile and decile dummies have been included to test whether the relationship between lending growth and surplus ratios is significantly different depending on the capitalisation degree of the banks. Unlike the disappointing results in section 7.2.3 above we get highly interesting results when regressing loan growth on surplus ratios and its interactions with its lower decile. We find that banks with surplus levels in the lowest decile of our sample experience a reduced lending growth of 0.88-1.23%-points compared to the remaining banks in the sample. The results are significant at the 5% level. This provides substantial evidence in support of the predictions made in section 6.2.5, where it was argued that under-capitalized banks should have less room to absorb "shocks" to their capital ratios and are therefore more likely to reduce lending growth as a means of rebuilding capital ratios. Our results directly contradict those of Kragh & Rangvid (2016) who do not find evidence in support of the prediction that under-capitalized banks should be relatively more affected by changes in capital ratios than other banks. Our results are however not directly comparable due to the differences in type of study. We do not find any significant difference in the lending behaviour of banks with surplus ratios in the lower quartile. This suggests that lending growth is only significantly impacted for banks with the very lowest capital surplus levels. Finally, we do not find any significant difference in the lending behaviour of well-capitalized banks.

7.3.3 Segmentation

Table 7.9 reports the results of regressing lending growth on capital surplus ratios and interactions of capital surplus ratios with dummies for the various segments in the sample. Column (a) reports results including interactions of the surplus ratio with the *Large bank* dummy, column

Table 7.8: The Impact of Capital Surplus on Loan Growth – Relative Capitalisation

	Capital surplus$_{t-1}$		Capital surplus$_t$		Capital surplus$_{'19}$	
	1(a)	*1(b)*	*2(a)*	*2(b)*	*5(a)*	*5(b)*
Capital surplus$_{t-1}$	-0.2291	-0.4507**	-0.2483	-0.3309*	-0.3208	-0.2301
(SE)	*(0.24)*	*(0.21)*	*(0.23)*	*(0.19)*	*(0.22)*	*(0.18)*
Δ%Loan$_{t-1}$	-0.2658***	-0.2954***	-0.2622***	-0.2812***	-0.2594***	-0.2621
(SE)	*(0.06)*	*(0.06)*	*(0.06)*	*(0.06)*	*(0.06)*	*(0.06)*
Return on assets$_{t-1}$	0.802	0.8784*	0.8021*	0.8885*	0.7565	0.7842
(SE)	*(0.51)*	*(0.50)*	*(0.49)*	*(0.50)*	*(0.49)*	*(0.49)*
Loan loss reserves$_{t-1}$ / gross loan$_{t-1}$	-0.2067	-0.3379	-0.2299	-0.1442	-0.2614	-0.2256
(SE)	*(0.33)*	*(0.29)*	*(0.32)*	*(0.36)*	*(0.32)*	*(0.33)*
Log assets$_{t-1}$	-13.4749**	-11.9847**	-13.3058**	-11.4147**	-13.6292**	-13.2512**
(SE)	*(5.63)*	*(5.64)*	*(5.69)*	*(5.75)*	*(5.69)*	*(5.59)*
Liquid assets$_{t-1}$ / total assets$_{t-1}$	0.1232	0.1022	0.1182	0.0835	0.1214	0.1164
(SE)	*(0.11)*	*(0.11)*	*(0.11)*	*(0.11)*	*(0.11)*	*(0.11)*
Capital surplus$_{t-1}$ x Q1	-0.0135		-0.215		-0.3781	
(SE)	*(0.19)*		*(0.21)*		*(0.28)*	
Capital surplus$_{t-1}$ x Q4	-0.0904		-0.0510		0.0615	
(SE)	*(0.11)*		*(0.14)*		*(0.13)*	
Capital surplus$_{t-1}$ x D1		-0.8844**		-1.1007**		-0.9329
(SE)		*(0.36)*		*(0.52)*		*(0.89)*
Capital surplus$_{t-1}$ x D9		0.0293		-0.0098		-0.0108
(SE)		*(0.09)*		*(0.09)*		*(0.09)*
R^2	0.80	0.80	0.80	0.80	0.80	0.80
Bank fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Time fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	432	432	432	432	432	432

The table reports the fixed effects regression estimates of equation (6.4) for the determinants of gross loan growth on three changes in capital surpluses and control variables. The dependent variable is the annual gross loan growth rate. Column (a) reports the regression with quartile interactions while column (b) reports the regression with decile interactions. Reported standard errors are given in parentheses. The standard errors are robust (heteroskedasticity-consistent) and clustered by time. For statistical significance, we use the following convention: *, **, and *** denote significance at the 10%, 5% and 1% levels, respectively.

(b) reports results including interactions of the surplus ratio with the *Listed bank* dummy, and column (c) reports results including interactions of the surplus ratio with the country dummies. Robust standard errors are reported in parentheses.

The results are similar to those presented in section 7.2.4 for and TCR, however the magnitude of the coefficients as well as the significance levels have generally increased.

First, the results show that an increase in capital surplus ratio of 1%-point for listed banks is 0.67-0.92%-points higher (more positive) than for non-listed banks. This is a highly interesting result as it suggests that listed banks behave significantly different that non-listed banks. Adding the coefficient for surplus and the interaction term we see that a 1%-point increase in the surplus ratio for listed banks in fact *increases* lending growth by 0.03-0.07%-points. These magnitudes are similar to those of Francis & Osborne (2009) and slightly below those of Berrospide & Edge (2010). One possible explanation is that the data used in the two studies just mentioned

Table 7.9: The Impact of Capital Surplus on Loan Growth - Segmentation

	Capital surplus$_{t-1}$			**Capital Surplus$_{t}$**			**Capital Surplus$_{'19}$**		
	1(a)	*1(b)*	*1(c)*	*2(a)*	*2(b)*	*2(c)*	*5(a)*	*5(b)*	*5(c)*
Capital surplus$_{t-1}$	-0.8504***	-0.5581*	-0.2231	-0.7369***	-0.37208	-0.1172	-0.7219**	-0.3787	-0.2908
(SE)	*(0.26)*	*(0.29)*	*(0.33)*	*(0.27)*	*(0.29)*	*(0.35)*	*(0.29)*	*(0.32)*	*(0.35)*
Δ%Loan$_{t-1}$	-0.2675	-0.2711***	-0.2860***	-0.2664***	-0.26769***	-0.2809***	-0.2741***	-0.2695***	-0.2782***
(SE)	*(0.06)*	*(0.06)*	*(0.06)*	*(0.06)*	*(0.06)*	*(0.06)*	*(0.06)*	*(0.06)*	*(0.06)*
Return on assets$_{t-1}$	0.9167*	0.9890*	1.0596*	0.8307*	0.8503*	0.9948**	0.8885*	0.8493*	1.1191**
(SE)	*(0.47)*	*(0.52)*	*(0.51)*	*(0.47)*	*(0.50)*	*(0.51)*	*(0.47)*	*(0.52)*	*(0.55)*
Loan loss reserves$_{t-1}$ / gross loan$_{t-1}$	-0.1287	-0.21387	-0.26045	-0.1698	-0.23198	-0.26588	-0.2095	-0.2359	-0.1991
(SE)	*(0.30)*	*(0.33)*	*(0.34)*	*(0.30)*	*(0.33)*	*(0.34)*	*(0.31)*	*(0.33)*	*(0.33)*
Log assets$_{t-1}$	-13.1658**	-14.7494***	-13.7000**	-13.2772**	-13.8824**	-13.3555**	-13.6441**	-13.6376**	-14.4122**
(SE)	*(5.35)*	*(5.66)*	*(5.63)*	*(5.38)*	*(5.69)*	*(5.64)*	*(5.35)*	*(5.62)*	*(5.88)*
Liquid assets$_{t-1}$ / total assets$_{t-1}$	0.1269	0.1289	0.0993	0.1253	0.1187	0.0946	0.1231	0.1181	0.1180
(SE)	*(0.11)*	*(0.11)*	*(0.11)*	*(0.11)*	*(0.28)*	*(0.11)*	*(0.11)*	*(0.11)*	*(0.11)*
Capital surplus$_{t-1}$ x Listed Bank	0.9233***			0.7875**			0.6269*		
(SE)	*(0.32)*			*(0.33)*			*(0.32)*		
Capital surplus$_{t-1}$ x Large Bank		0.5320			0.2226			0.1681	
(SE)		*(0.37)*			*(0.37)*			*(0.36)*	
Capital surplus$_{t-1}$ x Danish Bank			-0.7979*			-0.7592			-0.6212
(SE)			*(0.49)*			*(0.51)*			*(0.61)*
Capital surplus$_{t-1}$ x Swedish Bank			0.2546			0.1187			0.2004
(SE)			*(0.42)*			*(0.43)*			*(0.37)*
R^2	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80
Bank fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	432	432	432	432	432	432	432	432	432

