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Master's Thesis

The Consequences of Capital Shocks on US Bank Lending

Author: Maria Kogelnik, BSc

Supervisor: Univ.-Prof. Dr. Johann Scharler

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Declaration of Authorship

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"(. . .) I can't help smiling at complaints from bankers about their capital requirements, knowing that they have always imposed even stronger requirements on people in debt to them."

Nobel laureate Merton H. Miller

LEOPOLD-FRANZENS UNIVERSITÄT INNSBRUCK

Abstract

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by Maria Kogelnik, BSc

This thesis studies the effects that a capitalization shock has on the lending outcomes of US banks between 2005 and 2012. The Jordà [2005] local projection method is applied to estimate impulse response functions that capture the impact on loans following an innovation in the capital-to-assets ratio, which might originate from more restricted capital requirements and unexpected earnings during that time. Results suggest that an impulse of the capital variable of 1% leads to an immediate decline of bank lending of almost 1%, with smaller values of the estimated coefficients at longer horizons. Further, different samples of the panel are examined. For big banks in general as well as for banks during the recent financial crisis, an innovation of capitalization leads to an increase of lending, starting a year after the impulse. In contrast, hardly any impact is found for banks with a capital ratio above the 90^{th} percentile, suggesting that when banks are well capitalized, capital shocks do not result in significant changes of their lending.

JEL Categories: E5, G1, G2, O4, L2

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Chapter 1

Introduction

One of the major roles that banks have in our economic system is to grant credit. With the help of the lent money, long-term investments are made possible, and economic growth is enhanced. If banks cannot maintain their lending, however, borrowers may in turn not be able to invest. This may cause an economic downturn. A famous illustration of this negative dynamic is provided by Peek and Rosengren [2000]. They identify an external shock to the US credit market, caused by the Japanese banking crisis, and explain how the decline in lending damages economic activity in the United States.

Bank lending becomes especially important during crises, when investments are needed to boost the economy. However, in the short aftermath of the recent financial crisis, the loans granted by US banks declined drastically. Figure 1.1 shows the quarterly granted loans in their balance sheets from 2006 to 2012. Clearly, one can observe a strong decline in lending from the third quarter of 2008 onwards (marked in red).[1] The cummulated total loans decreased by about 20% during the third quarter of 2008 and the fourth quarter of 2012. Even sharper declines in lending are observed by Ivashina and Scharfstein [2010], who state that new loans to large borrowers fell by 47% during the peak period of the financial crisis (fourth quarter of 2008) relative to the prior quarter and by 79% relative to the peak of the credit boom (second quarter of 2007). What was driving these developments? What makes banks expand or restrict the loans they grant? Given that bank lending is so crucial for economic growth, it is in the best interest of policy makers to understand how it is determined.

In the literature, many factors that influence or correlate with lending are discussed, including monetary policy and macroeconomic factors as well as bank-individual factors such as a bank's size, liquidity and capitalization. The latter is probably the most

[1] Note that the absolute values of the y-axis can hardly be interpreted in a meaningful way, as only banks which reported constant and error-free data within the Call Reports were included to construct the figure. Section 3.1 further discussed the Call Reports data and the sample selection.

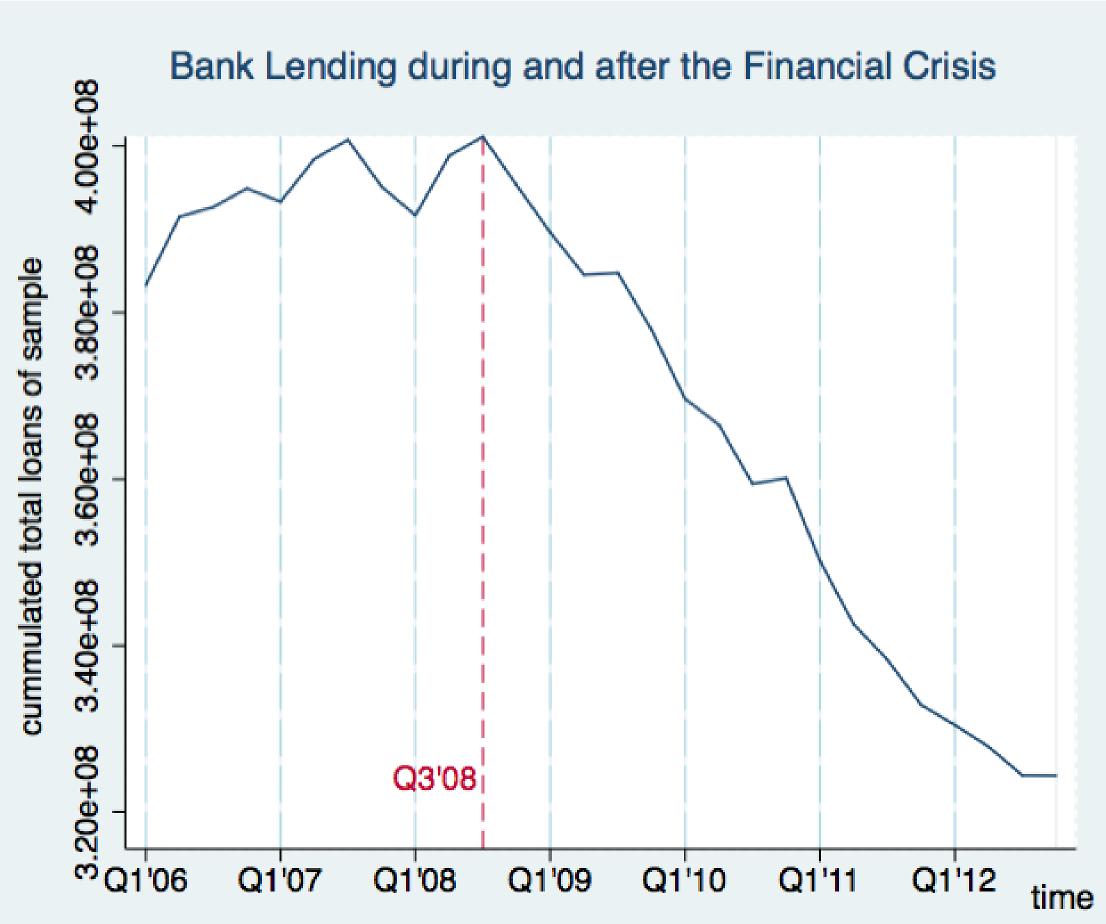

Figure 1.1: Quarterly (Q1.2006-Q4.2012) cummulated total loans of banks in the sample.

controversial one. On the one hand, it is argued that more capital would make banks safer, and that higher capitalized banks would be better able to maintain their lending rates in difficult times (cf. Admati and Hellwig [2014], Brunnermeier [2009], Martynova [2015]). Moreover, several empirical studies find a positive correlation of capital and lending (cf. Kapan and Minoiu [2014], Gambacorta and Marques-Ibanez [2011]). On the other hand, opponents of more capital warn that increasing banks' capital positions would be too expensive and would come at the expense of lending and thus economic growth (cf. *Financial Times*, [2011-03-31], *Süddeutsche Zeitung*, [2009-11-20]).

From an ex-ante perspective, it is not clear whether a higher capitalization would lead to increases in bank lending. On the one hand, one might argue that high capitalization is an indicator of a more risk-averse behavior in banks. Consequently, better capitalized banks might rather think twice before granting a credit - especially during times of crisis, which results in a decline of lending. On the other hand, one might argue that high capitalization might provide banks with the sufficient means to continue lending, also during recessions.

The thesis at hand contributes to the discussion in two ways: First, by critically evaluating the existing literature and the arguments that are being made for and against a better capitalization of banks. Capital requirements and their feasability are discussed, too. Second, and more importantly, by providing additional empirical insights about how capital affects bank lending, using impulse response functions to investigate which effects an innovation of capital has on lending. Specifically, an exogneous positive change in the capital ratio might be assumed due to changes in regulatory capital requirements and unexpected earnings. The empirical approach of this thesis uses the Jordà [2005] local projection method, which is applied on quarterly panel data, in particular on the Call Reports balance sheet entries of 2,824 US banks between 2005 and 2012.[2] In addition to discussing the results of a baseline model, using a similar approach as Romer and Romer [2015], different sample sets are examined within the empirical analysis. Doing so makes it possible to investigate whether lending reacts differently to capital shocks during financial crises. In addition, one can study whether the effects vary if the banks in the sample are bigger, better capitalized, or more liquid.

To anticipate the main findings of this thesis, a positive innovation to the capital variable leads to an immediate negative response of the lending variable throughout all examined specifications and samples. This is consistent with the findings of similar studies, for instance Aiyar et al. [2014], Bridges et al. [2014] and Hancock et al. [1995]. However, at longer horizons, the response of the lending variable differs significantly depending on the what specification and sample is investigated. In particular, positive responses of lending are observed for samples during the crisis and big banks in terms of total assets. On the contrary, hardly any effects can be identified for banks with a high initial capital ratio. This suggests that banks do not adjust their lending as much after a capital shock when they are well capitalized.

The remainder of this thesis is structured as follows: First, the literature review in Section 2 gives an overview about the role of banks' capitalization and explains why banks might have incentives to take on more debt than other corporations. Further, advantages as well as undesireable consequences of more capital are discussed, with a particular focus on capital requirements and their effects on bank lending. After that, Section 3 includes the empirical analysis, which seeks to investigate in how far capital shocks matter for lending outcomes. In addition to exploring a baseline model and its implications, several different subsamples of the data are examined. In Section 4, the empirical approach and the findings are further discussed. Finally, Section 5 concludes.

[2] The data and sample selection are explained in detail in Section 3.1.

Chapter 2

Literature Review and Theoretical Considerations

This section reviews the literature on banks' capitalization, and introduces some important considerations concerning its relation with bank lending. This builds a fundament for the empirical anaylsis of this thesis. It is examined why US banks generally have incentives to choose low capital positions in their funding mix, and whether more capital would have undesirable consequences, in particular declines in lending. After that, ways to increase capital are illustrated.

2.1 Why Banks' Capitalization matters

It is attributed to the Chinese philosopher Confucius that before having an argument, the terms should be defined. The term *capital* is often used in multiple contexts. Confusing it with other concepts makes some arguments appear to be valid although they are not. In banking language, capital means *equity*, and refers to the money a bank has received from its owners or shareholders, which is to be distinguished from the money a bank has borrowed, called *liabilities*. This money might come from other banks as well as private and public lenders. In this thesis, *borrowing* refers to the money that a bank owes to somebody else, whereas *lending* refers to the money somebody else owes to a bank. Taken together, a bank's capital and liabilities equal its total assets. Hence, the *capital ratio* is the ratio of capital to total assets. Another relevant term is *leverage*, which refers to the ratio of liabilities to capital. In other words, high leverage is identical with low capital positions, as the sum of the leverage ratio and the capital ratio has to equal 1. Unless indicated otherwise, the term capital in this thesis does *not* refer to core capital, also known as Tier 1, as these terms take into account risk-weighted assets and hence cannot be used objectively. The term *capitalization* refers to the height of the capital ratio within this thesis. Similarly, a "better" capitalization/capital positions means that banks have a higher capital-to-assets ratio.

Recently, banks' capital ratios have gained lots of attention in both the public debate and the economic literature. Capital requirements are discussed frequently, too. So why does banks' capitalization matter? And why do capital ratios play a crucial role in times of crises?

