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Liquidity regulation and bank behavior

Bonner, C.

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Liquidity Regulation

and

Bank Behavior

PROEFSCHRIFT

ter verkrijging van de graad van doctor aan Tilburg University op gezag van de rector magnificus, prof. dr. Ph. Eijlander, in het openbaar te verdedigen ten overstaan van een door het college voor promoties aangewezen commissie in de aula van de Universiteit op donderdag 11 december 2014 om 10.15 uur door

CLEMENS BONNER

geboren op 28 september 1985 te Stuttgart, Duitsland.

Promotores
Prof. dr. S.C.W. Eijffinger
Prof. dr. P.L.C. Hilbers

Overige leden van de Promotiecommissie
Prof. dr. R.J. Berndsen
Prof. dr. J. de Haan
Prof. dr. C.G. de Vries
Prof. dr. H.P. Huizinga

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Writing a PhD thesis is rightly characterized as a solitary endeavor. Solitude should, however, not be confused with loneliness. While solitude is commonly referred to as a conscious choice to be alone, loneliness refers to an involuntary state of seclusion. During the time of writing this thesis, I have been fully employed in the Supervisory Policy Division of De Nederlandsche Bank (DNB). Naturally, this setup required me - even more than is anyways the case for PhD students - to spend many hours during evenings and weekends alone at my desk. However, at no point of this journey did I feel left alone. There are a few people who directly or indirectly contributed to this thesis and I would like to acknowledge their support.

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"The difference between stumbling blocks and stepping stones is how you use them."
- Unknown

Contents

List of Figures

List of Tables

CHAPTER 1

Introduction

"Liquidity is a public good. Liquidity requirements can internalize some of the externalities that are generated by the price impact of selling into a falling market."

(Cifuentes, Ferrucci, and Shin, 2005, p.565)

The 2007-08 financial crisis constituted the largest shock to the world financial system since the Great Depression in the 1930s. Financial crises tend to have common factors but also unique elements.[1] Most financial crises are preceded by asset and credit booms, which, in turn, are fostered by accommodative monetary policy.[2] Calomiris (1998) argues that the most severe crises arise when favorable financial market conditions coincide with rapid expansion in financial innovation. As many other crises, the 2007-08 financial crisis has its origins in the real estate market. Making a historic comparison, Calomiris (2009) argues that similar to previous real estate-related crises, the 2007-08 financial crisis has been the result of government policies incentivizing excessive real estate risk taking. According to Brunnermeier (2009), this was supported by low interest rates caused by the Federal Reserve Bank's fear of deflation after the bursting of the internet bubble.
Apart from these policy-related factors, two financial industry trends laid the foundation of the lending boom and housing frenzy that eventually led to the financial crisis: banks' increased issuance of asset-backed securities (ABS) and the reliance on short-term funding from institutional investors.[3]

[1] See Reinhart and Rogoff (2008, 2009) among others.
[2] See for instance Bordo and Wheelock (2007a,b), Allen and Gale (2007), Allen et al. (2009) or Claessens and Kose (2013).
[3] See Brunnermeier (2009).

The process of securitizing is often described as the "originate to distribute" model and begins with a bank originating regular loans.[4] To turn illiquid, individual loans into tradable securities, "sponsoring" banks sell pools of loans to specifically established off-balance vehicles, usually referred to as Special Purpose Vehicle (SPV). The SPV has no employees or physical location and is not subject to banking regulation. However, since SPVs finance their asset purchases by issuing short-term paper in the capital markets, they act similar to banks ("borrow short, lend long"). For this reason, SPVs have been described as "shadow banks".[5] To securitize, SPVs slice their purchased asset pools in so-called, qualitatively different tranches, which can be sold to investors. The exact cutoffs between tranches are chosen to ensure a specific rating for each tranche. The top tranches, for instance, are structured to be assigned a AAA rating. This is possible because, unlike other securities, securitizations depend on the cash flows from a specified pool of assets rather than the credit worthiness of the issuer.

Securitizations allow banks to distribute the credit risk from issuing mortgages over different investor groups that wish to bear it. Brunnermeier (2009) argues that this has led to lower mortgage and corporate lending rates. Additionally - as shown by Keys et al. (2010) - securitizations led to reduced lending standards. Since a bank only faces the risk of holding issued loans for some months, its incentives for screening are reduced. However, large amounts of securitizations never left the banking system and therefore rather than leading to better risk diversification, securitizations increased the interconnectedness among banks. Additionally, sponsoring banks usually grant credit lines ("liquidity backstop") to ensure that the SPV has sufficient liquidity in case investors stop buying short-term paper.

Since there were insufficient retail deposits to finance the housing boom, banks became dependent on short-term wholesale funding, especially asset-backed commercial paper (ABCP) and repurchase agreements (repo).[6] Both of these trends were directly related to the rise of ABS.[7] The marketability of ABS created a large pool of assets, banks could use as collateral for secured financing transactions. At the same time, non-financial corporations and institutional investors looked for options to place their growing cash reserves. Gorton (2009) argues that ABCP and repos were ideal instruments because they showed characteristics similar to deposits. They could be withdrawn on short notice, were secured by high quality collateral and offered market return.

[4] For more details, see Gorton and Souleles (2007).

[5] See Gorton (2009).

[6] See Demirgüç-Kunt and Huizinga (2010), Perotti and Suarez (2011) and Acharya et al. (2013).