The table reports the panel fixed effects regression estimates of equation (6.5) for the determinants of gross loan growth on three changes in surpluses and control variables. The dependent variable is the annual gross loan growth rate. Column (a) reports the regression with listed bank interaction, column (b) reports the regression with large bank interaction while column (c) reports the regression with country interactions. Reported standard errors are given in parentheses. The standard errors are robust (heteroskedasticity-consistent) and clustered by time. For statistical significance, we use the following convention: *, **, and *** denote significance at the 10%, 5% and 1% levels, respectively.

includes only commercial banks, whereas we use both commercial and savings banks in ours. Most of the savings banks in our data are not publicly listed (87%), hence when including an interaction term for listed banks we effectively isolate the relationship for commercial banks. In this way, our study becomes somewhat more comparable to those of Francis & Osborne (2009) and Berrospide & Edge (2010). However, as will be presented in section 7.4 these findings do not hold when running the regression on a subsample of listed banks only.

The coefficient on the interaction of capital surplus with *Large bank* is positive but insignificant for all capital surplus ratios, hence we find no evidence of the hypothesis that an additional positive non-linear relationship between the largest banks and lending growth exists. This is in line with Berrospide & Edge (2010) who also find no significant difference in the estimated impact on lending growth for the largest banks in their samples.

Finally, we test whether the impact of capital ratios on lending growth differ significantly between banks in the three Scandinavian countries. The results of the interaction of surplus on *Danish bank* show that Danish banks are relatively more impacted by increases in their capital surplus ratios relative to their Norwegian and Swedish peers. The coefficient on capital surplus is however insignificant, thus blurring the results. A careful interpretation of the estimated effects of the country interactions, despite blurred result, indicates that the macroeconomic argument provided in section 6.2.5 is more appropriate compared to the regulatory stringency argument. Danish banks have experienced markedly lower growth rates during the investigation period along with a much flatter development in the real estate market. This seems to have some non-linear explanatory power that is not captured by the time fixed effects. Further it contradicts the careful interpretation of the E/A interaction term in section 7.2.4 where support for the regulatory stringency argument was found. This indicates that different mechanisms are at play depending on whether one is looking at the effect of E/A ratios or capital surplus ratios.

7.4 Robustness of Results

In this final section of the analysis we perform and present several alternative tests of the baseline models. This is done to ensure the validity of the results found in the previous three sections. In the following subsections, all three baseline models will be investigated jointly but discussions may be separate based on the outcome of the alternative specifications. All results of the alternative tests are presented in the appendix. First, we conduct two re-specifications of the model: (1) we include macroeconomic variables and (2) we use different proxies for *risk*. Second, we decompose the sample to test for robustness across subsamples of our data. Third, we test for robustness to our methodology. [3]

7.4.1 Re-specifications of the Baseline Models

Controlling for Macroeconomic Variables

Time fixed effects was used in the baseline models to control for aggregated demand and supply effects as time fixed effects would be able to capture all time varying macroeconomic effects, also those unobservable and uncorrelated with GDP and inflation. In an alternative model we include national GDP, inflation and central bank lending rates to test the robustness of excluding time fixed effects (cf. appendix A.4. This is the same procedure as in Bridges et al. (2015) who find that their results are robust to explicitly including macro controls instead of time fixed effects, and that the latter is better at capturing all common bank factors at any point in time without needing to model them. We find that the estimated effects of GDP, inflation, and central bank lending rate on lending growth is significant and of similar magnitude as in Berrospide & Edge. Further, the magnitude of estimated effects of all explanatory variables become slightly more positive. This means that the , TCR, CRR and surplus that were all negative and significant in the baseline regressions are now insignificant, while the E/A ratio is now significant at the 1% level (up from 5% in the baseline regression). The inclusion of lagged loan growth remains significant and of similar order of magnitude. Surprisingly, the control measure *size* that has been consistently significant in all baseline regression is now insignificant. We ascribe this finding to the fact that size is highly correlated with inflation is our sample. The remaining variables remain in the same order of magnitude. We conclude that our results are robust to including macroeconomic control variables instead of time fixed effects.

3. Note that baseline regressions where multiple versions of the same variable were used (such as T1CRRs in period t=0, t=1, and so on) only the current versions, that is t=0, are presented in the regression output.

Changing the Measures of Risk

As specified in section 6.2.4, several measures of risk have been used in the empirical literature. Loan loss reserves was chosen for our model based on the relatively better data coverage in the Bank Focus database. However, other risk measures such as net charge-offs and RW are more common in the empirical literature, although a consensus on which measure is better remains unreached. Hence, motivated by this missing consensus we change the measure of risk to net charge-offs and subsequently to RW to test for consistency across different risk measures. The results are presented in appendix A.5 and A.6

The estimated impact of net charge-offs is positive but insignificant. The estimated impacts of the main explanatory variables maintain their operational signs and order of magnitude, but become insignificant for all variables. The order of magnitude and significance is also slightly reduced for the control measures *size* and *liquidity.* Finally, the magnitude and significance of the control measures *lagged loan growth* and *profitability* has increased. As mentioned above data quality of net charge-offs is poorer than for net loan loss reserves, hence the number of observations is reduced to 364-368 in the alternative regressions. Given the reduced number of observations concluding on the robustness is difficult, however, for comparison we run the reduced sample regression with loan loss reserves and find that the estimated effects and corresponding significance remain similar. Hence, we conclude that the model is robust to changing the risk measure to net charge-offs.

Different from net charge-offs, data quality for RW is similar to net loan loss reserves, hence comparison is seemingly more straightforward. However, another issue arises with the use of RW as it is an inherently different variable despite also measuring risk. Recall that RW is directly correlated with and TCR, i.e. when RW decreases so does the amount of RWA and hence the capital ratios increase by automation. Due to this relationship, we argue that comparison is only appropriate with the E/A baseline model. The order of magnitude and significance of the E/A and *lagged loan growth* coefficients remains almost identical, while the estimated impact and significance of the remaining control measures changes only slightly. Hence, we conclude that the model is robust to including RW as an alternative risk measure.

7.4.2 Decomposing the sample

An important aspect of analysing the impact of bank capital ratios and capital requirements on lending growth is whether the results are consistent for all banks in the sample. Given the wide range of bank types in our sample it is possible that our baseline results are skewed due to segment specific characteristics such as the higher loan growth rates in Norway and Sweden or the generally lower capital ratios of listed banks. We have already included interaction terms to test for differences across segments in section 7.2.4 and found limited differences. Another way to test for differences across segments is to split the sample into smaller subsamples depending on various bank characteristics, such as size, country, and whether the bank is listed or not. We conduct the following three decompositions:

(i) Three subsamples depending on size: small banks (book assets below EUR 10 million), medium banks (book assets above EUR 10 million and below EUR 100 million), and large banks (book assets above EUR 100 million).