One of the main functions that banks are supposed to perform is to grant credit. Banks with higher capital positions might be better at doing so. It is argued that they may find it easier to raise money during crises, which enables them to maintain their loan growth rates during unstable times (Gambacorta and Marques-Ibanez [2011], Kapan and Minoiu [2014]). This is an important consideration: Especially during uncertain times, investments are needed to enhance economic growth. The realization of most investments depends on the availability of credits. Now if capitalization had a positive impact on lending, this would be a strong argument in favor of policies that aim at increasing banks' capital ratios. However, the validity of this *lending argument* is not at all trivial. More on that later.

Another reason why capital matters is that it is considered to make banks *safer*. Better capitalized banks are regarded to be less fragile and more capable of absorbing losses in times of crises (Brunnermeier [2009], Admati and Hellwig [2014], Martynova [2015]). Why is this *safety argument* important for lending considerations? First, it makes sense to assume that a highly indebted, struggling bank will have to cut back on lending at some point. Moreover, safety matters as it will most likely be taxpayers' money to pay for banks' errors if they should fail. These issues will be examined carefully in what follows.

2.1.1 US Banks' Capitalization and Incentives - an Overview

In general, US banks have poor capital-to-asset ratios. In recent years, their debt accounted for almost more than 90% of their assets. For many European banks, this fraction even exceeds 97%.[1] This number is especially surprising when comparing it to other profit-oriented corporations: The vast majority of non-financial US corporations have equity levels of more than 50% [Admati and Hellwig, 2014]. It is not intuitive why banks choose a much higher leverage ratio in their funding mix. Like other corporations, banks are considered to have clear incentives to reduce their leverage in order to keep

[1] See http://data.worldbank.org/indicator/FB.BNK.CAPA.ZS/countries for details. Checked on May 18, 2015.

funding costs low [Berger and Udell, 1994]. What is more, better capitalized banks appear to be more *successful*. Demirguc-Kunt et al. [2013] study banks from economically advanced countries during the financial crisis, and find that banks with more capital experienced higher stock returns. This finding also seems to hold when taking into account a longer time horizon. Baker and Wurgler [2013] study US banks over the last decades, and likewise conclude that banks with more capital experienced higher stock returns. Moreover, Berger and Bouwman [2013] stress that capital helps small banks to increase their probability of survival and market share during crises as well as "normal" times. As for medium and large banks, they observe that capital enhances their performance primarily during banking crises. In addition, Miles et al. [2013] introduce a model to study what amount of capital would be desirable from a bank's perspective, and conclude that banks would be better off if they had a much higher capital-to-asset ratio than they have had in recent years.

Summing up, more capital is associated with lower funding costs, a better stock performance and a higher market share. And according to Miles et al. [2013], even theory suggests that it is desirable for banks to have more capital. But as a matter of fact, most banks are highly indebted and prefer low capital positions in their funding mix. What can explain this behavior?

To understand what motivates banks to keep their leverage high, it is worthwhile to take a look at the incentives and borrowing conditions they face. An obvious supposition would be that banks might be able to borrow at more favorable terms than other institutions. Hence, taking on debt might be more attractive for them. But why should creditors let banks borrow at more favorable terms? In the light of the recent crisis, low default risks do not sound like a plausible explanation. However, according to Admati and Hellwig [2014], banks and their creditors benefit from implicit and explicit government guarantees. Given that depositors are protected by deposit insurance, and governments are likely to bailout banks if they go bankrupt, they argue that banks are facing relatively low interest rates when indebting themselves. The authors point out that when it comes down to it, taxpayers would pay for the banks' errors. From a creditor's perspectives, this reduces the risk of default, and they are willing to let banks borrow at more favorable terms. As a result, banks have incentives to borrow excessively and take additional risks.[2] What further contributes to the problem is that banks have incentives to grow and merge because they aim to reach a "too big to fail" status (Demirguc-Kunt et al. [2013], Meltzer [2012], Gambacorta and Marques-Ibanez [2011]). These arguments are all built on the assumption that creditors expect governments to

[2]Note that the relationship between capital and risk-taking is not trivial. Calem and Rob [1999] observe a U-shaped relationship, meaning that as a bank's capital increases it first takes less risk, then more risk. However, if banks are well capitalized, their risk-taking will mostly affect themselves, not third parties such as taxpayers.

step in to bailout banks in case they cannot pay back their debt. But is that a realistic assumption?

In fact, government bailouts have been forbidded by US law. The Dodd-Frank Act, which was signed by president Obama on July 21, 2010, forbids government bailouts in the United States. “The American people will never again be asked to foot the bill for Wall Street’s mistakes,” Mr. Obama said. “There will be no more taxpayer-funded bailouts. Period.”[*Wall Street Journal*,, 2010-07-21]. Still, the question whether bailout scenarios are realistic remains. The act, which gives more authority to the FCIC (Financial Crisis Inquiry Commission) to resolve financial institutions without tax money, is heavily critizised by Admati and Hellwig [2014]. They stress that although the FCIC should be self-financing, it is guaranteed by taxpayers. When it comes down to it, they argue, taxpayers would have to step in to support the FCIC. Furthermore, they point out that such a law may be changed again quickly, especially in times of crisis. Now if the possibility of future bailouts cannot be fully eliminated, one might argue, why not change the incentives for bankers such that they will try to avoid this scenario by all means? Requiring banks to have higher capital ratios might be one way to do so. Alternatively, Martin Jacomb, former chariman of the international financial services group Prudential, suggests that when a bank gets into trouble, the whole board should be removed without compensation and “a new regime would click into place”, but also mentions that he does not expect this to happen [*Financial Times*,, 2011-04-10*a*].

All in all, because of implicit and explicit governmental guarantees, banks have incentives to take on more debt than they would otherwise. Bad capitalization makes banks more vulnerable in times of crisis, as it reduces their ability to absorb losses with their own ressources. This is problematic as it encourages risk-taking and excessive borrowing. Consequently, as low-capitalized banks are more likely to struggle and might rather need governmental help, they impose negative externalities on society. It seems as if in the event of bank failures, governments could only choose between letting a major institition fail and put up with expensive bank runs, or committing to an expensive bailout.

This line of reasoning suggests that it would be socially desirable to have better capitalized banks. Consequently, it supports policies that aim at increasing bank capital - for instance in the form of capital requirements or taxes on leverage. However, to conclude whether more capital would be socially desirable, banks’ costs and benefits have to be considered, too. In addition, it is crucial to understand if more capital might contradict with other services that banks should provide, such as lending. These issues shall be examined in the following section. After that, the empirical part of this thesis focuses entirely on the question how bank lending would be affected as banks increase their capital ratios.

2.1.2 Undesirable Consequences of more Capital

In the defence of low capital ratios, a number of pro-leverage arguments are put forward, mainly from bankers. It is argued that having more capital would have undesirable consequences. More capital is considered to be *too expensive* and that banks would have to pass on the additional costs. Moreover, it is warned that more capital would *restrict lending* and consequently *reduce economic growth*. Above all, taking a closer look at the lending argument is crucial for the research question of this thesis. In what follows, arguments that oppose a better capitalization of banks and their validity are examined carefully.

Concern 1: More capital is too expensive.

Needless to say, when talking about overall economic (social) costs, costs for banks have to be considered likewise. Although theory predicts that reducing banks' leverage would reduce the cost and risk of their equity [Baker and Wurgler, 2013], opponents of higher capital requirements warn that more capital would be too expensive for banks. Why is that? Martin Jacomb, a former chairman of the financial services institution Prudential, writes that too much capital damages banks' profitability such that they would have to increase their prices for lending. He argues that banks would consequently lose business to non-bank sources of finance, and warns of a growing unregulated and potentially dangerous parallel banking system [*Financial Times*,, 2011-04-10*a*]. However, he does not make a clear point about what dangers he is referring to exactly.

To clarify why banks consider capital as expensive, it is worthwhile to take a short side glance at the expectations that investors have when they provide capital to banks. It is reasonable to assume that investors are interested in high returns to equity (ROE). These are calculated by dividing a bank's profit by its capital, and the number obviously gets higher as capital gets lower. It is criticized that banks therefore have incentives to keep their capital low in order to offer higher ROE rates to their investors [*Süddeutsche Zeitung*,, 2010-05-17]. Opponents of more capital argue that to keep ROEs at a competitive level, a higher division of profits would be necessary. With everything else equal, this would lead to higher costs for banks.

But does it make sense to expect that investors would always require the same ROE, independently of banks' capital? Admati et al. [2013] consider it incorrect to assume that the required ROE remains fixed as capital increases. They argue that ROE contains a risk premium that must go down if banks have more equity. As capital increases, shareholders' risk is reduced. Consequently, they stress that investors will require a lower

ROE when providing capital to a better capitalized bank. The authors conclude that higher capital ratios of banks would not be socially expensive, and that high leverage is not necessary for banks to perform all their socially valuable functions, including lending, deposit taking and issuing money-like securities. In the face of this reasoning, the argument that more capital would be too expensive appears weak.

Concern 2: More capital reduces lending and economic growth.

The other argument against more capital is the concern that it might lead banks to reduce their lending. Consequently, as loans are important to realize investments, more capital would come at the expense of economic growth. Jamie Dimon, chief executive of JPMorgan Chase, warned that requiring banks to have more capital would result in a competitive disadvantage for the US economy and affect growth negatively [*Financial Times*,, 2011-03-31]. Likewise, Josef Ackermann, then CEO of Deutsche Bank, warned that capital requirements would restrict banks' lending abilities. He acknowledged that more capital might make banks safer, but warned from weakening consequences for the economy and reduced wealth effects for all [*Süddeutsche Zeitung*,, 2009-11-20].

With regard to economic growth, Admati and Hellwig [2014] criticize that the mentioned anti-capital arguments do not take into account how financial instability and turmoil affect growth. (Probably not much, argue Romer and Romer [2015]. Very negatively, argue Cecchetti et al. [2009].)

But for the growth argument to be discussed further, the presumption that more capital would restrict lending has to be examined. When taking a closer look at the line of reasoning behind it, it does not appear to be valid. Capital requirements, unlike liquidity requirements, do not restrict the money that banks can reinvest into the economy. Capital is nothing that banks have to hold back physically - it simply changes their funding mix on the liabilities side. What is more, a number of empirical studies (Kapan and Minoiu [2014], Gambacorta and Marques-Ibanez [2011]) find a positive correlation between capital and lending. They observe that banks with weaker capital positions restrict their loan supply more in times of crisis. In addition, Admati and Hellwig [2014] use theoretical considerations to argue that poor capitalization made banks cut back sharply on their lending during the recent crisis. Whether this holds empirically will be further examined in Section 3.

However, there might be circumstances under which more capital actually restricts bank lending. Let us consider a scenario in which an increase in the market interest rate encounters capital requirements. Gambacorta and Mistrulli [2004] explain the mechanism of a so-called credit channel, which supports the idea that capital requirements might restrict bank lending. They describe the mechanism as follows: Banks are typically subject to maturity transformation - meaning that they normally finance short-term assets with long-term liabilities. Now if the market interest rates increase, banks' assets adjust slower than their liabilities, and they make losses because of the maturity mismatch. This reduces banks' profits and then capital. As the market's interest rates are high in this scenario, other investment options become relatively more attractive for a bank's potential investors. Therefore, competing by issuing new shares might be too costly for banks. Consequently, they reduce their lending, as they would not be able to meet the imposed capital requirements otherwise.