[7] The rise of ABS has commonly been associated with four driving forces: 1) Regulatory arbitrage: Moving a pool of assets off-balance to the SPV reduces banks' capital requirement; 2) Banks' increased need for collateral to finance the housing boom with short-term secured wholesale funding; 3) Minimization of bankruptcy costs due to off-balance financing, and 4) Favorable ratings compared to bonds with similar yields or risk characteristics. See Gorton (2009), Calomiris (2009) or Kowalik (2013).

The period preceding the 2007-08 financial crisis was characterized by low interest rates spurred by accommodative monetary policy, government subsidies related to real estate, financial innovation in the form of securitizations, reduced lending standards, increased reliance on short-term wholesale funding, and a credit boom. On top of that and in contrast to initial expectations, securitizations did not transfer risks out of the banking system but rather increased the interconnectedness among financial institutions. Most of these factors have also been present prior to previous financial crises.[8] But what triggered the 2007-08 financial crisis?[9]

A significant number of mortgages prior to the crisis was granted under the premise of steadily increasing house prices and therefore under the expectation that borrowers could refinance loans with the increased value of their houses. When house prices stagnated and even dropped, default rates on subprime mortgages increased.

The shock to the subprime mortgage market was revealed by the ABX index. The ABX index was the only observable market in the nexus of derivatives and structured finance. It is based on the price of credit default swaps referencing twenty equally weighted securities containing subprime mortgages. The index reflects the costs of insuring a basket of mortgages against default.

In early 2007, the ABX index started deteriorating, which led to a drop in prices of mortgage-related products. Brunnermeier (2009), for instance, shows that concerns about subprime mortgages led the market for ABCP to dry up. Most other asset classes, on the other hand, did not show increasing spreads until in August 2007, when the Libor-OIS spread sharply increased. Only the increase of the Libor-OIS spread led the value of other securitized asset classes to deteriorate.

Gorton (2009) argues that the reason for the shock in the subprime market being transmitted to other parts of the banking system was asymmetric information. With a number of institutions being reportedly in difficulties in July 2007, investors got nervous.[10] Similar to previous crises, depositors "ran" on banks because it was not clear which banks were most exposed to subprime-related assets and investors did not trust banks' equity cushions.[11]

The flight to quality in repo markets - all firms wanted to hold cash or government bonds - reduced the demand for banks' collateral and therefore their price. An increase of haircuts in the repo market is akin to a withdrawal. If haircuts rise, the banking system either has to shrink, borrow or needs an equity injection. After some first equity injections in the fall of 2007 though, the source dried up and so did the possibility to borrow. The only option were asset sales. If everyone wants to

[8] See for instance Calomiris (1998), Reinhart and Rogoff (2009) or Claessens and Kose (2013).

[9] The chronology of the 2007-08 financial crisis is outlined in many papers. The following paragraphs mainly draw on Brunnermeier (2009), Gorton (2009) and Gorton and Metrick (2012).

[10] Institutions in difficulties were, for instance, BNP Paribas, the German IKB or the American Home Mortgage Investment Corp.

[11] Note that this was not a classic retail bank run, as described by Diamond and Dybvig (1983). Instead of cash withdrawals of retail clients, this crisis was reflected by haircut increases in repo markets.

sell, prices have to fall. Gorton (2009) argues that the developments in repo markets were the force behind the transmission of turmoil in the relatively small subprime market to the entire banking system.[12] An additional difficulty was that market participants lost their trust in securitizations and thus tried to obtain more information. However, most market participants could not cope with the sudden need to understand, value and trade these new products. Securitizations turned illiquid.[13]
Similar to previous crises, the 2007-08 financial crisis was caused by a shock to the housing market.[14] Being unsure about which counterparties were at risk, investors requested more collateral from all banks. Eventually this forced most institutions into severe fire sales and a significant number of them into failure with adverse consequences for the entire financial system.
There were many factors that led to the outbreak of the financial crisis and observers differ on the weight given to individual aspects. There is, however, wide agreement that liquidity risks and lapses in liquidity risk management were key factors leading to the outbreak of this crisis and especially its rapid expansion.[15] The financial crisis also showed that capital regulation does not (fully) mitigate liquidity risks. To better understand why this is the case, it is useful to classify liquidity into two categories: market liquidity and funding liquidity.[16]
Funding liquidity refers to the ease with which an institution can attract funding. An institution's funding liquidity is high if it can easily raise money at reasonable costs. When financial institutions purchase an asset, they often use it as collateral for short-term borrowing. The haircut - the difference between the value of an asset and the amount one can borrow against it - needs to be financed by the institution's equity. Funding liquidity risk can take three forms: 1) Changes of margins and haircuts; 2) cost increases or the impossibility of rolling over short-term borrowing, and 3) withdrawal of funding. The three sources of funding liquidity risk have a severe adverse impact if assets can only be sold at fire sale prices. Funding liquidity is therefore closely linked to market liquidity.[17]
Market liquidity is high when it is easy for institutions to raise money by selling the asset, instead of borrowing against it. If market liquidity is low, selling the asset would depress its price. Kyle (1985) distinguishes three forms of market liquidity: 1) the bid-ask spread, which measures the