(ii) Two subsamples depending on whether the bank is listed or not

(iii) Three subsamples depending on each bank's country of origin

(i) – Size

Beginning with the subsample of small banks we immediately see that the operational signs of the main explanatory variables and ROA change, although they are all highly insignificant. Moreover *risk* is significant for the T1CRR, TCR, and SP regressions. This could imply that the predictions made in section 6.2.4 are more pertinent to small banks, that is lending growth in small banks is more sensitive to the amount of risk the bank carries. This is an interesting observation. Possible explanations may be that small banks have fewer options at hand to tackle increased risk unlike larger banks who are generally more diversified and have the possibility of engaging in off-balance sheet activities such as securitization, which allow them to operate with a higher leverage than small banks (Koehler 2012). The second subsample of medium banks is more consistent with the baseline results. Operational signs do not change for any variables except *risk*, where it is now positive but only significant in the E/A regression. Moreover, the magnitude of *size* has reduced substantially and is now insignificant in all models. The latter is also true in the subsample of large banks. This is an interesting result, which indicates that a non-linear relationship between size and loan growth exist. It seems that size is highly relevant for explaining loan growth of small banks, but only up to a certain point after which it becomes irrelevant. Finally, the largest banks show the highest level of consistency with the baseline results in that all operational signs remain the same. However, results are generally insignificant, which implies that it is generally much harder to explain the variation in lending growth for the largest banks using the measures presented in this thesis. This might be due to their higher level of complexity or better options to adjust capital ratios without actually obtaining more capital, e.g. by adjusting RWA. Finally, the lower levels of significance may also partly be a consequence of the low number of large banks in this group (15). Summing up, it is quite evident that results are sensitive toward a decomposition by size. Especially, variation in loan growth for large banks seem much harder to explain. Our results are however not directly contradicted in any of the decompositions in the sense that nowhere does significant operational signs change direction.

(ii) – Listed and non-listed Banks

Decomposing the sample into listed banks and non-listed banks reveal major differences across the two subsamples. First, it stands out that , TCR, CRR, and SP are all insignificant for listed banks, while E/A is highly significant. Almost the exact opposite is true for non-listed banks where , TCR, and SP are highly significant, while E/A and CRR and insignificant.

Generally, it seems that our model specification better explains variation in loan growth for non-listed banks than for listed banks. This is particularly driven by the fact that lags of loan growth are insignificant for listed banks while it is highly significant for non-listed banks. At first this is an interesting observation, especially since it is one of only two specification in which lagged loan growth is insignificant. In section 6.2.5 it was described how lags of the dependent variable in addition to carrying explanatory power in itself also has the effect of mopping up residual autocorrelation (Bridges et al. 2015). Thus, a plausible explanation for why lagged lending growth is insignificant for listed banks is that they are less exposed to autocorrelation, which, in turn, may be related to their different business model, i.e. reduced focus on traditional lending activities. Further interpretation of this result is out of scope of this thesis, hence we proceed to the remaining control variables.

We find that *liquidity* and *risk* are highly significant in the subsample of listed banks and insignificant in the subsample of non-listed banks. The amount of liquidity (liquid-assets-to-total-assets) is on average 7%-points larger for listed banks than non-listed banks (22% and 15%) (see section 7.1. Therefore, the result is somewhat puzzling as the degree of liquidity does not seem to impact lending when liquidity is already low whereas it does seem to impact lending when liquidity is on average higher. Intuitively this seems contradictory to what one would expect. One possible explanation is that the option of "protecting" one's loan portfolio to a shock in financing, as explained in section 6.2.4, is only an option when the banks liquidity ratio is above some threshold. In other words, banks with lower liquidity do not have the opportunity to use it to withstand such shocks.

Similar to the observation made for small banks above it seems that loan growth for listed banks is more sensitive to the amount of risk the bank carries. As evident from section 7.1 listed banks in our sample are generally more risky than non-listed banks, an observation supported by Koehler (2012) who also find that listed banks carry more risk than non-listed banks. It therefore seems that risk is only a relevant factor in explaining loan growth when it is above some lower level, which is also the case for small banks. In summary, we find that our results are also sensitive toward a decomposition of listed and non-listed banks. Our results are again not contradicted as none of the significant operational signs change direction.

(iii) – Country of Origin

The final decomposition of banks by country of origin also shows differences across the three subsamples and several interesting observations are evident. Firstly, it stands out that E/A in the subsample of Danish banks is the only main explanatory variable that is significant across all three subsamples. Second, we find that *liquidity* and *risk* are highly significant in the subsample of Danish banks, but not in the Norwegian and Swedish subsamples. Danish banks are generally more liquid and riskier than their Norwegian peers (see section 7.1. Therefore, the findings are consistent with the above where it was found that liquidity and risk only become relevant explanatory measures when they are above some threshold. Third, *size* is an insignificant measure of loan growth in the subsample of Danish and Swedish banks, while it is highly significant in the subsample of Norwegian banks. One possible explanation is that the dispersion of bank sizes is substantially smaller among Norwegian banks compared to Danish and Swedish banks (see section 7.1). In other words, when banks in a sample are too similar in size, i.e. there is little variation, a measure of size effect is likely to be insignificant. Finally, *profitability* is highly significant in the subsample of Norwegian and Swedish banks, while it is insignificant in the subsample of Danish banks. One possible explanation may be that Norwegian and Swedish banks are generally more profitable (see section 7.1, indicating that profitability only becomes a relevant factor when it is above some threshold. In summary, we find that our results are sensitive to decomposing the sample by country of origin due to the substantial differences in liquidity, risk and profitability across the three subsamples.

7.4.3 Testing the Methodology

Estimating the Models using Changes in the Explanatory Variables As explained in subsection 4.1.3 the format of the main explanatory variable varies in the empirical literature. It is most common to use nominal ratios, i.e. the actual capital ratios from period to period, rather than using the *changes* in these capital ratios from period to period. Aiyar et al. (2014) who uses changes in their main explanatory variable, capital requirements, argue that doing so avoids the scenario of entry and exit of yearly observations distorting the results, hence abstracting from changes in the sample of banks between periods due to the inconsistency of observations per year. This potential distortion may apply to our regressions due to the unbalanced nature of our panel data, hence we estimate the baseline regressions using changes in the main explanatory variables instead of in levels. The results are reported in appendix A.7. We find that the operational signs of all measures remain the same, although the magnitude and significance of the coefficients are reduced slightly. We conclude that our results are robust to using *changes* in the main explanatory variables instead of *levels*.

Scaling the Explanatory Variables Given the wide range of bank sizes in our sample we tested for differences in results across bank size by both including an interaction term in the baseline regressions and by decomposing the data by size. Mésonnier & Monks (2014) suggest an additional method of controlling for differences in size by weighting the main explanatory variables using size (total assets) as the weighting factor. This is arguably a less manual and more precise procedure than the previous, hence justifying the use of it. We adopt this measure and while the magnitude and significance of the explanatory variables increases slightly the remaining control variables remain largely similar in order of magnitude and significance.

Excluding year 2012 and 2016 In section 5.2.3 the limitations of our data sample were discussed. Specifically, the sample suffers from poor data coverage in years 2012 and 2016. In section 6.3.3 it was explained that this unbalanced nature of our data does not immediately cause a bias, except if the reason data is missing is correlated with the idiosyncratic errors, $\epsilon_{i,t}$, i.e. the unobserved factors that change over time (Wooldridge 2012). Motivated by this possible bias, we first exclude data for year 2012 and subsequently for year 2016 and rerun the baseline regressions.[4] Excluding data from year 2012 we find that the magnitude of impact and significance of all explanatory measures increase, except E/A which decreases slightly in both magnitude and significance. All operational signs remain the same, hence on an overall level the results do not change as a consequence of excluding the first year of data. Excluding data from year 2016 yields a surprising result as the magnitude and significance of several explanatory variables change. First, the coefficient of , TCR, T1CRR, and SP are all highly insignificant, while the estimated magnitude and significance of E/A increases. Moreover, the coefficients of liquidity and risk increase in magnitude and are highly significant. Hence, the sample seems to be more homogeneous in the sense that overall explanatory power of the model increases. The results are robust to excluding year 2016 in the sense that operational signs of explanatory variables do not change, albeit the magnitude and significance of several variables do change substantially.