What contributes to the controversy in the discussion are empirical problems and the questionable transparency of available data. Gambacorta and Marques-Ibanez [2011] stress that when estimating the effect of a capital coefficient on lending, it has an unexpected negative sign. As a possible explanation, they suggest that bank data often lack transparency. They state that accounting practices have blurred the informative power of the capital-to-asset ratio. According to them, many of the risks have not been captured adequately on banks' books during the financial crisis. This raises questions about the analytical value of many recent studies.

Apart from data issues, it is also conceivable that capitalization in fact did not have a strong influence on lending decisions during the recent crisis. It might be the case that lending was not reduced because of an inability of banks to keep granting credit, but because they decided to do so on purpose. Granting a loan normally involves a long-term commitment that cannot be reversed easily. This may induce banks to follow a wait-and-see strategy leading to a restricted supply of loans in times of high uncertainty [Raunig et al., 2014].

There are many more questions that play a role when discussing the relation of lending and capitalization. What we know is that lending decreased sharply during the recent financial crisis, see Figure 1.1. In order to find a good explanation, one approach would be to not only consider the supply side - banks - but also the demand side - the lenders. It might be conceivable that banks were lending less simply because demand declined during the crisis, an issue that is also studied by Aiyar et al. [2014].

The preceding discussion illustrates that the literatue about how capital influences lending is highly controversial. It is not clear what impact capitalization has on lending (and consequently on growth). The empirical part of this thesis aims to contribute to a better understanding of this issue. However, although the lending effects have to be studied further, the view that more capital would make banks safer is widely accepted. A higher capitalization of banks is considered to be socially desirable. That being said, the question arises of what might lead banks to increase their capital positions.

2.2 Ways to increase Bank Capital

This section is divided into two parts. First, policies that aim at increasing capital are discussed. The focus will lie on the Basel III capital requirements and critiques. Second, an overview is given about how banks could realistically raise their capital positions. This is important because any policy will be meaningless if banks are not capable of reducing the leverage in their funding mix.

There are basically three options for policy makers to make banks increase their capital: First, legislation might forbid governmental bailouts. As discussed before, the enforcement of such a law might not be realistic. Second, taxes and subsidies might correct for negative externalities and encourage a better capitalization. Interestingly, this approach has not gained much attention in the literature yet. Finally, a third option is to impose capital requirements. An attempt to do so are the so-called Basel Accords. The most recent one, called Basel III, will be discussed in the next section.

Minimum Capital Requirements - Basel III

The Basel Accords are an international agreement, worked out and negotiated by the BCBS (Basel Committee on Banking Supervision). The BCBS consists of a body of supervisors from several countries and seeks to enhance financial stability by strengthening the regulation, supervision and practices of banks. In how far the committee's recommendations are then put into law is in the competence of each country.[3] Basel III requires banks to have capital positions that equal at least 7% of their risk-weighted assets. The 7% consist of a minimum capital ratio of 4.5% (which was only 2% under Basel II), and a so-called "capital conservation" buffer of an additional 2.5%. Furthermore, it includes a countercyclical buffer of up to 2.5%, which is at the discretion of country supervisors.[4] Basel III was elaborated in 2010/11, and has a phase-in between the beginning of 2013 and the end of 2018.[5].

This long transition period has been critizised by Philipp Hildebrand, former chairman of the Swiss National Bank, and Lee Sachs, a CEO of Alliance Partners and former

[3]See http://www.bis.org/bcbs/charter.htm for details. Accessed on May 6, 2015.
[4]See http://www.bis.org/publ/bcbs189.pdf for details. Accessed on May 6, 2015.
[5]See ftalphaville.ft.com/2012/10/24/1225821/and-now-for-some-basel-3-inspired-deleveraging/ for details. Accessed on May 10, 2015.

counsellor to the US Treasury secretary, among others. They argue that there is no good reason to wait several years to address the banking system's weaknesses, and warn of many more years of weak growth [*Financial Times*,, 2012-09-24].

Apart from the long transition period, the capital requirements under Basel III are considered as far *too low* by many authors. Peter Boone, an associate at the LSE's Center for Economic Performance, and Simon Johnson, a former chief economist at the IMF, point out that the Basel III capital requirements are not higher than the capital levels that Lehman reported the day before they failed [*Financial Times*,, 2011-04-10*b*]. This fact could be construed as an argument against capital requirements, as the required capital levels do not prevent banks from failing. However, one might as well argue that the Basel III capital requirements were set too low. Higher requirements might effectively reduce the safety problems banks are facing. This view is taken by a number of authors: Daniel Tarullo, who was then overseeing regulation for the Fed, argues in favor of higher capital requirements "above and beyond the levels agreed by (...) the Basel III deal" [*Financial Times*,, 2013-05-03]. As a reference point, economist Andreas Oehler [*Süddeutsche Zeitung*,, 2010-05-17] and Admati and Hellwig [2014] stress that a capitalization above 25%, or even 30%, respectiveley, would be socially desirable.

Furthermore, the grounds on which Basel III defines risk are questionable. As the suggested 7% capital requirement refers to risk-weighted assets, much will depend on how risk is calculated. Default risks have to be determined, and doing so is open to dispute. For instance, treasury bonds are commonly presumed not to default under any circumstances. Taking this for granted is highly questionable, especially with regard to the recent occurances in Greece. Moreover, Admati and Hellwig [2014] stress that Basel III is based on quantitative risk model and stress tests which can easily be manipulated.

All these considerations and points of critique raise the question of why capital requirements were not set much higher in the last Basel Accord. After all, what improvement is to be expected if capital requirements are set at a level that most banks already have? (Recall that Lehman Brothers failed with a reported capital ratio that was higher than requested under Basel III.) Lobbying might play an important role here. According to the Center for Responsive Politics in Washington, the finance industry more than doubled spending on lobbyists between 2000 and 2010, reaching $474 million in 2010. Since 1998, they spent a total of more than $4.5 billion, which exceeds the lobbying expenses of any other industry in the United States [*Financial Times*,, 2011-06-19]. But even if capital requirements were higher, the question arises whether banks would have the means to meet them.

How Banks can increase their Capital

It is claimed that many banks might not be able to raise new capital on the market. So what would happen if banks were struggling to fulfill the new requirements? There are several thinkable options, but concerns are made that when banks are struggling to find new investors, they would have to apply for governmental assistance [*Süddeutsche Zeitung*,, 2010-09-14]. In fact, the US Treasury pledged that any bank that did not raise sufficient private capital would instead receive the capital via investments by the US government [*Financial Times*,, 2012-09-24]. This suggests that capital requirements might induce a scenario that needs governmental intervention, without really solving the safety concern. However, what has been observed so far is that all banks were able to meet the new standards entirely from private sources [*Financial Times*,, 2012-09-24]. After all, attracting additional investors is not the only way banks can increase their capital. Admati and Hellwig [2014] mention that they can as well raise it internally, by retaining and reinvesting their profits. The authors further state that banks also have access to the "normal investor community" such a mutual funds, pension funds, and individual investors.

Chapter 3

Empirical Analysis

3.1 The Data

For the empirical analysis, quarterly income statements and bank balance sheet data from the Consolidated Reports of Condition and Income are used, also known as *Call Reports*. The clear advantage of using the Call Reports is that they provide an almost comprehensive survey of banks operating in the United States. Each quarter, banks are required to report the data to the Federal Financial Institutions Examination Council (FFIEC).[1] The data are then made available to the public by the Federal Reserve Bank of Chicago.[2] Due to the complexity of the panel, editing the data involves several challenges. Den Haan et al. [2002] provide a data manual in which they discuss the construction of the data set, and stress that constructing consistent time series is difficult given that the banking sector evolves and regulations change. Consequently, the reported variables and their measurement also change. Further, Gambacorta and Marques-Ibanez [2011] question the transparency of the available data. To address these issues, the data set at hand was adjusted; For instance, observations with unrealistic capital or liquidity ratios (below 0% or above 100%) as well as extreme outliers were excluded. In addition, only banks which were reporting their balance sheet data during the whole period of interest were included. As a further restriction, only those observations that included operations at the federal level were kept. For instance, if a bank would have been lending to international credit issuers exclusively, this observation would have been dropped. Moreover, banks that merged during the considered periods were not included in the analysis. All these adjustions lead to a balanced panel data set with a population of 2,824 US banks, with quarterly observations between the first quarter of 2005 and the

[1] See http://www.investopedia.com/terms/c/callreport.asp for details. Last checked on May 22, 2015.

[2] The data can be publicly accessed on the following website: http://www.federalreserve.gov/apps/mdrm/data-dictionary.

last quarter of 2012. This sample selection largely follows Demirguc-Kunt et al. [2013]. Periods before 2005 are not considered, as the focus of this investigation lies on the development of loan growth rates in quarters shortly preceding the financial crisis and the following periods. The following variables contain the most important information for the analysis:

- Bank Lending (Total Loans in Logs)
  The variable of main interest is the total loans in banks' balance sheets. For the analysis at hand, only loans that are granted on the federal level are included.

- Capital Ratio (in Percent)
  The capital variable is constructed as the capital-to-assets ratio. It represents the proportion of banks' total equity to total assets. Again, only values that refer to the federal level are considered.

- Liquidity Ratio (in Percent)
  This variable represents the share of a bank's liquid assets to its total assets on the federal level. Many studies in the literature focus on examining the relation between liquidity and lending. Cornett et al. [2011], for instance, find that banks with more illiquid assets on their balance sheets increased asset liquidity and reduced lending during the financial crisis.

- Total Deposits (in Logs)
  This variable represents total deposits from national creditors that a bank has in its balance sheets. With regard to the literature, Ivashina and Scharfstein [2010] observe that those banks which had better access to deposit financing cut their lending less during the financial crisis.

3.2 The Method

To estimate the behavior of lending following an impulse in capital, the local projection method of Jordà [2005] is used. The Jordà method runs separate sequential OLS regressions for lending at various horizons starting at time $t + i$ for the capital variable and at time t for the control variables. This means that the dependent variable (here lending) is shifted several steps ahead. In fact, for the underlying code, the lending variable is not shifted ahead, but lags of the dependent variables are used. Mathematically, this means that the estimated model remains unchanged, however the examined sample is slightly different.

The central idea of Jordà's method is that local projections are estimated at each period of interest. This approach has several advantages: Apart from the fact that local projections can be applied using simple regression techniques, a strong advantage of them is that the estimations are more robust to misspecification. This is because contrary to conventional estimation methods of impulse response functions, such as the vector auto regression (VAR), the projections of Jordà's method are *local* for each forecast horizon. By calculating the coefficient estimates for the various horizons, a nonparametric estimate of the impulse response function can be obtained. In addition (although less relevant for this thesis), joint or point-wise analytic inference is simple, and they can easily be applied to experiment with highly unlinear and flexible specifications that may be impractical in a multivariate context [Jordà, 2005].

The implementation strategy of Jordà's method and the structure of the following analysis largely follows Romer and Romer [2015]. First, a baseline model is estimated. After that, the obtained empirical results are discussed with special regard to serial correlation issues, endogeneity, and robustness. Finally, different samples are examined.