[12] Due to several downgrades, some banks also experienced large margin calls from their derivative positions.
[13] Gorton (2009) explains this problem (also referred to as the "lemons problem") as follows: *"Think of it as like electricity. Millions of people turn their lights on and off every day without knowing how electricity really works or where it comes from. The idea is for it to work without every consumer having to be an electrician (...). [However] when the shock hits, suddenly the electricity stops working. When that happens, an event no one really contemplated, it is too late for everyone to become an electrician."*
[14] See, for instance, Hilbers et al. (2008) for more details on the relevance of the housing market for financial stability.
[15] See Brunnermeier (2009) or Franklin and Carletti (2008) for overviews regarding the role of liquidity during the financial crisis.
[16] See Drehmann and Nikolaou (2009) and Brunnermeier (2009).
[17] See Brunnermeier and Pedersen (2009).

difference between buying and selling the same asset at the same time; 2) market depth, referring to the amount one can sell without causing the price of an asset to move, and 3) market resilience, describing the time it takes for prices that have temporarily fallen to bounce back.

The shock in the subprime market had a direct impact on banks' funding liquidity risk. Being unsure about their quality, investors increased haircuts on securitizations used in secured borrowing transactions. Since banks were already highly leveraged, they could not finance the increasing haircuts with their equity. As a consequence, many banks needed to sell their assets at the same time. These sales depressed prices even further, which in turn led to more sales and hence to a downward spiral. The risk and magnitude of downward spirals is larger for assets with lower market liquidity. By definition, sales of less liquid assets cause larger price drops than selling more liquid assets.

Another issue directly related to banks' funding risk were the credit lines banks granted to SPVs. When the markets for ABS and ABCP dried up, it became clear that many SPVs will draw on their credit lines, increasing banks' concerns about their own funding needs. Since there was uncertainty whether other banks faced the same issues, banks hoarded liquidity with adverse consequences for the functioning of interbank money markets.

The financial crisis has shown how quickly liquidity can evaporate and how rapidly this can transmit stress in one market to other markets.[18] Banks held too little market liquid assets to compensate for their increased funding liquidity risks. Against this background, Cifuentes et al. (2005) argue that liquidity buffers may be a useful instrument to prevent systemic stress. During severe crises, even well capitalized banks are forced into fire sales which reduce the value of other banks' assets. Apart from reducing the risk of fire sales, requiring institutions to increase their liquidity buffers can be expected to restore confidence of investors and therefore reduce the likelihood of bank runs, reduce banks' reliance on central banks and gives supervisors time to react in case institutions experience difficulties.[19]

Against this background, efforts have been underway internationally as well as in individual countries to establish or reform (existing) liquidity risk frameworks, most notably by the Basel Committee for Banking Supervision (BCBS). The BCBS' new regulatory framework (henceforth Basel III) proposes two liquidity requirements to reinforce the resilience of banks to liquidity risks.[20] The Liquidity Coverage Ratio (LCR) is a short-term ratio that requires financial institutions to hold enough liquid assets to withstand a 30 day stress period. The second measure, the Net Stable Funding Ratio (NSFR) aims at improving banks' longer-term, structural funding.

[18] See Adrian and Shin (2009, 2010).
[19] Also see Schnabel and Shin (2004), Franklin and Gale (2004, 2005), and Diamond and Rajan (2005).
[20] See BCBS (2010b, 2013b).

The LCR is based on classic liquidity "coverage" considerations. It requires financial institutions to hold enough liquid assets to cover net cash outflows over a 30 day stress horizon and is defined as follows:

$$LCR = \frac{High\ Quality\ Liquid\ Assets}{Net\ Cash\ Outflows} \geq 100\% \tag{1.1}$$

High Quality Liquid Assets (HQLA) are assets that are expected to remain market liquid during severe stress and include cash, central bank reserves and a number of marketable securities. Net cash outflows reflect the difference between stressed outflows and assumed inflows. This leads to moderate withdrawals of retail and operational corporate deposits as well as significant outflows of most types of wholesale funding. Additionally, the LCR assumes significant calls on off-balance sheet exposures. Regarding inflows, banks can rely only to a limited extent on their maturing retail and operational wholesale loans while relative inflows from maturing loans to financial institutions are higher.

The second measure, the NSFR, has a 1-year horizon and aims at ensuring a sustainable maturity structure of assets and liabilities. The NSFR is supposed to incentivize banks to fund their activities with more stable sources of funding and is defined as follows:

$$NSFR = \frac{Available\ Stable\ Funding}{Required\ Stable\ Funding} \geq 100\% \tag{1.2}$$

Available Stable Funding (ASF) is funding, such as regulatory capital or retail deposits, on which banks are likely able to rely on for a period of one year or longer. Required Stable Funding (RSF) is the part of a bank's balance sheet that could not be monetized within a year. Unencumbered high-quality securities and bonds have therefore very limited funding requirements while institutions' long-term loans have to be funded to a large extent.[21]

The proposals for the LCR and NSFR started an intense public debate among academics and policymakers.[22] Most of these contributions are, however, either of a theoretical or a political nature while there is only limited *empirical* evidence regarding the potential impact of the new standards. The purpose of this thesis is to fill this gap and to shed light on a number of key issues regarding the impact of financial regulation, and especially liquidity regulation, on bank behavior.[23]

[21] Sections 2.5 and 2.6 provide more detail on the two liquidity standards.