7.4.4 Data and Methodology Issues

The results presented in this chapter have been mixed and at times conflicting the theory and other empirical studies. The results may have been affected by the data and methodology issues mentioned in chapters 5 and 6. Three issues seem to be particular burdensome. The first issue is the use of annual data instead of quarterly data in this study. Two reasons make quarterly data superior to annual data. Quarterly data can capture effects of short run movements in the explanatory variables on lending growth. That is, a bank may experience higher capital requirement in one quarter and in the next quarter adjust its loan growth. The effect will not be observed when using annual data. The use of quarterly data will also generate significantly more observations improving the validity of the results. Further, the majority of the empirical literature uses quarterly data to test the effect of capital ratios, capital requirement and surplus capital on lending growth.

The second issue relates to errors in variables and omitted variable bias. We do not have access to firm-specific capital requirements. That is, we cannot observe the full capital requirements but instead proxy capital requirements with the national minimum capital requirement. Therefore, the capital requirement and surplus regressions suffer from errors-in-variables that bias our results negatively. The surplus variable may therefore not actually reflect a bank's "true" surplus to total capital requirement, as the bank specific capital requirement component is unknown. If it were assumed that the bank specific capital requirements are constant during the period then it would not impact our regression. However, given the modest results and our general understanding of the bank-specific capital requirement then the assumption seems to be fairly unrealistic. Thirdly, the results suffer from Nickell's bias as described in chapter 6, *methodology.* The Nickell bias arises from the use of fixed effects estimation instead of the GMM estimation, and it can have a significant impact on the results (Nickell 1981).

4. Note that we cannot exclude both years simultaneously due to the limited amount of years in our sample

With the findings of the thesis presented in the preceding chapter, this chapter will discuss the findings in relation to the theory and methodology employed. The main objective of the chapter is to provide insights into the validity and limitations of the overall research design and argumentation of the thesis. Specifically, the theoretical framework informing the research design of the thesis will be examined. Particular emphasis will be given to the discrepancies between the drivers of the theoretical model and the eventual research design. Next, the aforementioned data and methodology issues will be reviewed again. This time, focus will be on whether the issues could have been avoided. Lastly, the validity of empirical studies in general within capital requirements and bank lending will be discussed. Focus will be on to what extent the complexity of the real world can be captured in empirical studies.

7.5 The Applicability of The Theoretical Model

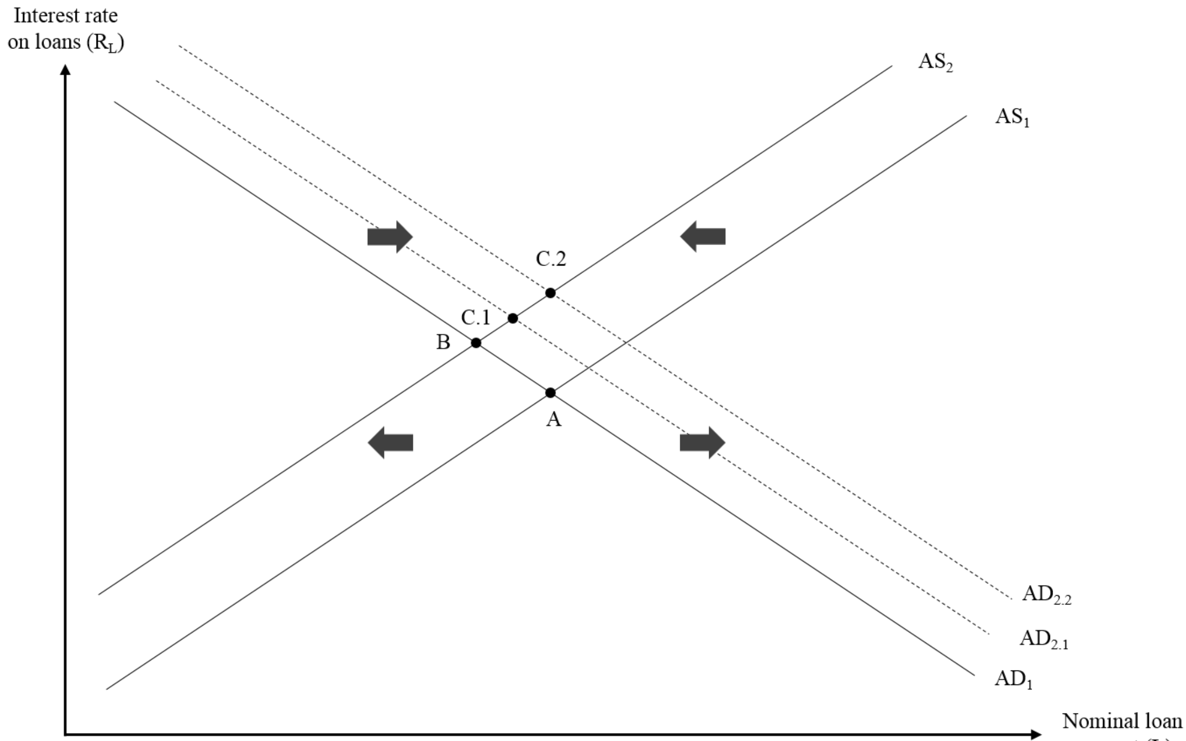
Francis & Osborne's (2009) model, which have been presented and solved in chapter 3, constitutes the theoretical argument of how capital and capital requirements can affect a bank's loan growth. The model relies on two important assumptions, the presence of national and firm-specific capital requirements and adjustment costs to equity, which both have implications for our study. Recall that capital requirements in the theoretical model, which has three time periods ($t = 0, 1, 2$), is defined as: $K_t^R = k_{R,t}L = (k_t^{min} + k_t^{disc})L$, where K_t^R is the required *level* of regulatory capital at time t, $k_{R,t}$ is the *total* capital requirement ratio in percentage ($\in (0, 100)$), k_t^{min} is the *minimum* (national) capital requirement ratio in percentage ($\in (0, 100)$), and k_t^{disc} is the bank-specific *discretionary* capital requirement ratio in percentage ($\in (0, 100)$). Regulators determine both the national minimum capital requirement ratio and the bank-specific capital requirement ratio. An additional assumption is that the bank-specific capital requirement ratio of the next period is uncertain to the bank, while the minimum capital requirement ratio in the next period is assumed to be known by the bank. Given that part of the capital requirement is unknown then the total capital requirement of the next period must also be unknown. The uncertainty of the total capital requirement creates a probability for a bank to be in shortfall and given that a shortfall must be offset with equity issuance, which is assumed to be expensive, then capital requirements can affect lending. The driver of the model is thus the assumption of uncertain bank-specific capital requirements in the next period.

Certain minimum capital requirements and uncertain bank-specific requirements in the next period seem to some extent to be a realistic assumption, however, it is not well-aligned with the empirical study of the thesis. Recall from chapter 2, *Institutional review*, that minimum capital requirements are developed by the Basel Committee and implemented by national authorities. Basel III was developed in the aftermath of the financial crisis and officially endorsed in 2010 and implemented from 2013. With national implementation plans of the Basel III accord developed in the period between 2010 and 2013, then national capital requirements of Basel III were in fact mostly certain for banks. Recall further that the bank-specific requirements are generally unknown to banks since the FSA of each country each year can choose to assign banks with additional bank specific requirements above the national requirement. Therefore the assumptions of the model seem to be well aligned with the 'real world'. However, the bank-specific requirements are not observed in our sample and instead we rely on the national requirement of Basel III. Thus, it seems that there is a mismatch between the driver of the theoretical model being unexpected bank-specific capital requirement, and the empirical study relying on expected national minimum capital requirements. However, the mismatch may not be severe. National minimum capital requirements have been increasing over the period studied, and they can serve as shocks to banks' capital holdings as well leading banks to increase their capital ratios (assuming a constant capital buffer) through either increasing equity, reducing assets / loans (slowing asset / loan growth) or reducing risk weights.