3.3 Model Specification

As a baseline specification, the case where capital is not affected by bank lending contemporaneously is considered. However, lending may be affected by a bank's capital-to-assets ratio within the period. This makes sense since in the short run, banks may find it easier to restrict their lending than to increase their capital. If capital restrictions such as Basel III apply, one could hence assume that capital might affect lending within the period, but probably not vice versa. Whether this assumption is valid will be discussed later in this section. To shortly anticipate the findings, this baseline timing assumption appears to be robust.

In particular, the following baseline specification is estimated:

$$\begin{aligned} log(y_{j,t+i}) \quad = \quad & \alpha_j^i + \gamma_t^i + \beta^i C_{j,t} + \sum_{k=1}^{4} \varphi_k^i C_{j,t-k} + \sum_{k=1}^{4} \theta_k^i log(y_{j,t-k}) \\ & + \sum_{k=1}^{4} \phi_k^i liq_{j,t-k} + \sum_{k=1}^{4} \rho_k^i log(dep_{j,t-k}) + \epsilon_{j,t}^i, \end{aligned} \tag{3.1}$$

where the j subscripts index banks, and t subscripts index time, and the i superscripts denote the horizon (quarters after time t) being considered. $y_{j,t+i}$ stands for the total loans in the balance sheets of bank j at time $t+i$. $C_{j,t}$ is the capital-to-assets ratio for bank j at time t. Likewise, $liq_{j,t}$ denotes the liquidity-to-assets ratio for bank j at time t. Further, $dep_{j,t}$ denotes the total deposits of bank j at time t. Four lags (the k's) are included for the variables that capture total lending, the capital ratio, the liquidity ratio as well as the total deposits variable. The model also includes fixed effects for banks and time.[3] The bank fixed effects (the α's) control for unobserved heterogenity at the bank level. In other words, they capture the fact that normal lending behavior may differ among banks. This might be due to bank-internal politics, a bank's size, the regions a bank operates in or the clients / business fields they are specialized in - just to name a few examples. Similarly, the time fixed effects (the γ's) control for economic developments facing all banks within one period, such as macroeconomic and demand-side effects that are common to all banks at a given point of time. For instance, if lending was low due to weak demand in a particular period, this would be captured by the time fixed effects by taking a lower value in that period. Controlling for these effects that change over time might be especially important, recalling that the data for the analysis at hand includes the recent crisis.

Equation 3.1 is estimated for values of i from 0 to 20 quarters. In other words, five years after time t are considered. The sequence of coefficients on the capital ratio variable at time t shows how bank lending behaves in response to an innovation in the capital variable of 1.

Next, the results that are obtained with this baseline model are discussed, and issues such as autocorrelation, endogeneity and robustness are examined carefully.

3.4 Examining the Results under the Baseline Specification

Figure 3.1 shows the impulse response functions of the lending series estimated over the full sample of 2,824 banks, and the shaded area around it represents the area of the 95% confidence interval around the estimate.[4] The immediate response of bank lending to an impulse to the capital-to-assets ratio variable is significantly negative, explicitely -0.93% (t-value -31.65). The absolute values of the estimated coefficients then keep declining in the subsequent periods. During almost all horizons considered, the response of bank lending stays negative, but never hits a lower value than at the time of the impulse. The response hits the zero line and becomes positive twice - in quarter 9 and quarter

[3] A fixed effects specification is preferred to random effects, as random effects would require that there is no correlation among explanatory variables, which cannot be expluded here.

[4] The same graphical illustration applies to all other graphs used within this thesis, although it might not always be pointed out explicetely. The colors of the impulse response functions and the confidence areas around them vary in each section, for the purpose of a clear overview.

11 after the impulse. However, the coefficient in period 9 (+0.14%) is not statistically significant from zero at the 5% level (t-value 1.74), although it is significant at the 10% level. In period 11, the coefficient of +0.17% is statistically significant (t-value 2.07). But when facing the big picture, it will be hard to argue that an impulse of capital might lead to a positive response of bank lending.[5] What these first results suggest is that an impulse in the capital-to-assets ratio variable has an immediate negative impact of about -1% on bank lending. This effect then weakens in the following periods, and the impulse response function first hits the zero line in quarter 9. There is no clear positive effect at longer horizons, even if the response gets significantly positive in quarter 11. Starting in period 14, so $3\frac{1}{2}$ years after the impulse, the response of the lending variable gets significantly negative again, with a slight increase of the confidence error bands at longer horizons.

Summing up, an impulse to the capital ratio variable of 1% leads to an immediate response of lending of almost -1%, and the response is persistent. The effects become smaller in the following quarters, but the response of lending is still significantly negative five years after the impulse.

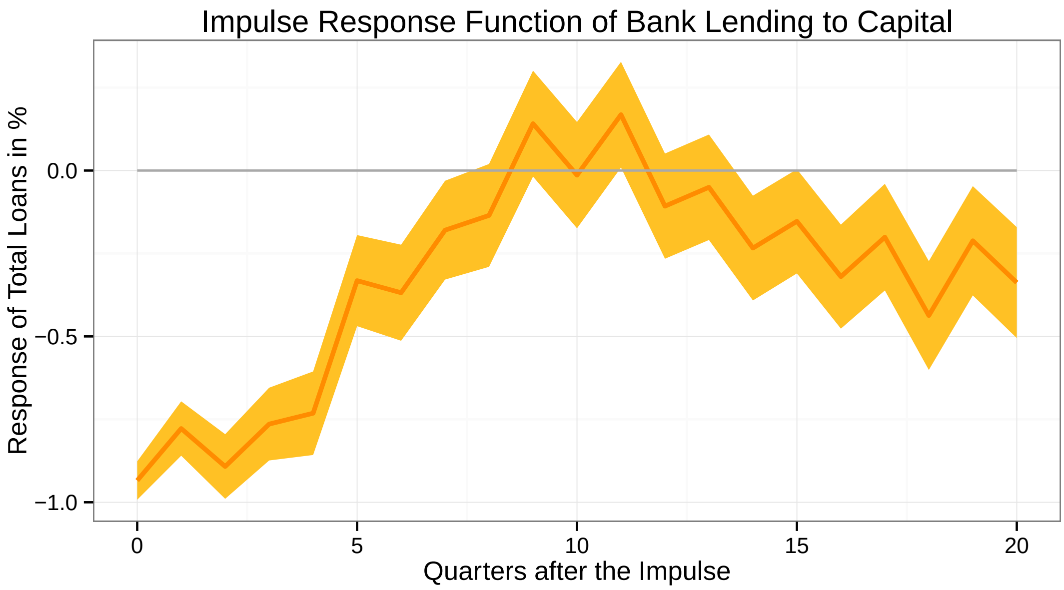

FIGURE 3.1: IRF of the Baseline Specification of the Model (Equation 3.1).

With regard to the empirical literature, these first results are not very surprising. Similar studies mostly focus on the effects of increases of capital requirements, that lead banks

[5]Note, however, that I also tried a specification where the response of bank lending was represented in total dollar values instead of logs. In that case, the estimated coefficients of quarters 9-11 were significantly positive at the 5% level, and the coefficients of quarters 8 and 12 were significantly positive at the 10% level.

to increase their capital ratios, and findings show that bank lending responds negatively in the time following these changes (Aiyar et al. [2014], Bridges et al. [2014]). Further, Hancock et al. [1995] investigate responses of bank lending (among several categories) to shocks in the capital ratio, and state that it took most loan categories two to three years to adjust to the higher capitalization and reach their initial lending level again.

One could criticize, however, that the local projection approach to estimating the impulse response function for bank lending does not provide any information about how the capital variable evolves and is determined over time. What if there was high autocorrelation within the capital variable? This would weaken the informative content of the impulse response function estimated under Equation 3.1. Therefore, let us take a closer look at the persistence of the capital variable and the issue of possible autocorrelation.

3.4.1 Autocorrelation & Persistence of Capital

Let us consider the response of the capital-to-assets variable to itself. If there was strong serial correlation in capitalization, one could argue that some of the near-time persistence in the impact that capital has on lending might in fact be due to persistence in the capital ratio itself. How can this be examined? One approach that is suggested by Romer and Romer [2015] is to estimate Equation 3.1 again, but this time the left-hand-side variable is replaced with $C_{j,t+i}$, the capital ratio at $t+i$.

Recall the baseline assumption of Equation 3.1 that lending does not affect capital within the same period. This approach is applied analogously on estimating the response of the capital-to-assets ratio to itself. Now, the following equation is estimated for horizons from 1 to 20 quarters after time t:

$$\begin{aligned} C_{j,t+i} &= \alpha_j^i + \gamma_t^i + \beta^i C_{j,t} + \sum_{k=1}^{4} \varphi_k^i C_{j,t-k} + \sum_{k=1}^{4} \theta_k^i log(y_{j,t-k}) \\ &\quad + \sum_{k=1}^{4} \phi_k^i liq_{j,t-k} + \sum_{k=1}^{4} \rho_k^i log(dep_{j,t-k}) + \epsilon_{j,t}^i, \end{aligned} \tag{3.2}$$

Figure 3.2 shows the smoothed impulse response function of capital to itself, estimated over the full sample of 2,824 banks. The graph shows the smoothed curve of the impulse response function, as what matters here is to see after how many quarters the effect that an impulse of capital has to itself is gone.[6] The figure shows that there is important

[6]Smoothing in this case means that the graph is only allowed to take a bi-polynomial form. This appears to be a natural approach here, as the variation among the estimates is small, and the only question of particular interest is when the zero line is reached. Note that none of the relevant points of the graph would change if smoothing was not applied.

serial correlation in the capital ratio variable, at least during the first 10 quarters. An impulse of 1 is followed by a value greater than 0.75 a quarter later, and falls steadily for the sequential quarters. It takes more than $2\frac{1}{2}$ years after the impulse that the effect of the capital ratio on itself is gone. After the tenth quarter, it looks as if the curve was going up again, but in fact, the grey 95% confidence bands include the zero line from that quartal onwards. Put differently, the impact that an impulse of the capital variable has on itselft vanished after the first $2\frac{1}{2}$ years, as it is no longer statistically different from zero.