[22] See for instance Bindseil and Lamoot (2011), Bini Smaghi (2010), Noyer (2010), MAG (2010a), Perotti and Suarez (2011), Bech and Keister (2013) and many others.

[23] Also see Swank (1994).

This thesis consists of six chapters followed by an epilogue on liquidity stress testing.[24] Although the individual chapters are self-contained, the structure of this thesis is similar to a classic monograph. Chapter 2 provides a general overview regarding the history of liquidity regulation and therefore serves as a more elaborate introduction to the topic. Apart from the historical background, the chapter also provides stylized facts regarding the functioning of liquidity standards and their interaction with capital regulation. The following Chapter 3 is more analytical but still takes a wider, more conceptual view on the interaction of liquidity regulation with the overall institutional environment and analyzes how this interaction affects banks' liquidity risk management. The following two chapters address more specific issues but can still be put in institutional and political context. Specifically, Chapter 4 discusses the interaction of financial regulation with monetary policy while Chapter 5 assesses the impact of financial regulation on banks' demand for government bonds and hence relates to fiscal policy.

Starting with the Basel Committee's first meeting in 1975, Chapter 2 presents the discussions of the BCBS regarding liquidity and specifically focuses on the question why earlier attempts regarding the harmonization of liquidity regulation failed. It also discusses the potential impact of harmonizing capital regulation on banks' liquidity buffers and assesses which role the 2007-08 financial crisis played in overcoming previous obstacles regarding the harmonization of liquidity regulation.[25]

The third chapter is based on Bonner et al. (2014) and uses data for almost 7000 banks from 25 countries. The purpose of this chapter is to highlight the role of several bank-specific and institutional variables in shaping banks' liquidity risk management. The key question is whether the presence of liquidity regulation substitutes or complements banks' incentives to hold liquid assets. Understanding the effects of liquidity regulation on banks' risk management helps policymakers to appropriately design the new liquidity requirements, thereby ensuring that they fit the context in which they will take their effect.

After discussing the impact of liquidity regulation on banks' risk management in a wider context, Chapter 4 zooms in on one of the key questions regarding the interaction of the LCR with monetary policy transmission. Chapter 4 follows Bonner and Eijffinger (2013) and uses detailed data from the Dutch Pillar 1 liquidity requirement as proxy of the LCR. The purpose of the chapter is to analyze the impact of liquidity regulation on interest rates and volumes in the unsecured interbank money market. Since most central banks around the globe use the interbank rate as target for monetary policy implementation, it is important to understand whether the LCR might affect interest rates and volumes in the interbank market. The rationale for central banks to target the overnight rate is the

[24] The epilogue is based on Bonner (2014a).

[25] Chapter 2 is based on Bonner and Hilbers (2014).

view that developments in the interbank money market are transmitted to the real economy. Against this background, Chapter 4 also analyzes whether quantitative liquidity regulation affects the spread of banks' funding costs in the interbank money market and their lending rates to non-financial corporations.

While the aftermath of the 2007-08 financial crisis was characterized by efforts to strengthen regulatory frameworks, the European sovereign debt crisis gave rise to several new issues around banking regulation. The regulatory treatment of government bonds and their interaction with bank behavior was especially subject to discussions. Acharya and Steffen (2013) and Gennaioli et al. (2014), for instance, argue that financial regulation is one of the key drivers of banks' demand for government bonds, which in turn, has adverse effects on banks' role as financial intermediaries.

However, there is very little evidence of whether regulatory treatment is truly the main driver of banks' large holdings of government bonds or whether this is not rather caused by banks' own targets and risk management processes. The correlation between banks' funding and liquidity needs and their compliance with regulatory requirements poses a challenge to establishing a causal link from the various incentives for banks to hold government bonds and their actual holdings. Combining unique transaction-level data obtained from the Markets in Financial Instruments Directive (MiFID) database with DNB's prudential capital and liquidity data, Chapter 5 attempts to distinguish *regulatory* from *internal* effects and aims to answer the question whether financial regulation increases banks' demand for government bonds beyond their own risk appetite. Chapter 5 is based on Bonner (2014b).

CHAPTER 2

Harmonized liquidity regulation - History and stylized facts

Bank capital and liquidity are two intrinsically linked concepts and important mitigants of the risks included in banks' core business. While capital is part of banks' liabilities and therefore a source of funding, liquid assets appear on the other side as a use of funding. Capital can absorb losses; liquid assets can be used to compensate the risk of other funding sources drying up.[1] Although they are usually considered separately, bank capital and liquidity interact in a number of direct and indirect ways or as Goodhart (2009) puts it: *"An illiquid bank can rapidly become insolvent, and an insolvent bank illiquid."*

It should therefore not come as a surprise that the then chairman of the BCBS, George Blunden, stated at its initial meeting in 1975 that the Committee's aim is to ensure adequate capital and liquidity levels of the main international banks. Indeed, when the BCBS was in the process of defining the first globally harmonized capital standards, it also attempted to harmonize liquidity regulation. However, while the BCBS succeeded to introduce global capital standards, known as the Basel Accord or Basel I in 1988, it failed to harmonize liquidity regulation.

While Goodhart (2009, 2011a) provide a comprehensive summary of why the earliest attempts failed, the purpose of this chapter is to provide an overview why after the first attempts in the 1980s, regulators continued to struggle with the introduction of global liquidity regulation and why, in the end, they did succeed. The chapter also provides an analysis regarding the impact of capital regulation on banks' liquidity buffers.