However, a theoretical model with uncertain minimum national capital requirements would likely work differently than Francis & Osborne's (2009) model, but it would most likely still be able to imply a negative relationship between capital requirements and lending. The mismatch between the theoretical model and the empirical model mentioned in the previous paragraph could perhaps be solved by uncertain national minimum capital requirements. Even though, national minimum capital requirements are mostly known to banks then political processes could create some uncertainty regardless. Imagine, Francis & Osborne's (2009) model with a shock to national minimum capital requirement. Whereas, the bank-specific requirements will only impact the individual bank then the entire banking industry would be affected by a national minimum capital requirement increase. Recall from the model that $L = L(r_L)$ and $L'(r_L) < 0$ where L is the loan stock of bank i and r_L is the loan rate. The model would imply that an increase in requirement would lead to an increase in loan rate and a reduction in the nominal amount of loans.

Now imagine, an increase in the national minimum capital requirement in a simple AD-AS model as illustrated in figure **??** below. Given that all banks are now facing a shock to requirements then the aggregated supply curve relating loan rate and loan amount would shift left (i.e. inward) implying a new equilibrium (B in the figure) where the rate on loans is higher and the loan amount is lower compared to before the regulatory shock. The equilibrium is similar to the effect predicted in the Francis & Osborne model. However, the demand curve could shift to partially or completely offset the reduction in loan supply, if consumers regardless of the increase in loan rate would demand the same amount of loans. This could be due to consumers not being able to substitute loans with another 'product'. Realistically, it would probably be that the AS curve would shift inward and the AD curve would shift outward to some extent but not all the way back to its initial amount of loans. Some consumers might have other financing options and other consumers will not undertake the project it needs financing for and thereby not take on the loan. Overall though, a model with national requirements might not be a departure from the theoretical inference that requirements are negatively associated with lending.

Figure 7.9: AD/AS Graph



The graph illustrates the effect of an increase in the national minimum capital requirement in a simplistic AD-AS framework. The y-axis illustrates the aggregated (market) interest rate on loans (price of loans). The x-axis illustrates the aggregated amount of loans in nominal terms. Demand for loans (in nominal terms) is assumed to be negatively (linearly) associated with the interest rate on loans. The supply of loans (in nominal terms) is assumed to be positively (linearly) associated with nominal amount of lending. At the starting point, the economy is in equilibrium (A). An increase in the national minimum capital requirement causes the AS curve to shift left. The new equilibrium is (B). As substitution possibilities for borrowers are limited, and the number of borrowers is large the AD curve can potentially shift right, as borrowers will now demand a higher nominal amount of loans at every price as compared to before. The new equilibrium depends on how far right the AD curve shifts. The new equilibrium will be between point B and C.2 on the AS curve. The equilibriums C.1 and C.2 are for illustrative purposes.

7.6 Data and Methodology Issues Revisited

In Chapter 7, *Empirical Results*, we emphasized three potential issues related to our study: The use of annual instead or quarterly data, errors in variables from not observing bank-specific requirements and Nickell's bias. The issues are important to the study but also mostly unavoidable. Previous literature has to a large extent relied on quarterly frequency data, however notable exceptions are De Nicolo (2015) and Deli & Hasan (2016) who use annual frequency data. Quarterly data in the scope of a master thesis is unrealistic. No database available to the authors have quarterly data and given the time frame, number of banks and variables in the study a rough calculation would suggest that a minimum of 45,000 data points and more realistically around 80,000 data points would be needed to be extracted manually.[5] Given the number of data points it is thus not feasible to manually extract the data. Further, most non-listed banks may not even have publicly available quarterly data. The literature, which has used quarterly data, has relied on datasets provided by central banks and Financial Services Authorities (FSAs), which have not been possible to gain access to. Thus, it has not been possible to obtain quarterly data. Bank-specific capital requirements would have improved the study,

5. 150 (200) banks * 20 (20) quarters * 15 (20) variables = 45.000 (80.000)

however bank-specific requirements are not publicly available across the three countries, and they have thereby not been available either. The Nickell bias is an unavoidable feature of our sample given the time span. It could perhaps have been avoided, if we had expanded the time, period however the recent changes to the database Bank Focus made it impossible to do so. Further, as explained in chapter 5, *Data*, it would have caused other issues to expand the time frame.

Given the scope of the master thesis, it seems that we have actually obtained the best suboptimal sample. Further, the suboptimal feature of the sample and method is however not equivalent to actually dismissing the study. The results presented should be considered with caution however empirical studies will in general be affected by some biases. De Nicolo (2015) and Deli & Hasan (2016) uses annual instead of quarterly data, multiple studies, e.g. Labonne & Lame (2014) do not use GMM procedure despite a fairly low T and multiple studies, e.g. Hancock & Wilcox (1993, 1994) do not observe capital requirements (i.e. errors in variables) and instead construct a target capital ratio to build a capital surplus / shortfall. Thus, data and methodology issues are unavoidable in empirical analysis. With being forthcoming of the limitations of the study, it is possible to access the validity of results.

7.7 The Validity of Empirical Studies on the Effect of Capital Requirements on Lending

The preceding section discussed some specific data and methodology issues that we have experienced in our empirical study but also issues that other papers to some degree suffer from. However, a more general discussion of the validity of empirical analysis of banking and capital requirements might be necessary before concluding the thesis. Empirical studies are simplifications of a complex and interconnected 'real' world. This is not surprising as it is often necessary to be simplistic to gain useful insights. However, certain issues, which will be discussed in the next paragraphs, arise when conducting empirical studies on capital requirements and banking. Firstly, reverse causality might distort the relationship between requirements and lending growth. Secondly, heterogeneity among banks can affect panel regression methods. Lastly, omitted variables, beyond what has already been covered in the thesis, can be a potential source of bias.

The relationship between lending and requirements can in some cases be reverse in that lending explains requirements instead. The housing development of Sweden and Norway in appendix A.1 and explained in section 6.2.5 in the methodology chapter might be an example of it. The large lending volume (due to the price increases) in the housing markets by Norwegian and Swedish banks and mortgage lenders may have caused the increase in the counter-cyclical buffer by the FSAs in the two countries. FSAs' bank-specific requirements can also be an example of it. If a bank has grown lending in previous periods then the national FSA might increase the bank-specific requirement in response to rapid loan growth or risk-taking. Overall, reverse causality is however of minor importance, as lagged explanatory variables are used in the empirical literature, and thus the obvious balance sheet relation is avoided.

The second issue of empirical studies are heterogeneity among banks. For panel data regression to be effective then homogeneity among banks are assumed. However, banks may not be particularly alike and may not behave particularly uniformly. Size, business model and management are among the factors that challenge the homogeneity assumption. Even though, we try to control for the factors and further test the robustness of the results, the results can to some extent be affected by heterogeneity in the sample. Most importantly to the empirical studies on capital requirements and lending is omitted variable bias. None of the studies examined, including our own, have focused on the impact of other banking regulations. Banks have experienced increasing regulation over the past decades with regards to many aspect of their business model that could potentially influence the behaviour of the banks in many of the empirical studies conducted to date. Further, omitted demand effects may also bias the empirical studies even if a study uses two-fixed effects or control directly for demand by including variables like GDP and inflation. It could be the case that demand of loans from different sectors of the economy is comparably different. If banks are specialised in lending to specific sectors then controlling only for aggregated demand will bias the results. Similarly, regional loan demand may differ and impact the regression estimation. E.g. the demand for loans in Northern Jutland ('Nordjylland') may be different from Northern Sealand ('Nordsjælland') due to the characteristics of the customers. Of the studies reviewed, Bridges et al. (2015) is the only study reviewed that controls for demand at a disaggregated level. Regression estimations are difficult, as they entail practical compromises on data and methodology. Still, it is one of the most important methods of investigating empirical themes.