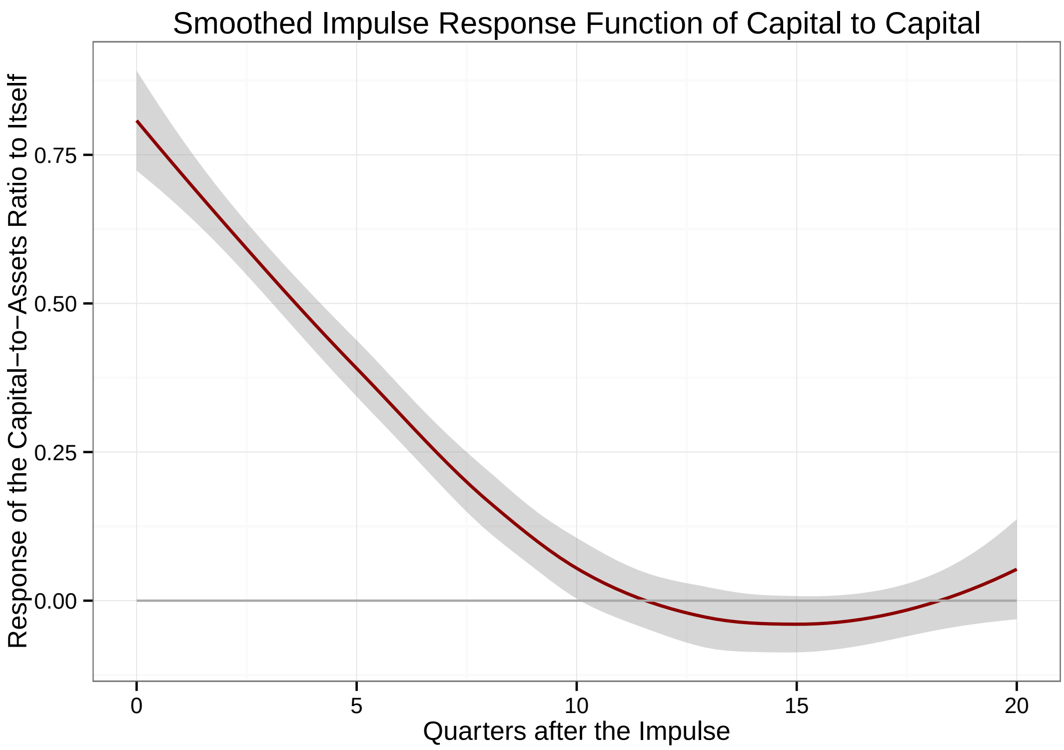

Figure 3.2: Smoothed IRF of the Capital Variable to Itself

Why does this matter? Given the fact that there is substantial autocorrelation in the capital variable, one might conclude that some of the near-term impact that capital has on bank lending is actually due to persistence of capitalization itself. Hence, it is conceivable that the impact of capital on lending is not that important. Rather, the capital ratio that banks choose for their funding mix might last for a while. A possible explanation could be that capitalization depends on a bank's long term policies. This finding puts the effect that capital has on lending unter Equation 3.1 into perspective. Probably, capitalization is just very persistent and the impact that it has on lending might be smaller in absolute terms than the estimated impulse response function suggests. Hence, the results have to be interpreted with caution.

Note that autocorrelation is present in the model by construction. Hence, it is no surprise that the Breusch-Godfrey Test with a H_0 of no serial correlation is rejected at the 1% level with a p-value $< 10^{-16}$. To control for this issue, the implementation in R provides spatial correlation consistent standard errors (SCC). These standard error estimates, introduced by Driscoll and Kraay [1998], are robust to both spatial and serial correlation in panel models, and are similar to the Newey and West [1994] standard errors.

Besides autocorrelation, one problem of the baseline model might be that the capital variable is correlated with its error term, and the endogeneity issue will therefore be discussed next.

3.4.2 Endogeneity

There are several cases that may generally lead to the problem of endogeneous variables. Among them are omitted variables biases, simultaneous/reverse causalities that lead to feed-back mechanisms, measurement errors in the explanatory variables, and autocorrelation of lagged endogenous variables. In the empirical analysis at hand, it is conceivable that at least some of these problems might apply. Especially omitted variable biases (such as risk taking preferences, national regulations and economic cycles) and reverse causality might be an issue. Therefore, it is unclear whether considering changes of the capital ratio as exogenous is justified. All these issues will be examined carefully within this section.

Reverse causality within the model is examined twofold here. One approach is to use a Granger causality test to see if lending also has an impact on capitalization. When this test is run with four lags of both variables, and the results show that both capital Granger-causes lending (F-value 20.06) and lending Granger-causes capital (F-value 25.67). Hence, the hypotheses that all of the coefficients of lagged lending/capital are zero have to be rejected at the 1% level. This suggests that reverse causality is likely present in the model.

Another way to check for reverse causality is to simply estimate another model. The baseline specification is now changed such that the response of capital to an impulse in lending can be analysed, similar to an idea of Romer and Romer [2015]. In particular, the following equation is estimated:

$$\begin{aligned} C_{j,t+i} &= \alpha_j^i + \gamma_t^i + \beta^i log(y_{j,t}) + \sum_{k=0}^{3} \varphi_k^i C_{j,t-k} + \sum_{k=1}^{3} \theta_k^i log(y_{j,t-k}) \\ &+ \sum_{k=1}^{3} \phi_k^i liq_{j,t-k} + \sum_{k=1}^{3} \rho_k^i log(dep_{j,t-k}) + \epsilon_{j,t}^i, \end{aligned} \tag{3.3}$$

for horizons 1 through 16. This means that it is controlled for capital at t with the sequence of β^i's, which show the response of capital at $t+1$ to $t+16$.

Figure 3.3 shows the resulting impulse response function along with the two-standard-error bands. One can see that the capital variable responds negatively to an innovation in lending of 1. This graph is another indicator of reverse causality in the model. Facing this issue, the question arises in how far it is a valid assumption that capital mainly influences lending and not vice versa. Aiyar et al. [2014] argue that this assumption is realistic because regulators can only observe bank lending with a lag, and even if they could observe it contemporaneously, their procedures might have longer reaction times. As one might consider changes in capital to be largely driven by regulatory enforcements (among others), this supports the idea that lending is mostly driven by capital and not the other way round.

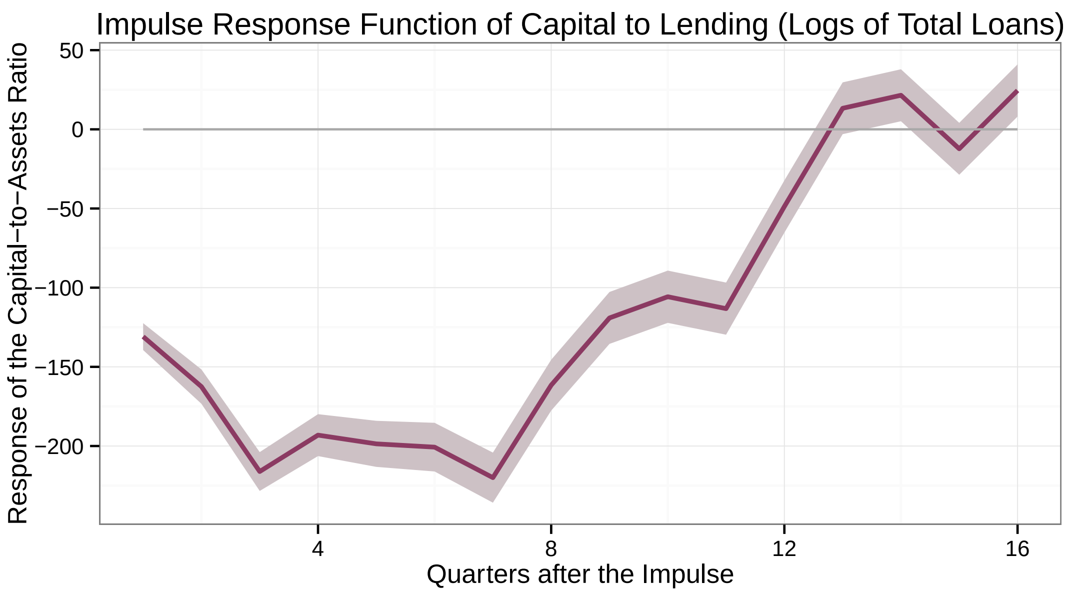

Figure 3.3: IRF of Capital to Bank Lending

Another endogeneity issue is the possibility of an omitted variable bias. One might argue that both lending and capitalization of banks might in fact be driven by a factor that is not contained directly in the model, such as fluctuation in the level of economic activity, national banking regulations (other than capital requirements) or willingness of risk taking. Let us take a look at each of these. It is conceivable that both economic activity fluctuations and changes in banking regulations might influence both lending and capitalization decisions, however, these are captured by the time fixed effects (the γ's) of the model.[7] The same hold true for demand-side effects that might change over time.

But what about banks' willingness to take risks? This might be another driving force behind the changes of both lending and capitalization. Aiyar et al. [2014] have an interesting approach to address this argument: They examine whether there is a correlation of their proxy for loan quality (write-offs) and minimum capital requirements, and state that there is none. This suggests that willingness to taks risks is probably not an important omitted variable. Further, risky behavior might be regarded as a bank-specific feature. In this case, the effect would be captured by the bank fixed effects (the α's) of the model.

Summing up, an omitted variable bias does not seem to be a problem in the model, however reverse causality is likely present. Further, it is questionable whether the capital shocks can be justifiably regarded as exogenous. Changes in regulatory capital requirements during the periods considered (especially Basel II and Basel III) might be considered as an exogenous variaton. However, most of the variation in capital may originate from other sources, such as the losses and gains that banks make. In the analysis of hand, indicators why these changes should be exogenous are absent.[8] This is problematic as the Jordà [2005] local projection method implies the occurrence of exogenous capital shocks in each period.

Consequently, the results need to be interpreted very cautiously, as the capital shocks cannot be fully isolated. Berrospide and Edge [2010] make aware of this issue, but argue that this should not be a major problem when bearing in mind that there might be an upward bias of the capital variable. Similarly, Bridges et al. [2014] state that capital shocks might not be purely exogenous, but claim that the results might still be a "useful guide" to understand the lending adjustments following an increase in banks' capitalization.

[7] Another way to address this problem would have been to directly include GDP growth in the lending equation, as suggested by Berrospide and Edge [2010]. However, they do not include time fixed effects.

[8] One interesting approach in the literature is to regard capital shocks as exogeneous because they might orginiate from different geographical regions. Mora and Logan [2012] use the fact that British banks are also actively lending abroad, independently from lending to UK nationals. They stress that if their capital positions experience a shock due to a significant change in non-resident write-offs, this might be regarded as exogeneous from the national market's perspective. Unfortunately, with the data set at hand, one cannot examine the gains and losses that US banks make abroad, so this approach cannot be applied to control for endogeneity issues here.

3.4.3 Robustness

There are several ways to check the model for robustness issues. In what follows, the robustness of the results that were obtained under the baseline equation is investigated along two dimensions. First, a very simplified version of the model in Equation 3.1 is examined, excluding both the liquidity ratio and the total deposits as explanatory variables. This leaves the model with the lags of the capital and the lending variable as the only explanatory terms, aside from the fixed effects. After that, an alternative timing assumption is considered. Recall that in the baseline specification, capital is allowed to have an effect on lending *within the same period*. Contrary to this assumption of a contemporaneous relationship, one could examine the case that lending does not respond to an innovation of capital in the same period, but *only in the subsequent periods*. Put differently, one could estimate Equation 3.3 again, now from horizons 1 to 20, with the roles of capital and lending reversed, similar to what is suggested by Romer and Romer [2015]. This leads to a model that differs from the baseline equation only with respect to the underlying timing assumption, now excluding the case of a contemporaneous effect from capital on lending. With this change, a banks' capital-to-assets ratio in period t is uncorrelated with lending in period t as well as lending in periods preceding t. In particular, the following model equation is estimated:

$$\begin{aligned} log(y_{j,t+i}) &= \alpha_j^i + \gamma_t^i + \beta^i C_{j,t} + \sum_{k=0}^{3} \varphi_k^i log(y_{j,t-k}) + \sum_{k=1}^{3} \theta_k^i C_{j,t-k} \\ &\quad + \sum_{k=1}^{3} \phi_k^i liq_{j,t-k} + \sum_{k=1}^{3} \rho_k^i log(dep_{j,t-k}) + \epsilon_{j,t}^i, \end{aligned} \tag{3.4}$$

What the impulse response functions in Figure 3.4 clearly show is that the "big picture" of the impact that an innovation of capitalization has on lending hardly changes with these different specifications. Note that by construction, the contemporaneous effect of a capital shock on lending is now zero. Therefore, the impulse response function under the alternative timing assumption starts at horizon 1 instead of horizon 0.