The remainder of the chapter is organized as follows: Section 2.1 provides an overview of the history of global liquidity regulation, while Section 2.2 illustrates why the initial attempts regarding the harmonization of liquidity regulation failed. Section 2.3 sketches the interaction of capital and

[1] See Farag et al. (2013).

liquidity and discusses whether the harmonization of capital regulation had an impact on banks' liquidity holdings. Sections 2.4 to 2.7 illustrate the path to Basel III and the role of the 2007-08 financial crisis. Section 2.8 concludes.

2.1. The history of liquidity regulation from 1975 to 2008

As indicated during its first meeting, the BCBS started to work on both capital and liquidity in 1975.[2] Although initial discussions were more focused on the question which authority - home or host - should be responsible for supervision as opposed to ways of measuring the risk, liquidity remained prominent on the agenda until the 19th meeting of the BCBS in June 1980, where the then Chairman Peter Cooke proposed to discuss liquidity and capital adequacy of international banks.

The Latin American debt crisis, however, pushed liquidity off the agenda until 1984.[3] In 1984, the BCBS established a subgroup on liquidity which was mandated to answer a number of conceptual questions regarding the measurement and management of liquidity risk as well as specific questions about the role of interbank markets and the supervision of liquidity risks of foreign branches.

After first discussions, the work started with the BCBS Secretariat providing a summary of member countries' approaches to monitor banks' liquidity as well as the subgroup issuing a questionnaire regarding the prudential supervision of liquidity risks.

In February 1985, the subgroup presented a full report, which pointed towards a potential over-reliance on money market funds, foreign currencies and central bank facilities. Remarkably, the report recommended the BCBS to take a similar approach for liquidity as it did for capital adequacy: a harmonized minimum standard.

Until then, most policymakers considered liquidity to be too complex as well as bank-specific and therefore it was seen as more appropriate to issue general guidelines as opposed to a harmonized minimum standard. Another important conclusion was that most international banks raise deposits through foreign branches and that, therefore, the overall assessment of liquidity adequacy should be carried out by the home supervisor. Up to this point, the general opinion was that the supervision of liquidity falls under the responsibility of the host supervisor. The initial report was later amended with a new chapter, which introduced the concept of a survival time, reflecting the time an institution can withstand stress without central bank interventions.

[2] The presented facts until 1997 are largely based on Goodhart (2011a). The interpretations and opinions are the author's.

[3] While this chapter focuses on the developments around liquidity, an overview of the Basel I, II and III capital Accords as well as information regarding the Latin American debt crisis can be found in the Appendix.

Although the conclusions of the report suggested further work on liquidity, there was no appetite in the BCBS to develop harmonized liquidity principles or to further investigate the concept of a survival time. Rather, the Secretariat concluded that liquidity issues are a matter for national authorities. A likely reason for this decision was the common view that banks were already under high pressure to reach capital adequacy. A particular problem during that time was the view that liquidity regulation could only be harmonized if central bank collateral frameworks are harmonized as well. Many members considered it essential to closely link the eligibility of an asset in the context of liquidity regulation to its central bank eligibility. Since the definition of central bank eligibility significantly differed across countries, a harmonization of liquidity regulation was considered unfeasible.

Soon after the decision against harmonized liquidity standards, the BCBS still decided to establish another liquidity subgroup, which delivered a new report in 1987 with a focus on assessing the feasibility of a survival period concept. Due to large differences in approaches and the limited availability of data, the report was rather skeptical regarding the introduction of this concept.

Despite this conclusion, the group was still mandated to develop a simple framework for liquidity measurement, which had to be based on existing data and the idea of a survival concept. Interestingly, the described framework showed a number of parallels to the later Basel III LCR. The subgroup recommended to 1) focus on a one and three month horizon; 2) compare the stock of readily marketable securities to net cash outflows, and 3) distinguish between stable retail deposits and more volatile wholesale funds.

Due to other events - especially the introduction of Basel I and issues encountered by the NYSE - the liquidity proposal has never been discussed in detail. Even more so, the subgroup then changed its position and recommended against harmonized liquidity standards. While the key arguments were the lack of harmonized data and the large differences in national approaches, several members questioned whether liquidity regulation is needed in general. Specifically, *"some members (...) questioned whether there was the same (...) need to seek convergence of liquidity regulation compared with capital. They suggested that (...) capital adequacy would itself tend to raise standards of liquidity by inducing banks to hold low-weighted assets."*[4]

Although the critical view on harmonizing liquidity regulation remained within the Committee, the subgroup continued doing some work between 1990 and 1992. The group produced two papers on similar topics as before. Specifically, the group provided a more systematic approach on how to measure and manage liquidity risks and how home and host supervisors should coordinate the liquidity risk assessment in foreign branches.[5] In 1992, the group was dissolved.

[4] See Goodhart (2011a).

[5] See BCBS (1992).