7.8 Summary

The chapter has discussed overall validity implications of the study and of the empirical literature in general. Firstly, it must be acknowledged that there is a partial mismatch between the theoretical model developed by Francis & Osborne (2009) and the empirical study conducted. It is however not deemed to be of a serious concern, as other theoretical explanations could be possible. Secondly, the discussion has reviewed general data and methodology issues inherent in empirical studies that have the potential to impact the validity of the results of empirical analysis. Yet, regression estimation is a widely used tool to provide insights into empirical themes.

Chapter 8

Conclusion

This thesis has examined the effect of bank capital and capital requirements on bank lending growth estimating a two-way fixed effects panel data regression on a sample of 137 Scandinavian banks in the period 2013-2016. Theoretical inferences from Francis & Osborne's (2009) 'bank capital channel' model, which links bank capital and capital requirements to bank lending, has been used as the foundation of the empirical study. Further, for comparison reasons our research design resembles that of other empirical studies within the field of research. However, the thesis adds important complements to the research designs of previous studies by specifically testing for differences across various segments of banks. The main finding of the thesis is that lending growth is positively associated with a bank's equity-to-assets ratio. Further, we find that the relationship is non-linear in that under-capitalised banks significantly reduces lending compared to adequately capitalised banks, and that lending behaviour varies between certain segments of banks. The findings of the thesis both support and contradict theoretical inferences and earlier empirical studies. Data and methodology issues can to some extent have biased the results and caution must be taken when interpreting the findings. Thus, further research is warranted.

8.1 Main Findings

First, we find that bank lending behaves differently to changes in capital ratios depending on whether the change occurs to equity-to-assets or to capital-to-risk-weighted-assets. We find a strong positive relationship between equity-to-assets and lending growth, which supports theoretical predictions and previous empirical studies, in that banks with higher equity-to-assets ratios have higher lending growth. Specifically, a 1%-point increase in equity-to-assets is associated with a 0.9%-point increase in lending growth, which is in similar order of magnitude as other empirical studies. Surprisingly, we find a significant negative relationship between capital-to-risk-weighted-assets and lending growth. These results are however not robust to explicitly including risk weights in the estimation, hence indicating that banks' lending behaviour is more affected by changes in equity-to-assets ratio rather than regulatory-defined capital ratios. Further, we find a negative, albeit insignificant, relationship between capital requirements and lending behaviour, hence failing to confirm that such a relationship exists. It also contradicts the results of previous empirical studies that find a significant negative relationship between capital requirements and lending growth. Finally, we find a negative relationship between excess capital above the national minimum capital requirement and lending growth. The relationship is however not robust to explicitly including risk weights in the estimation, which is not surprising given the other findings just outlined.

We find some evidence that under-capitalised banks are associated with lower lending growth compared to adequately capitalised banks. It indicates that under-capitalised banks have less room to absorb "shocks" to their capital ratios, and they are therefore more likely to reduce lending growth as a means of 'protecting' their capital ratios.[1] Specifically, a 1%-point increase in the ratio of excess capital to national requirements is associated with a decline in lending growth of 1.4-1.6%-points for banks with the lowest levels (1st decile) of excess capital to national requirements compared to only a decline of 0.3-0.5%-points for adequately capitalised banks.

Investigating differences across segments of banks revealed several interesting findings. Firstly, our results suggest that lending behaviour for listed banks is less negatively affected by increases in capital, and excess capital, ratios. A 1%-point increase in excess capital is associated with a change in lending of (-)0.1-0.1%-points, which is 0.6-0.9%-points higher than for non-listed banks. This is an interesting result, especially since it is a completely unaddressed complication in earlier empirical studies. Seemingly, listed banks contain certain characteristics that influence their lending behaviour in a markedly different way than non-listed banks. It could support the notion put forward in the thesis that publicly listed banks have easier and cheaper access to funding to partially offset shocks to capital requirements. Further research would need to be done to confirm this. Secondly, the banking industry in Scandinavia is characterised by having a few very large banks and many small banks, which led us to investigate whether any inherent differences exist between these two groups. We find that a 1%-point increase in equity-to-assets is associated with a decline in lending growth of 1.54%-points for the very largest banks compared to an increase of 1.1% in loan growth for small and medium-sized banks. This is surprising, as other empirical studies find no evidence of non-linearity in the size of bank on lending growth. Finally, we find no evidence that Danish, Norwegian, or Swedish banks' lending behaviour is any differently affected by changes in capital and requirements.

8.2 Limitations and Further Research

Having outlined the main findings of our study, we find it important to stress certain limitations hereof. The results of our study have been mixed and at times conflicting the theoretical predictions as well as other empirical studies. This is not an issue per se, but given certain data and methodology issues caution must be taken when interpreting the results. Three issues seem

1. Under-capitalised is a relative in-sample measure of banks with the lowest capital, or excess capital, ratios

to be particularly burdensome. First, the use of annual data instead of quarterly data, besides significantly lowering the amount of observations, makes it more difficult to capture short run movements in capital ratios and capital requirements and the corresponding effect on lending. Moreover, the majority of empirical studies use quarterly data, which makes a direct comparison of results difficult. Second, by using national capital requirements instead of firm-specific requirements we fail to measure the "true" capital requirements and "true" excess capital ratios and thus their effect on lending growth. This issue is substantial since firm-specific requirements may vary independently of the national requirements and thus can potentially bias our results. Varying bank-specific requirements have become more pressing in recent years with the introduction of Basel III, where the second pillar (Supervisory Review) has given more power to national Financial Services Authorities (FSAs) to impose additional capital requirements upon specific banks. Third, the results suffer from a specific bias (Nickell Bias) related to the econometric method used. It was not possible to effectively mitigate the bias. The magnitude of the bias is unknown.

Overall, the findings of our study are small pieces in the puzzle of understanding and effectively estimating the 'true' relationship between capital ratios, capital requirements and bank lending. As outlined above our results support previous empirical findings by providing evidence of a positive relationship between equity-to-assets ratios and lending growth. However given the limited scope of a master thesis, further research should seek to confirm or reject our findings on a more comprehensive Nordic dataset. Furthermore, our results suggest that lending behaviour differs across segments of banks, which is an interesting finding that is relatively unexplored in the literature. Hence, future research should aim at investigating variations across segments of banks to provide more pieces to the puzzle.