In the simplified model, an impulse to the capital-to-assets ratio variable leads to an immediate negative response of the bank lending variable of almost 1% (-0.83% with a t-value of -28.03). In the subsequent periods, the estimated coefficients become less negative in absolute term, and the response function first gets statistically insignificant from zero five quarters after the impulse. The response of the lending variable then becomes significantly positive in quarters 9-11, and reaches its positive peak in period 9 with an estimated coefficient of +0.37% (t-value 4.57), which is significant at the 1%

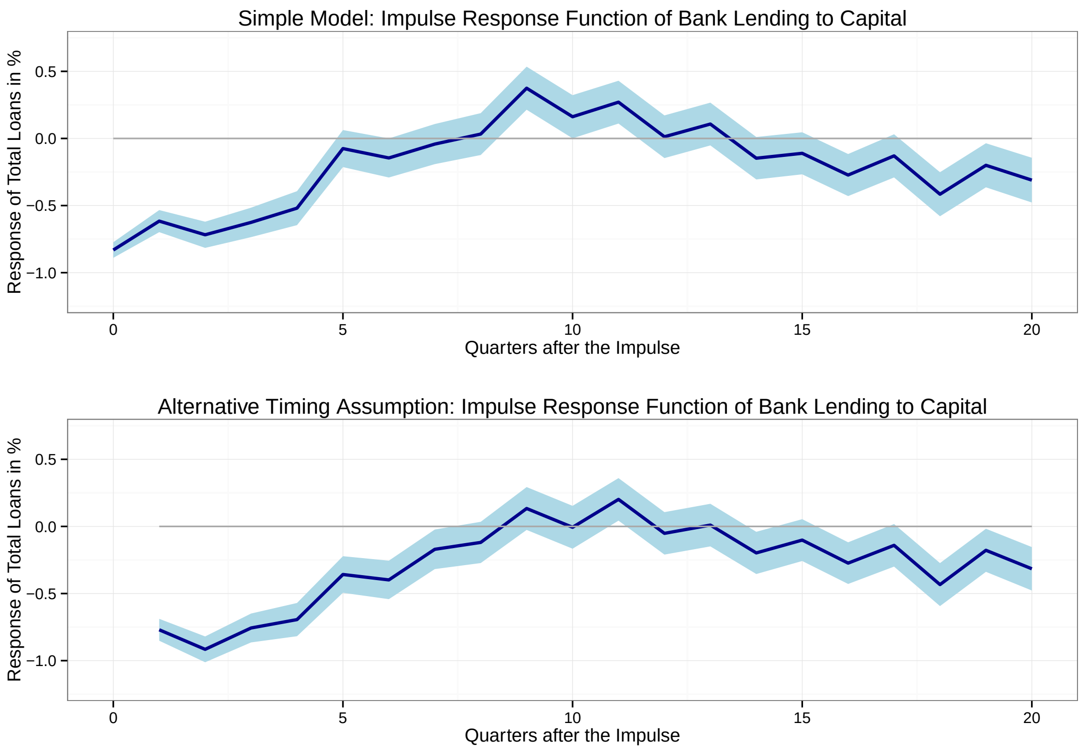

FIGURE 3.4: Robustness Considerations: IRFs of the Simplified Model (panel above) and the Alternative Timing Assumption (panel beyond)

level. Regarding more distant horizons, the response of bank lending becomes slightly negative again.[9]

As for the model with the alternative timing assumption, the capital shock is followed by a response of bank lending of -0.77% (t-value -18.49) one quarter after the impulse. Similar to the baseline specification, it takes the response of lending 8 periods to first become statistically significant from zero. The estimated coefficients become significantly positive just once, mainly at horizon 11, explicitely with an estimated value of +0.2% (t-value 2.49). However, by and large, the response of lending appears to be really persistent, as it is still negative five years after the impulse.

What are the implications of these observations? Most importantly, the baseline model appears to be quite robust. Even when bank lending is not allowed to affect the capital variable within the same period, the effect that an impulse to the capital ratio has on lending remains mostly unchanged. In addition, although the simplified model may not capture the determinants of lending as good as under the original specification, this has

[9]Note that just like in the baseline specification, the positive effects from quarters 9 onwards were more obvious and statistically significant if the lending variable was not specified in logs but in total dollars.

almost no impact on the response of lending. Hence, the findings strenghten the validity of the observations made under the original model specification.

3.5 Examining Different Samples

So far, only the full sample of 2,824 US banks during all available periods (Q1.2005-Q4.2012) has been analysed. But doing so might not tell the whole story. One might argue that the effect of an innovation to the capital variable on lending might differ when considering different samples. For instance, the effect might be different during the recent financial crisis and periods preceding the crisis. Further, bigger banks (in terms of total assets) might react differently than smaller banks. And lastly, the level of capitalization that a bank has before the impulse on the capital variable might lead to different responses in the lending variable. To investigate these issues, this section examines each of these different samples, and also refers the findings of similar studies in the literature.

3.5.1 Financial Crisis

As discussed in the literature review, the relationship between capital and lending might be different in times of crises. Demirguc-Kunt et al. [2013] observe that better capitalized banks experienced higher stock returns during the crisis period, which motivates the idea that one might as well observe systematic changes in bank lending with respect to capital during that time. Therefore, the time frame before the recent financial crisis is considered independently from the time sample during the crisis and its short aftermath. This might provide valuable insights in whether capitalization plays an especially important role in times of crisis and uncertainty.

To examine this issue, the full panel was separated into two groups, and the baseline model of Equation 3.1 was applied to both of them. The “pre-crisis group” contains all observations between the first quarter of 2005 and the second quarter of 2007, and the “crisis group” contains all observations starting in the third quarter of 2007. This sample split is the same as used by Demirguc-Kunt et al. [2013]. When the sample is divided like that, the estimation of impulse response functions becomes impossible at larger horizons as the number of available periods is obviously reduced. In particular, for the crisis sample, only horizons up to quarter 16 after the impulse were estimated. For the sample of the periods preceding the crisis, only the first four periods after the impulse could be estimated. This is due to the fact that the dataset only contains 10 quarters that preceed the crisis. Hence, after four periods, no meaningful responses could be calculated anymore, due to a lack of data points. Especially for the "pre-crisis group", this clearly reduces the interpretative value of the impulse response function, as no clear tendency can be identified at longer horizons. Nevertheless, examining the two samples independently provides some interesting insights.

Figure 3.5 shows the crisis sample in the upper panel and the pre-crisis sample beyond. An obvious difference that can be seen in comparison to the total sample is that the response of the lending hits the zero line much faster. The immediate response is similar to the one in the total sample: An innovation of the capital ratio variable has a significantly negative impact on bank lending at the time of the impulse. More specifically, the immediate response of the lending variable is -0.89% (t-value -23.27), and the absolute values of the estimated coefficients decline in the next four periods. Recall that in the total sample under the baseline specification, it took the response of lending more than two years after the impulse to hit the zero line. Even after that, it is not clear that the effect gets significantly positive at all. On the contrary, the impulse response function of the crisis sample clearly shows that after the first year following the impulse, in quarter 5, the effect of lending becomes significantly positive. Already in period 5, the estimated coefficient is +0.27% (t-value 3.50), and then stays positive for most subsequent horizons considered. The effect reaches its positive peak in quarter 9 after the impulse, with a coefficient estimate of +0.5% (t-value 6.40). These findings suggest that during times of crises, if the capital-to-assets ratio experiences an impulse of 1, banks first reduce their lending for almost 1%, but already one year after the impulse, the effect becomes positive, and after more than two years (here in period 9) the positive effect on the lending variable is highest. Note that from period 5 onwards, the effect of the lending is either positive or not significantly different from zero, and confidence bands get slightly bigger at longer horizons.

With regard to the pre-crisis sample, the immediate response of the lending variable is also negative, although it is not as big in absolute terms (-0.63% with a t-value of -9.69). After that, it is not statistically different from zero, with the only exception of quarter 4 after the impulse, where the effect gets negative again (with an estimated coefficient of -0.75% and a t-value of -4.74). However, especially this last value is to be interpreted with precaution, as it might be an "outlier" compared with longer horizons, and does not necessarily suggest that the response of lending would go down again for more than one period. Rather, the estimated coefficient in quarter 4 might as well be some minor noise in the long run. Either way, a further interpretation would only be possible if more time periods preceding the crisis were available in the dataset. But it is definitely conceivable that the impact of capitalization on lending is less strong during "normal" times.

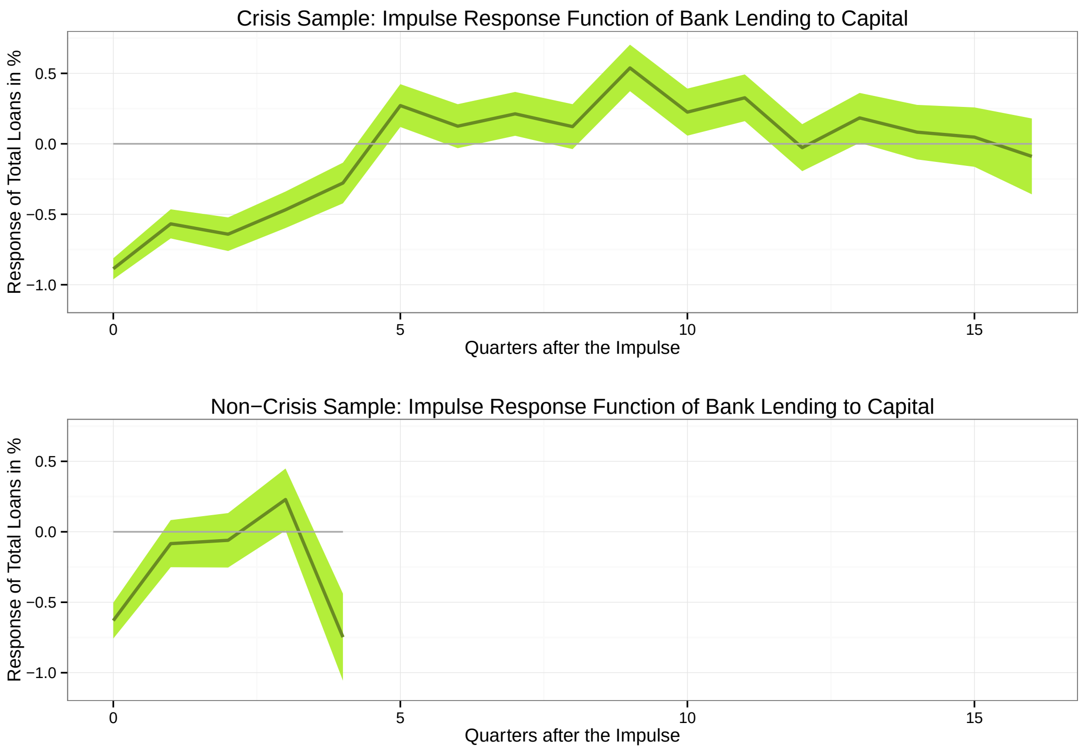

FIGURE 3.5: Examining different samples: periods during the financial crisis and its short aftermath (above) and periods before the crisis (beyond)

Summing up, one might argue that in times of crises, an increase in capitalization leads banks to lend slightly more, starting one year after an increase in the capital ratio.