Although both papers have been discussed in several international fora and there seems to have been some appetite for further work, no other papers on liquidity were produced until 2000.
After some further discussions between 1997 and 1999, in February 2000 the BCBS published an updated version of its paper from 1992, which outlined 14 principles. Apart from providing guidance on how banks can improve their internal liquidity risk management, the principles in BCBS (2000) also referred to public disclosure and the role of supervisors.
The focus of the paper was put on incentivizing banks to develop internal structures and processes for managing liquidity risk, measuring and monitoring net funding requirements, managing market access, contingency planning and foreign currency risks.[6]
After the publication of BCBS (2000), liquidity risk had a less prominent role on the BCBS agenda until - in 2004 - the Joint Forum agreed that liquidity risk management was an issue to be studied in more detail.[7] The initial focus was put on reviewing how financial institutions in different sectors manage liquidity risks and the regulatory standards adopted by various jurisdictions. A second focus was the impact of institutions' and supervisors' response to stress events and their impact on systemic risk.
By 2005, the Joint Forum signaled several findings about liquidity risk management. Regarding management policies and structures, it was found that there was a trend towards centralization of liquidity risk management. Also, firms seem to have improved their ability to provide quantitative indicators of their liquidity risk. The most common measures used were liquid asset ratios, cash flow projections and stress tests. Since most indicators only referred to idiosyncratic stress, the Joint Forum suggested that supervisors should explore the reasons why firms did not consider market-wide shocks.
Around the same time, the Institute of International Finance (IIF) established a Special Committee on Liquidity Risk.[8] The objective of this committee was to develop guidelines on liquidity risk management, monitoring, measurement and governance at financial institutions.[9] The main motivation was that *"the liquidity characteristics of international markets have been undergoing significant changes at a time when the industry and the regulatory community have been giving relatively*

[6] A more detailed summary of BCBS (2000) can be found in the Appendix.
[7] The Joint Forum was established in 1996 under the aegis of the Basel Committee on Banking Supervision (BCBS), the International Organization of Securities Commissions (IOSCO) and the International Association of Insurance Supervisors (IAIS) to deal with issues common to the banking, securities and insurance sectors, including the regulation of financial conglomerates. The objective of the Joint Forum is to support banking, insurance and securities supervisors in meeting their regulatory and supervisory objectives and, more broadly, to contribute to the international regulatory agenda in particular where risks exist across or in gaps between the three supervised sectors.
[8] The IIF is the global association of the financial industry. Its members include almost 500 financial institutions (commercial banks, asset managers, hedge funds etc.) from 70 countries.
[9] The guidelines developed by the Special Committee on Liquidity Risk are therefore somewhat related to BCBS (1992, 2000).

greater attention to other issues."[10] IIF (2007) further states that the increased concentration among firms that provide liquidity, the reliance on secured funding markets and the lack of harmonized liquidity regulation suggests that liquidity risk deserves a closer look.

IIF (2007) provides a number of recommendations to financial firms regarding the governance and organizational structure for managing liquidity as well as a framework to measure and monitor the risk. The report also includes guidance regarding stress testing and contingency funding. Interestingly, IIF (2007) also states that the increasing importance of globalized markets and the substantial amount of institutions conducting their business across borders motivates the introduction of harmonized liquidity regulation, including efficient communication between home and host supervisors. However, IIF (2007) also states that *"liquidity regulations should be based on qualitative approaches designed to foster sound enterprise risk management, not prescriptive, quantitative requirements."*

Given the role of the IIF and the close links between IIF (2007) and BCBS (2000), members of the IIF and the BCBS held a meeting to discuss a first draft of IIF (2007). At this meeting, the Committee was asked to provide feedback on IIF (2007) and more specifically regarding the need for liquidity requirements, the impact of complex financial instruments on liquidity risk management, and liquidity risk management's impact on secured funding. Following the meeting with the IIF as well as parallel work of the European Central Bank (ECB) that pointed towards a divergence of approaches to liquidity risk management, both at the level of financial institutions and supervisors, the BCBS setup a new Working Group on Liquidity (WGL), which scheduled the submission of a report for the Committee's meeting in December 2007.

In this meeting, the WGL provided an overview and the main conclusions of their report. First, while there was broad agreement that liquidity supervision is important, practices and objectives varied widely across jurisdictions. Second, contextual factors, such as deposit insurance and central bank lending facilities, greatly influence the level of desired liquidity resilience.[11] Third, there are additional business costs for cross-border banks that arise from nationally determined liquidity regimes. Additionally, in light of the financial turmoil of mid-2007, the WGL emphasized the need to further review liquidity risks in the banking system. In particular, the WGL recommended to update BCBS (2000).

The BCBS agreed to this and the updated version was published in June 2008. BCBS (2008) is based on the same principles as BCBS (2000) but includes a few additions.[12]

Specifically, BCBS (2008) recommends the inclusion of liquidity costs and risks in the process of product pricing, performance measurement, and new product approval. Additionally, BCBS

[10] See IIF (2007).

[11] See Chapter 3 for more details regarding the role of these contextual factors in determining banks' liquidity buffers.

[12] See the Appendix for a more detailed description of BCBS (2008).

(2008) gives a more detailed outline on how to manage liquidity risks of specific items, such as correspondent, custody and settlement activities as well as off-balance sheet commitments and exposures in foreign currencies. Another addition to BCBS (2000) is the guidance on how to assess the health of banks. Suggested measures include both static ratios and forward-looking instruments as well as a few early warning indicators of liquidity risk.
Another new element in BCBS (2008) was the recommendation that banks should not only manage liquidity risk at the individual entity level, but also form a group-wide view of liquidity risk. Additionally, banks are prompted to differentiate between encumbered and unencumbered assets in order to appropriately manage their collateral positions. Finally, BCBS (2008) provides some more detail with respect to stress tests and contingency plans as well as the role of supervisors.