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Appendix A

Table A.1: Development of Housing Prices in Scandinavia

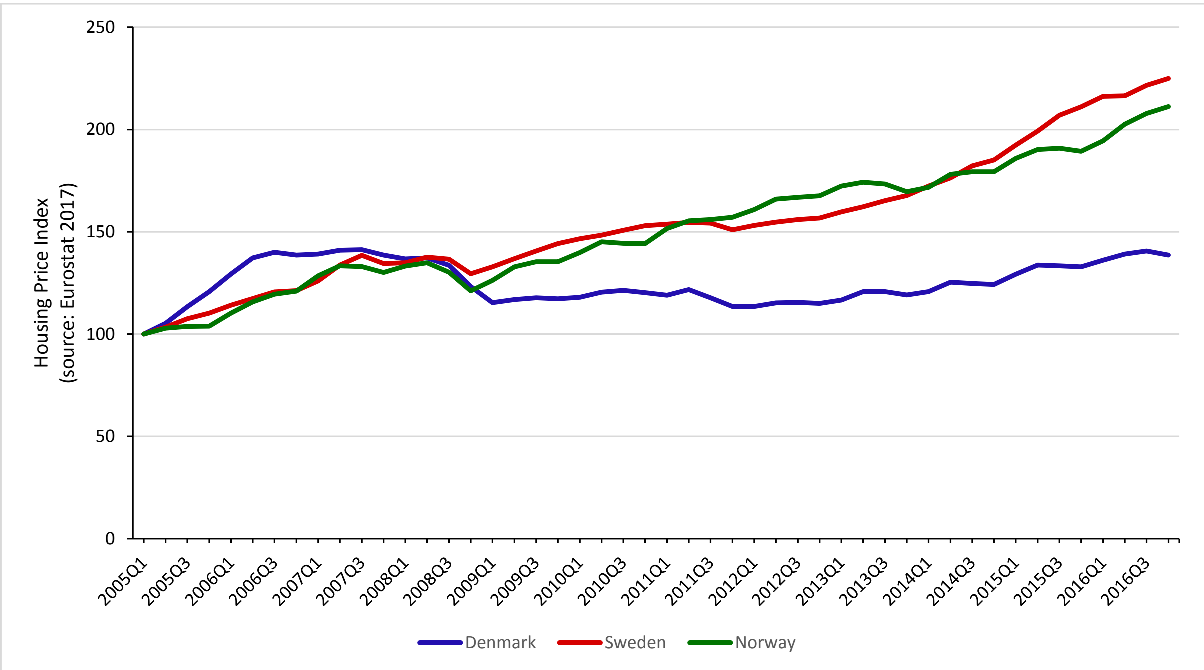

Table A.2: List of Variables

Variable	Equation	Definition
$\Delta\%Loan_{i,t}$	$\Delta\%Loan_{i,t}$ = (Gross $loan_{it}$ / gross $loan_{it-1}$) - 1	Precentage-point changes in bank i's gross loan from period t-1 to t
$T1CR_{i,t-1}$	$T1R_{i,t-1}$ = Tier 1 $Capital_{it-1}$ / Risk weighted $assets_{it-1}$	Tier 1 capital to total risk weighted assets for bank i at period t-1
$TCR_{i,t-1}$	$TCR_{i,t-1}$ = Total $capital_{it-1}$ / Risk weighted $assets_{it-1}$	Total regulatory capital (tier 1 + tier 2) to total risk weighted assets for bank i at period t-1
$E/A_{i,t-1}$	$E/A_{i,t-1}$ = $Equity_{it-1}$ / Total $assets_{it-1}$	Equity to total assets for bank i at period t-1
$T1CRR_{i,t-1}$		Tier 1 capital requirement ratio for bank i at period t-1
$T1CRR_{i,t}$		Tier 1 capital requirement ratio for bank i at period t
$T1CRR_{i,t+1}$		Tier 1 capital requirement ratio for bank i at period t+1
$SP_{i,t}$	$SP_{i,t}$=$T1R_{i,t-1}$ - $T1RR_{i,t-1}$	Tier 1 capital ratio surplus to national tier 1 capital ratio requirement at period t-1
$SP_{i,t}^{1}$	$SP_{i,t}^{1}$=$T1R_{i,t-1}$ - $T1RR_{i,t}$	Tier 1 capital ratio surplus to national tier 1 capital ratio requirement at period t
$SP_{i,t}^{'19}$	$SP_{i,t}$=$T1R_{i,t-1}$ - $T1RR_{i,2019}$	Tier 1 capital ratio surplus to national tier 1 capital ratio requirement in year 2019
$Loans_{i,t-1}$	$\Delta\%Loan_{i,t}$ = (Gross $loan_{it-1}$ / gross $loan_{it-2}$) -1	Precentage-point changes in bank i's gross loan from period t-2 to t-1
$ROA_{i,t-1}$	$ROA_{i,t-1}$ = Net $income_{t-1}$ / Total $assets_{t-1}$	Net income to total assets for bank i at period t-1
$Reserves_{i,t-1}$	$Rerserves_{i,t-1}$ = Loan loss $reserves_{t-1}$ / Gross $loans_{t-1}$	Loan loss reserves to gross loans for bank i at period t-1
$Log(Assets)_{i,t-1}$	$Log(Assets)_{i,t-1}$ = log(total $assets)_{i,t-1}$	The logarithm of total assets for bank i at period t-1
$Liquid_{i,t-1}$	$Liquid_{i,t-1}$ = Liquid $assets_{t-1}$ / Total $assets_{t-1}$	Liquid asssets to total assets for bank i at period t-1
Q1 (Q4)		Takes the value 1 if bank i's T1CR, TCR, T1CRR, or SP ratio is in the lowest (highest) quartile of the sample
C1 (C9)		Takes the value 1 if bank i's T1CR, TCR, T1CRR, or SP ratio is in the lowest (highest) decile of the sample
Listed Bank		Takes the value 1 if bank i is publicly listed, and 0 otherwise
Large Bank		Takes the value 1 if bank i's value of total assets is among the 20 largest bank in the sample, and 0 otherwise
Danish Bank		Takes the value 1 if bank i is a Danish bank
Swedish Bank		Takes the value 1 if bank i is a Swedish bank
Net charge $offs_{t-1}$	Net charge $offs_{t-1}$ = Net charge $offs_{t-1}$ / Gross $loans_{i,t-1}$	Net charge offs to gross loans for bank i at period t-1
Risk $weights_{t-1}$		Average risk weight for bank i at period t-1
GDP_{t-1}		National Gross Domestic Product at time t-1
$Inflation_{t-1}$		National Inflation rate at time t-1
Central Bank Lending $Rate_{t-1}$		National Central bank lending rate at time t-1

Table A.3: Hausman Test for Random for Random Effects

	DF	*m Value*	*Pr > m*
Tier 1 capital ratio$_{t-1}$	2	1715	0.0001
Total capital ratio$_{t-1}$	2	283	0.0001
Equity/assets$_{t-1}$	2	4175	0.0001
Capital surplus$_{t-1}$	2	1939	0.0001
Capital Req.$_{t-1}$	2	90	0.0001

Table A.4: Robustness test with Macroeconomic Variables

	$T1CR_{t-1}$	TCR_{t-1}	E/A_{t-1}	$T1CRR_t$	SP_t
	1	*2*	*3*	*4*	*5*
Capital ratios$_{t-1}$	-0.0265	-0.0225	0.9652***	0.2665	-0.0447
(SE)	*(0.14)*	*(0.12)*	*(0.39)*	*(0.36)*	*(0.18)*
Δ%Loan$_{t-1}$	-0.2254***	-0.2317***	-0.2085***	-0.2238***	-0.2301***
(SE)	*(0.06)*	*(0.06)*	*(0.06)*	*(0.06)*	*(0.06)*
Return on assets$_{t-1}$	0.5902	0.6365	0.1580	0.6014	0.6290
(SE)	*(0.52)*	*(0.52)*	*(0.50)*	*(0.60)*	*(0.51)*
Loan loss reserves$_{t-1}$ / gross loan$_{t-1}$	-0.3488	-0.3156	-0.215	-0.2810	-0.3479
(SE)	*(0.28)*	*(0.26)*	*(0.25)*	*(0.25)*	*(0.28)*
Log Assets$_{t-1}$	-5.4221	-5.7526	-4.0793	-6.9389	-5.4749
(SE)	*(5.17)*	*(5.20)*	*(4.97)*	*(5.69)*	*(5.10)*
Liquid assets$_{t-1}$ / total assets$_{t-1}$	0.0966	0.0925	0.1377	0.1005	0.0955
(SE)	*(0.11)*	*(0.11)*	*(0.12)*	*(0.11)*	*(0.11)*
GDP	0.2393**	0.2504**	0.2302**	0.2239*	0.2329**
(SE)	*(0.12)*	*(0.12)*	*(0.12)*	*(0.13)*	*(0.12)*
Inflation	-0.7517***	-0.7089***	-0.5236***	-0.6491***	-0.7497***
(SE)	*(0.18)*	*(0.18)*	*(0.19)*	*(0.18)*	*(0.18)*
Central Bank Lending Rate	-0.1686	-0.1203	-0.0739	-0.1161	-0.1689
(SE)	*(0.17)*	*(0.16)*	*(0.16)*	*(0.16)*	*(0.17)*
R^2	0.79	0.79	0.79	0.79	0.79
Bank fixed effects	Yes	Yes	Yes	Yes	Yes
Time fixed effects	No	No	No	No	No
Observations	432	436	438	438	432

The table reports the fixed effects regression estimates of panel equation (6.1, 6.2, and 6.3) for the determinants of gross loan growth on three lagged capital ratios, capital requirement, and capital surplus and control variables including macroeconomic variables. The dependent variable is the annual gross loan growth rate. Reported standard errors are given in parentheses. The standard errors are robust (heteroskedasticity-consistent) and clustered by time. For statistical significance, we use the following convention: *, **, and *** denote significance at the 10%, 5% and 1% levels, respectively.