3.5.2 Bank Size

The idea that bigger banks might react differently to capitalization shocks is widely discussed in the literature. Hancock et al. [1995] use quarterly Call Reports data to estimate impulse response functions (using VAR) to capital shocks, and state that larger banks adjust their lending faster than smaller banks. They explain this finding with the argument that larger banks might face economies of scale that enable them to raise additional capital at a lower cost than smaller banks. Consequently, smaller banks might find it more difficult to readjust their lending after having to increase their capitalization. In addition, Demirguc-Kunt et al. [2013] find that especially for larger banks, a stronger capitalization is associated with a better stock market performance during the recent financial crisis. This might enable larger banks to better maintain their lending.

To investigate whether bigger banks react differently to an impulse in the capital variable, the sample was divided into a sample of "big banks", including banks with total assets above the 80^{th} percentile of the total sample, and a second sample including all other banks.

Figure 3.6 shows the panel of big banks above and the panel of the remaining banks beyond. The immediate response of an impulse to the capital variable is quite similar in both samples - explicitely with a response of the lending variable of -0.97% (t-value -15.37) for bigger banks and -0.91% (t-value -28.04) for the other banks. With regard to longer horizons, however, clear differences between the two samples become visible. In the sample of the big banks, three quarters after the impulse, the response of the lending variable is not significantly different from zero anymore. In the quarters 5-13 after the impulse, the response of lending even gets significantly positive, with a peak value of over 1%, explicitely +1.10% (t-value 5.03) in period 11. After that, the estimated values of the coefficients slightly decrease again, but from period 14 onwards, the response of lending hardly gets significantly different from zero - with the minor exception of period 18 after the impulse (-0.61%; t-value -2.39). In the case of the sample that includes banks under the 80^{th} percentile, the response at longer horizons is quite different: The estimated coefficients never get significantly positive in all horizons considered. In the quarters 9-11 following the impulse, the impulse response function gets significantly indifferent from zero, and in subsequent periods, the estimated coefficients stay in a range between -0.15% (t-value -1.65) in quarter 13 after the impulse and -0.38% (t-value -4.22) four years after the impulse.

Summing up, for big banks (above the 80^{th} percentile of the total assets distribution), an impulse of capitalization appears to have a very different impact on the lending variable than it is the case for smaller banks. Already in quarter 5, meaning one year after the impulse, the effect of lending becomes significantly positive and stays positive for more than two years, until quarter 13. After that, the effect seems to vanish. As for the smaller banks in the sample, an innovation of the capital ratio reduces lending in almost all five years considered that follow the impulse. This has relevant policy implications, as minimum capital requirements might be especially relevant for big banks, as they might lead to higher lending outcomes of those banks in the medium run.

3.5.3 Capitalization

Bridges et al. [2014] suggest that banks with very low capital positions might be particularly sensitive to changes in regulatory capital requirements. They estimate the effect that changes in capital requirements have on bank lending, using a panel dataset of banks in the UK from 1990-2011, and find that banks with a very low capital buffer reduce lending more as an initial reaction to a capital shock. Based on this idea, one

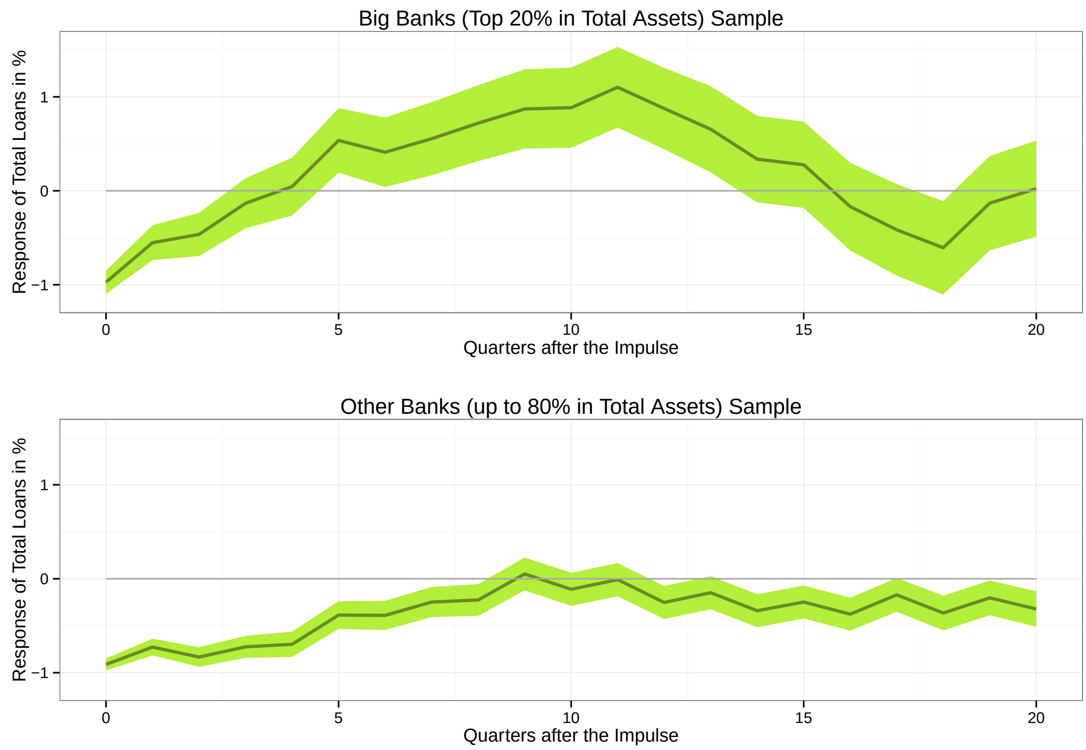

FIGURE 3.6: Examining different samples: banks with total assets above the 80^{th} percentile (above) and the sample with all other banks (beyond).

might argue that bank lending probably reacts stronger to an impulse of capitalization if the initial level of capitalization is extremely high or low.

To examine whether effects on lending differ among poor, medium and strong capitalized banks, three different sample sets are created. The sample group of "strong" capitalized banks includes all banks of the initial sample that have a capital-to-assets ratio above the 90^{th} percentile. Likewise, the set of "poor" capitalized banks includes banks beyond the 10^{th} percentile of the capital-to-assets distribution. To control for effects in "medium" capitalized banks, a third sample includes all banks with a capital-to-assets ratio within the interquartile range of the total sample.

The three panels of Figure 3.7 show strong capitalized banks on the top, medium capitalized banks in the middle, and poorly capitalized banks at the bottom. The immediate impact on lending in the three sample sets are -0.75% (t-value -7.78), -1.14% (t-value -16.48) and -1.72% (t-value -7.66), respectively. Put differently, the smaller a bank's initial capital ratio is, the more does lending decline as an immediate response to an impulse to the capital variable. It is worth mentioning that in no other sample or under any other specification in the analysis so far, the immediate impact on the lending variable has been as negative in absolute terms as in the sample of poorly capitalized banks. With regard to all considered horizons, an obvious difference between the three samples is that the 95% confidence bands are much wider for the sample of poorly capitalized banks. The fact that precise estimates are harder to obtain for low capitalized banks might indicate that lending is determined by additional factors that might not be captured by the model.

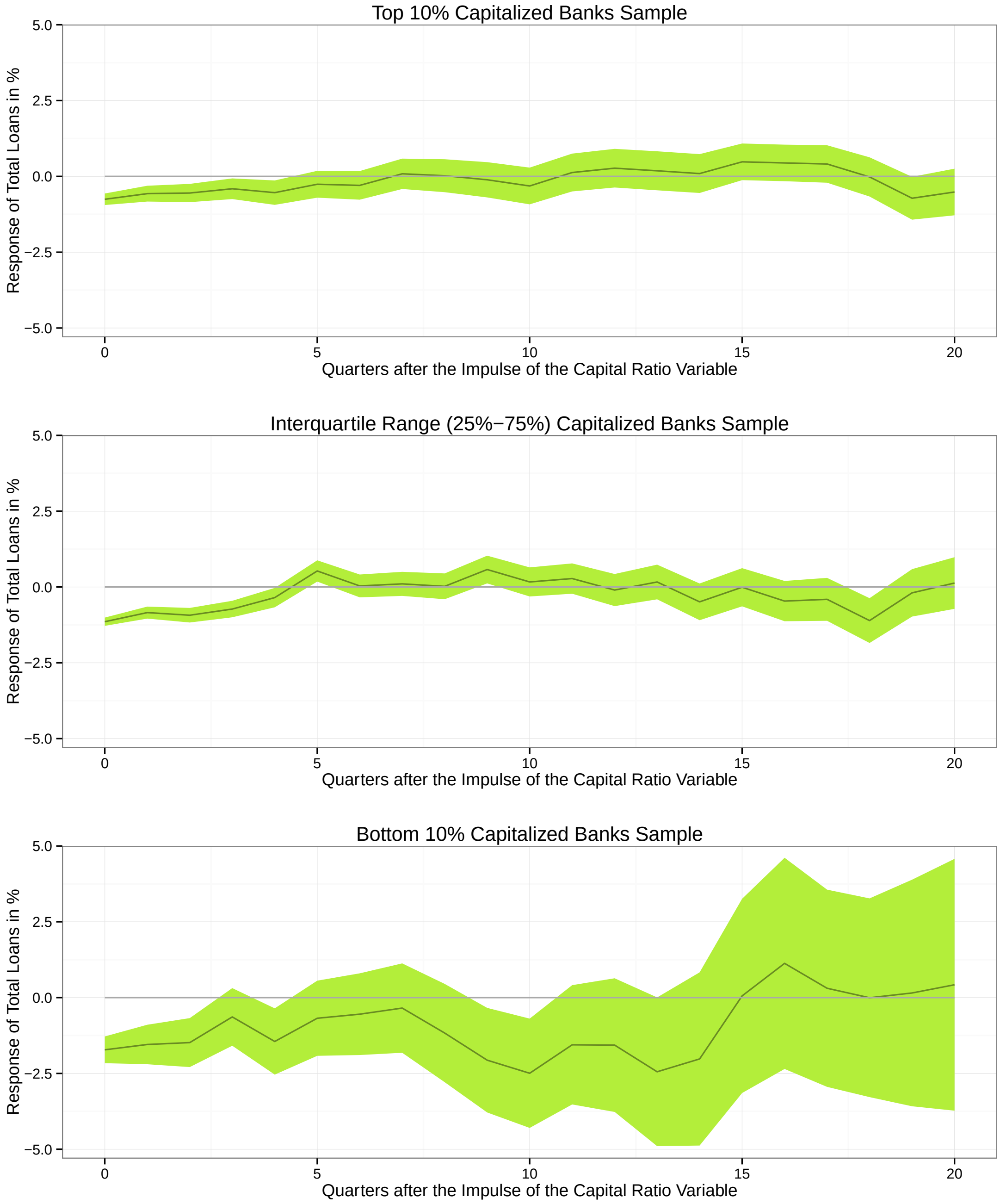

FIGURE 3.7: Examining different samples: The panel above shows banks with a capital ratio above the 90^{th} percentile, the bottom panel shows banks with a capital ratio beyond the 10^{th} percentile. The panel in the middle shows banks with a capital ratio within the interquartile range.

With regard to subsequent periods following the impulse, it is noteworthy that in the sample of the highest capitalized banks, from quarter 5 onwards, the response of the lending variable is not significantly different from zero anymore. In other words, one year after the impulse of the capital variable, all effects on lending vanish within the sample of banks above the 10^{th} capital ratio percentile. A similar pattern can be observed for banks in the medium capitalized sample, although the impulse response function occasionally deviated from the zero line here.