2.2. Key obstacles regarding harmonizing liquidity regulation

With BCBS (1992, 2000, 2008), the BCBS made important progress in the area of harmonizing liquidity regulation for internationally active banks. While these three guidelines aim to improve banks' liquidity risk management, there has also been some appetite throughout the years to introduce minimum standards for liquidity on the same footing as those for capital. The issue of developing minimum liquidity standards has been brought to the table several times and while there were many different reasons, there seem to be three obstacles that have repeatedly hampered the harmonization of liquidity regulation: 1) The lack of supervisory momentum; 2) the view that capital addresses liquidity risks, and 3) the interaction of liquidity regulation and monetary policy implementation.

2.2.1. Lack of supervisory momentum

The emergence of the Latin-American debt crisis and the subsequent shift towards capital was a first indication regarding the importance of a crisis exposing a particular risk for its regulation.[13] Also the fact that the BCBS neglected one of the earlier proposals regarding liquidity with the argument that banks are already under pressure to reach capital adequacy shows that succeeding in the harmonization of a particular risk seems to at least partially depend on supervisory momentum.[14]
The issue of a lack of supervisory momentum becomes particular apparent by the events during the late 1980s. The feasibility of the survival period concept was partially questioned because of limited data availability. With the supervisory momentum of a crisis, regulators are likely to be

[13] Please see the Appendix for somewhat more information on the Latin-American debt crisis and the role it played in the development of Basel I.
[14] Also see Goodhart (2009).

more comfortable regarding burdening banks with additional requests to overcome issues such as limited data availability.

2.2.2. The view that capital addresses liquidity risks

Related to the lack of a global liquidity crisis was the common perception that ensuring capital adequacy also addresses liquidity risks. Two arguments were brought forward to support this hypothesis: First, as long as an institution holds sufficient capital, it will be able to refinance itself in the market or via the central bank at any time and will therefore not face excessive liquidity shortages.[15] Second, requiring banks to hold sufficient capital relative to risk-weighted assets directly incentivizes banks to hold more assets with lower risk-weights, which usually have better liquidity quality. Considering liquidity risk to be a subcomponent of capital risk, reduces the need for liquidity-specific minimum standards.

2.2.3. Central banks and monetary policy

An important determinant of an asset's liquidity is whether or not it is central bank eligible. An asset is central bank eligible if it can be used as collateral for central bank credit operations. For a long time, the BCBS considered fully harmonized collateral frameworks an essential subcomponent of harmonized liquidity regulation. Due to the long tradition and different sentiments around central bank policies in all countries, it is easy to imagine that the harmonization of collateral frameworks is an almost impossible task. Consequently, Goodhart (2011a) argues that the different collateral frameworks of the various central banks around the globe were the main stumbling block in the liquidity negotiations during the 1980s. Being already exhausted by the efforts to find a common approach to capital adequacy, the BCBS considered it unfeasible to additionally harmonize the definition of central bank eligibility. In later years, another issue was the concern of liquidity regulation hampering interbank money markets and therefore monetary policy transmission.[16] Before turning to the more recent events around the harmonization of liquidity regulation and the role of the 2007-08 financial crisis, however, it is important to first understand the interaction of liquidity buffers and capital regulation.

2.3. The interplay of capital and liquidity regulation

Although there are many different views on the actual interaction between liquidity and capital regulation, it is possible to classify these views into two broad categories. The first category considers

[15] See Admati and Hellwig (2013).
[16] See Chapter 4 for more information.

capital regulation to substitute liquidity regulation. Capital regulation incentivizes institutions to hold more assets with low risk-weights. Since assets with low risk-weights usually have good liquidity quality, regulating capital would also regulate liquidity. Related to this is the view that well capitalized banks are better able to attract funding and that high capital levels reduce the risk of bank runs. Again, regulating capital would reduce liquidity risks. Admati and Hellwig (2013), for instance, argue that if institutions are solvent, meaning that the value of the bank's equity remains positive during stress, the central bank can provide liquidity to help the bank overcoming liquidity problems and therefore regulating liquidity might not be necessary.[17]

On the other hand, one might argue that capital and liquidity are both costly and therefore regulating capital might incentivize banks to shift risks to the asset side. The rationale behind this view is that banks will optimize their balance sheets in order to reduce costs. Requiring higher levels of capital is likely to reduce banks' profits, in turn incentivizing banks to adopt riskier strategies and to reduce the holdings of costly liquid assets.[18] The 2007-08 financial crisis suggests that this might have been the case.[19]

Supervisory attention is another factor that might cause negative correlation. When new requirements for one risk are implemented it is likely that banking supervisors pay more attention to this risk, and given limited resources, potentially leading to imprudent behavior in other types of risks. Due to the important role of capital and liquidity for banks' activities and their connectedness with the various risks a bank is facing, it is challenging to develop an analytical view on their interaction. An appropriate starting point for the analysis appears to be the prediction that regulating capital *directly* increases banks' liquidity holdings because assets with lower risk-weights have better liquidity quality. To understand whether there is direct substitution, the first step analyzes the correlation of risk-weighted assets and liquid assets. The following steps take a more conceptual approach and aim at understanding the interaction of liquidity buffers and capital regulation, especially during times of regulating capital more tightly.[20]

[17] Note that the authors argue in favor of an equity ratio between 20% and 25%, which is significantly higher than current levels.