Table A.5: Robustness Test with Net Charge-offs

	$T1CR_{t-1}$	TCR_{t-1}	E/A_{t-1}	$T1CRR_t$	SP_t
	1	*2*	*3*	*4*	*5*
Capital $ratios_{t-1}$	-0.2585	-0.2025	0.6903	-0.7103	-0.2572
(SE)	*(0.16)*	*(0.14)*	*(0.43)*	*(0.68)*	*(0.18)*
$\Delta\%Loan_{t-1}$	-0.2788***	0.2775***	-0.2454***	-0.2654***	-0.2776***
(SE)	*(0.07)*	*(0.07)*	*(0.07)*	*(0.07)*	*(0.07)*
Return on $assets_{t-1}$	1.2289**	1.2001**	0.8182	1.0848*	1.2361**
(SE)	*(0.61)*	*(0.59)*	*(0.55)*	*(0.57)*	*(0.61)*
Net charge $offs_{t-1}$	0.0886	0.0850	0.0775	0.0889	0.0887
(SE)	*(0.08)*	*(0.08)*	*(0.08)*	*(0.08)*	*(0.08)*
Log $Assets_{t-1}$	-10.5278*	-10.9833*	-9.5984	-10.6134*	-10.7708*
(SE)	*(6.20)*	*(6.23)*	*(6.29)*	*(6.35)*	*(6.19)*
Liquid $assets_{t-1}$ / total $assets_{t-1}$	0.0663	0.0767	0.1049	0.0718	0.0669
(SE)	*(0.10)*	*(0.10)*	*(0.10)*	*(0.10)*	*(0.10)*
R^2	0.80	0.80	0.80	0.80	0.80
Bank fixed effects	Yes	Yes	Yes	Yes	Yes
Time fixed effects	Yes	Yes	Yes	Yes	Yes
Observations	364	367	368	368	364

The table reports the fixed effects regression estimates of panel equations (6.1, 6.2, and 6.3) for the determinants of gross loan growth on three lagged capital ratios, capital requirement, and capital surplus and control variables including net charge offs. The dependent variable is the annual gross loan growth rate. Reported standard errors are given in parentheses. The standard errors are robust (heteroskedasticity-consistent) and clustered by time. For statistical significance, we use the following convention: *, **, and *** denote significance at the 10%, 5% and 1% levels, respectively.

Table A.6: Robustness Test with Net Charge Offs

	$T1CR_{t-1}$	TCR_{t-1}	E/A_{t-1}	CRR_t	SP_t
	1	*2*	*3*	*4*	*5*
Capital ratios$_{t-1}$	-0.0274	-0.1156	0.8839**	-0.3591	-0.0017
(SE)	*(0.21)*	*(0.17)*	*(0.43)*	*(0.72)*	*(0.23)*
Δ%Loan$_{t-1}$	-0.2667***	-0.2696***	-0.2327***	-0.2566***	-0.2655***
(SE)	*(0.06)*	*(0.06)*	*(0.06)*	*(0.06)*	*(0.06)*
Return on assets$_{t-1}$	0.8258*	0.8648*	0.4499	0.8141*	0.8172*
(SE)	*(0.45)*	*(0.45)*	*(0.43)*	*(0.45)*	*(0.46)*
Risk weights$_{t-1}$	0.1701	0.1318	0.1366	0.1496*	0.1780*
(SE)	*(0.10)*	*(0.10)*	*(0.09)*	*(0.09)*	*(0.10)*
Log Assets$_{t-1}$	-10.0358*	-10.8531**	-9.0541*	-10.6235*	-9.9055*
(SE)	*(5.59)*	*(5.49)*	*(5.53)*	*(5.56)*	*(5.65)*
Liquid assets$_{t-1}$ / total assets$_{t-1}$	0.1504	0.1514	0.2053*	0.1632	0.1517
(SE)	*(0.11)*	*(0.11)*	*(0.11)*	*(0.11)*	*(0.11)*
R^2	0.80	0.80	0.80	0.80	0.80
Bank fixed effects	Yes	Yes	Yes	Yes	Yes
Time fixed effects	Yes	Yes	Yes	Yes	Yes
Observations	430	434	435	435	430

The table reports the fixed effects regression estimates of panel equations (6.1, 6.2, and 6.3) for the determinants of gross loan growth on three lagged capital ratios, capital requirement, and capital surplus and control variables including risk weights. The dependent variable is the annual gross loan growth rate. Reported standard errors are given in parentheses. The standard errors are robust (heteroskedasticity-consistent) and clustered by time. For statistical significance, we use the following convention: *, **, and *** denote significance at the 10%, 5% and 1% levels, respectively.

Table A.7: Robustness Test with Delta Explanatory Variables

	$T1CR_{t-1}$	TCR_{t-1}	E/A_{t-1}	$T1CRR_t$	SP_t
	1	*2*	*3*	*4*	*5*
ΔCapital $ratios_{t-1}$	-0.0599	-0.1381	0.1559	-03569	-0.0797
(SE)	*(0.14)*	*(0.15)*	*(0.11)*	*(0.49)*	*(0.15)*
Δ%$Loan_{t-1}$	-0.2531***	-0.2613***	-0.2306***	-0.2368***	-0.2565***
(SE)	*(0.06)*	*(0.06)*	*(0.06)*	*(0.06)*	*(0.07)*
Return on $assets_{t-1}$	0.6195	0.7517	0.5165	0.7637	0.6304
(SE)	*(0.50)*	*(0.51)*	*(0.49)*	*(0.48)*	*(0.51)*
Loan loss $reserves_{t-1}$ / gross $loan_{t-1}$	-0.2017	-0.1373	-0.1500	-0.0991	-0.2075
(SE)	*(0.34)*	*(0.34)*	*(0.31)*	*(0.29)*	*(0.34)*
Log $Assets_{t-1}$	-13.9121**	-14.5085**	-14.8094**	-13.0221**	-13.6662**
(SE)	*(6.75)*	*(6.76)*	*(6.60)*	*(5.70)*	*(6.82)*
Liquid $assets_{t-1}$ / total $assets_{t-1}$	0.1246	0.1188	0.1495	0.1382	-0.20752
(SE)	*(0.11)*	*(0.34)*	*(0.11)*	*(0.11)*	*(0.34)*
R^2	0.80	0.80	0.80	0.80	0.80
Bank fixed effects	Yes	Yes	Yes	Yes	Yes
Time fixed effects	Yes	Yes	Yes	Yes	Yes
Observations	416	424	429	438	416

The table reports the fixed effects regression estimates of panel equation (6.1, 6.2, and 6.3) for the determinants of gross loan growth on changes in three lagged capital ratios, capital requirement, and capital surplus and control variables. The dependent variable is the annual gross loan growth rate. Reported standard errors are given in parentheses. The standard errors are robust (heteroskedasticity-consistent) and clustered by time. For statistical significance, we use the following convention: *, **, and *** denote significance at the 10%, 5% and 1% levels, respectively.