What these findings show is that there is hardly any difference between banks in the top and in the medium capitalization sample. However, one can observe a much more negative immediate effect on the lending variable at the time of the capital shock for the lowest capitalized banks. Further, one might expect that when banks are poorly capitalized, additional factors might play a role to control for the effect that an impulse to the capital variable has on lending.

3.5.4 Liquidity

Finally, different samples with regard to liquidity are examined. The relationship of bank lending and liquidity of banks are broadly discussed in the literature, often suggesting that banks with lower liquidity positions find it harder to maintain their loan growth rates (f.e. Cornett et al. [2011], Kashyap and Stein [2000], Iyer et al. [2014]). In what follows, it is examined whether different liquidity-to-assets ratios of banks lead to different outcomes in terms of the effect that a capital shock has on lending.

To distinguish banks with the highest liquidity ratios from the banks with the lowest liquidity ratios in their balance sheets, two samples sets were created: In Figure 3.8, the upper panel shows the sample of banks with a liquidity ratio above the 75^{th} percentile of the total sample. Likewise, the panel beyond captures all banks beyond the 25^{th} percentile of the liquidity distribution.

The impulse response functions of these two different bank samples suggest that less liquidity indeed leads to a more negative immediate response of lending to a shock in the capital variable. In particular, the response of the lending variable at the time of the impulse is -1.45% (t-value -20.62) for banks with low liquidity positions and only -0.48% (t-value -6.98) for banks with the highest liquidity positions. However, the absolute values of the estimated coefficients in the low liquidity sample successively decrease after that, and five quarters after the impulse and at all longer horizons, the effect on lending is not significantly different from zero anymore, with wider confidence bands at longer horizons. As for the sample that includes banks with the highest liquidity ratios, the response of lending first gets statistically indifferent from zero and then stays at this level with minor deviations. The confidence bands slightly increase at longer horizons, too.

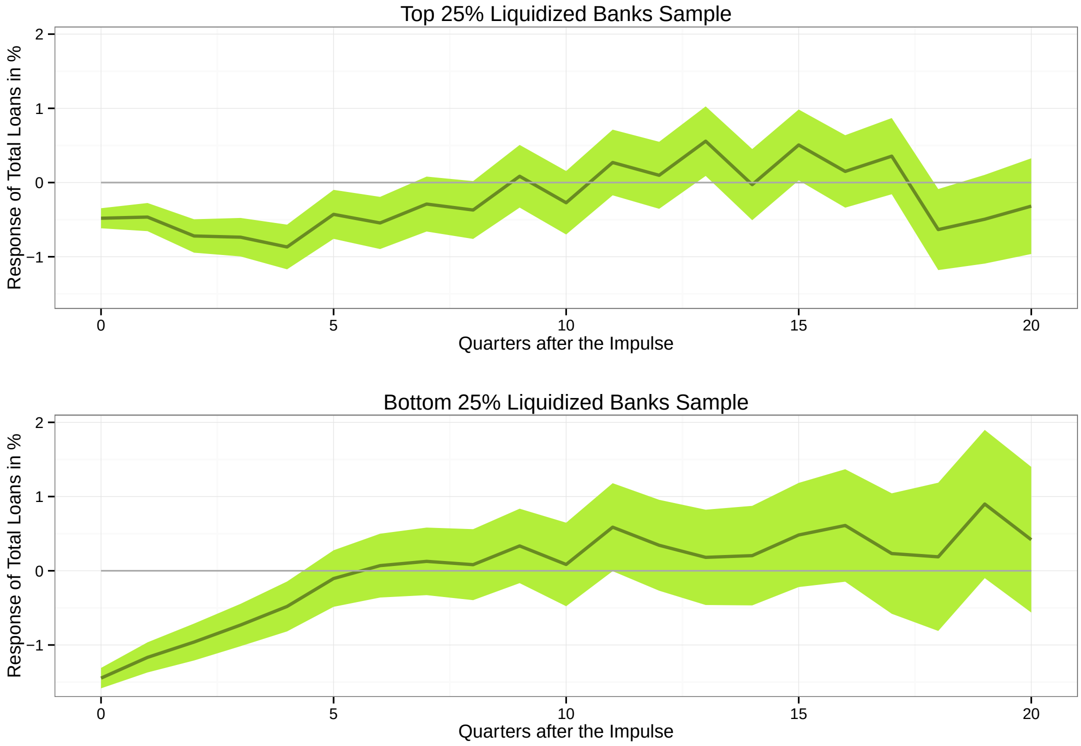

FIGURE 3.8: Examining different sample: banks with a liquidity ratio above the 75^{th} percentile (above) and below the 25^{th} percentile (beyond).

In conclusion, if banks have lower liquidity positions in their balance sheets, an innovation of the capital variable first leads to a more negative response of lending than in the sample of banks with high liquidity positions. However, this effect vanishes starting in the second year after the impulse.

Chapter 4

Discussion

In the light of the findings of this thesis, several interesting issues for future research arise. One question is whether capital requirements in the long run might lead to an increase of lending in initially poorly capitalized banks, for instance if creditors get more confident, which might in turn facilitate lending. The results at hand show that banks that have capital rations beyond the 10^{th} percentile of the sample distribution decreased their lending much more as an immediate response to a capital shock. However, although lending on average seems to decrease for those banks, one important feature of the estimates is that confidence bands were augmenting drastically at longer horizons for that sample group. This might indicate that in the medium and long run, increases in lending are certainly possible. But most likely, other factors play a role then, which might be identified using a different data source and approach.

Another question that arises from the analysis is which loans were reduced in particular after an impulse of the capital variable. In all examined specifications and samples, the initial reaction of the lending variable was significantly negative. However, the data does not capture information regarding the risk of the reduced loans. It might be the case that the granting of high-risk loans was affected in particular after an increase of capital. Answering this question would be highly relevant for the public discussion about banks' safety and risk sharing, but cannot be answered with the dataset at hand.

More information regarding the composition of loans would also be of interest with regard to different sectors of the economy. Bridges et al. [2014] observe that as a consequence of a capital shock, banks first cut lending on commercial real estate, then other corporates, and finally household secured lending. Iyer et al. [2014] state that credit supply reduction is stronger for firms that are smaller, with weaker banking relationships, and that smaller firms find it harder to compensate the credit crunch with other sources of debt. It would be interesting to investigate how different sectors are affected differently, and whether there are relations about which sectors are most important for economic growth. How dependent are they on bank lending? And is lending to them reduced in particular as capital requirements are imposed?

Similarly, it is not clear if the amount of granted loans increases/decreases as the total loans increase/decrease. From a macroeconomic perspective, this may not be of major interest, yet it could have important implications on the microeconomic level. For instance, it might be conceivable that little loans on the household level augment and large loans to corporations decline as total loans decrease. Again, a more comprehensive data base would be needed to further explore this issue.

Furthermore, it is remarkable that to the best of my knowledge, the literature does not discuss taxes on bank debt as an alternative to capital requirements. If it is really the case that banks have incentives to indebt themselves excessively at the expense of social costs, as argued by Admati et al. [2013], then taxes on bank debt appear to be a natural alternative to capital requirements. They could help to overcome the problem of negative externalities and might be less bureaucratic to implement. Moreover, there is no obvious reason why capital requirements should be imposed at a certain level, given that higher levels might be socially optimal, as discussed in the literature review section. Further, significant information asymmetries come along with assigning risks to loans. With regard to lending implications, one advantage might be that taxes would not necessarily affect banks' capital positions at the moment they are implemented. Thus, they might not be experienced as "capital shocks" and consequently might not reduce lending that strongly.

Lastly, the results of this analysis imply that it is hard to conclude that more capital would be either "good" or "bad" in order to increase bank lending. Looking at the existing literature, this might help to explain why there is so much controversy about the effect that capital has on lending. Further research might help to better understand in how far lending is really affected by changes in banks' capitalization, and whether this is something to be concerned about with regard to economic growth.

Chapter 5

Conclusion

The thesis at hand contributes to the empirical literature regarding how bank capital influences the granting of loans by studying impulse response functions of bank lending to an innovation in the capital-to-assets ratio.

It is argued in the literature that higher capital positions would make banks safer (Admati and Hellwig [2014], Brunnermeier [2009], Martynova [2015]), whereas highly indebted banks that are struggling might have to cut back on lending. Attempts to increase banks' capitalization include imposing minimum capital requirements, such as Basel II or Basel III. However, opponents of more capital argue that such restrictions would have undesirable consequences, in particular being too expensive, and further by reducing bank lending and consequently economic growth.

After carefully examining the theoretical arguments in the literature review section, the empirical part of this thesis investigates the impact that shocks in the capital ratio variable have on lending outcomes of banks. To do so, quarterly Call Reports balance sheets data are used, including 2,824 US banks between the first quarter of 2005 and the last quarter of 2012. With the Jordà [2005] local projection method, impulse response functions of lending to an innovation of the capital variable are estimated. The findings suggest that an innovation in the capital ratio of 1% leads to an immediate response of the lending variable of almost -1%. The estimated coefficients then decline successively at longer horizons, and first become statistically insignificant from zero 9 quarters after the impulse. $2\frac{1}{2}$ years after the impulse, the response of lending becomes slightly negative again, suggesting that lending reduces as the capital ratio experiences a positive shock. These findings appear to be robust, although the estimates have to be interpreted with precaution due to a possible reverse causality bias. Further, a strong persistence in the capital variable itself suggests that the impact that a capital shock has on lending might be smaller than the estimated impulse response functions suggest.

To investigate whether the results differ among samples, several subsets are examined. First, periods preceding the recent financial crisis are analysed separately from periods during the crisis. Findings show that the response of lending became statistically positive for some horizons, starting on year after the capital shock. This suggests that a higher capitalization of banks might lead to better lending outcomes particularly in times of crisis. Second, banks with total assets above the 80th percentile ("big banks") were analysed separately from the other banks in the sample. The results indicate that bigger banks lend up to 1% more 2-4 years after the impulse as if they would have without an innovation to the capital ratio. In addition the total sample was divided with regard to initial capitalization levels. What the findings suggest is that banks beyond the 10th percentile of the capital ratio distribution react most negatively to a capital shock - with an immediate response of lending of -1.72%. At longer horizons, the confidence bands augment drastically, which might indicate that for poorly capitalized banks, additional factors drive the response of lending. Lastly, seperate samples for banks in the first and the last quadrant of the liquidity ratio distribution were examined. The approximate pattern of the estimated impulse response functions is the same here, with the difference that banks with the lowest liquidity had a response of lending to the initial shock that was almost 1% more negative (-1.45% for the most unliquid banks in comparison to -0.48% for banks with the highest liquidity).

Summing up, a positive shock to the capital variable led to an immediate negative response of bank lending in all examined specifications and samples. At longer horizons, the response of lending varies significantly among samples - implying that positive responses of lending could be observed in particular for times of crisis and for big banks. On the other hand, hardly any significant effects could be observed for the sample of banks with a high initial capital ratio. The latter suggest that when banks are already well capitalized, changes in their capital ratio have hardly any effect on lending. Hence, a legislature that aims at stable lending rates might find it desirable to change incentives for banks such that they choose to hold more capital. Regulatory capital requirements as well as taxes on bank debt might be a way to do so.

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