[18] Also see Hellmann et al. (2014).

[19] See the Introduction for more details.

[20] Note that our analysis suffers from a number of shortcomings, which are mainly related to the availability of data. Due to data constraints, the definition of capital and liquidity in the following sections is very narrow. Ideally, one would want to use a risk-weighted capital ratio as opposed to an unweighted ratio akin to the leverage ratio. The definition of liquidity seems appropriate for the Dutch sample, while in the cross-country analysis it would be preferable to also include marketable securities as opposed to only cash and central bank reserves.

2.3.1. Correlation of risk-weighted assets and liquid assets

Table 2.1 shows the correlation between risk-weighted and liquid assets for several countries. Negative coefficients indicate that assets with low risk-weights have high liquidity quality. The data stems from the IMF's International Financial Statistics (IFS) database and includes quarterly observations from Q1 2005 to Q1 2014.

Table 2.1: Correlation of liquid assets and risk-weighted assets

Period	AUS	AT	BE	BRA	CA	DK	FR	GR	IT	NL	US
Correlation	-0.92	-0.25	-0.64	0.91	0.75	-0.29	0.47	-0.06	-0.86	0.28	0.64

Note: The table shows correlation coefficients of liquid assets and risk-weighted assets for individual countries from Q1 2005 to Q1 2014. Liquid assets correspond to the IMF's core measure of liquid assets while risk-weighted assets are calculated in accordance with the Basel capital accords.

The correlation coefficients of liquid assets and risk-weighted assets differ substantially across countries. There are countries, such as Brazil (0.91) or Canada (0.75), with very high correlation coefficients. However, in Australia, Italy and Belgium, the correlation of risk-weighted and liquid assets is below -0.6.

These large differences are likely caused by banks' loan portfolios. While securities receive a similar treatment in capital and liquidity regulation, the risk-weights of loans vary widely. Loans to Public Sector Entities (PSE), for instance, receive risk-weights of 0%. In contrast, loans are not considered to be liquid and therefore receive no liquidity value in the context of liquidity regulation. The rationale behind this different treatment is the different purpose of the two requirements. While risk-weighted assets are intended to mainly capture credit risk, liquidity requirements should address liquidity risks. Loans to government-related entities are unlikely to default but cannot be monetized immediately.

2.3.2. Capital and liquidity holdings of Dutch banks from 1900 to 1990

Figure 2.1 is based on data from DNB (2000) and shows liquidity buffers and capital levels of the Dutch banking sector from 1900 to 1990.[21] Liquidity is defined as the sum of central and regional government debt, central bank reserves, cash and covered bonds (minus a 15% haircut) as percentage of all interbank deposits and 10% of all retail deposits while capital reflects the percentage of equity in total assets.[22]

[21] Note that 1990 is chosen because it is the last year available in this dataset. For all subsequent sections, the latest available data points are used.

[22] Being defined as capital over total assets, the measure for capital is therefore closer to a leverage ratio as opposed to the risk-weighted capital ratio. For the purpose of this analysis, however, the leverage ratio is equally suitable.

Figure 2.1: Capital levels and liquidity buffers of Dutch banks, 1900-1990

a: Liquidity ratio in % b: Capital ratio in %

Note: The figure presents capital levels and liquidity buffers of the Dutch banking system from 1900 to 1990. Liquidity is defined as the sum of central and regional government debt, central bank reserves, cash and covered bonds (minus a 15% haircut) as percentage of all interbank deposits and 10% of all retail deposits while capital reflects the percentage of equity in total assets.

Figure 2.1a shows that banks held small liquidity buffers at the beginning of the 20th century. Between 1920 and 1940, liquidity buffers increased by a factor of 10. This sharp increase is caused by the Great Depression, which led to a rapid expansion of government debt on banks' balance sheets. After 1945, liquidity buffers declined relatively steadily until 1980. From 1985 to 1987, a slight increase can be observed followed by another sharp decline from 82% to 60% between 1987 and 1990.

Another interesting observation from Figure 2.1a is the small spike between 1977 and 1980 when liquidity buffers rose from 59% to 78%. In 1977, DNB introduced its first liquidity requirement. The requirement expected institutions to hold enough cash and government bonds to cover domestic retail and wholesale outflows over a pre-defined stress period. While the rule did not stop the general decline in liquidity buffers, it seems to have slowed it down to a certain extent.

In contrast to liquidity, Figure 2.1b shows that banks have the highest capital levels at the beginning of the 20th century and apart from an increase between 1930 and 1940, banks' capital ratios decline steadily until 1980. Particularly sharp are the declines during both World Wars. From 1986 until 1990, however, banks' capital ratios rise again. Looking at Figure 2.1, it becomes evident that both liquidity and capital holdings have declined between 1950 and 1990. However, they do not seem to be highly correlated with each other. This can also be seen in Table 2.2, which shows that there were periods of high correlation (e.g. between 1960 and 1980) but also periods during which this was not the case. Although one needs to be cautious to draw conclusions in this regard, the graphic analysis shows some evidence that the beginning of the implementation period of Basel I in 1988 stopped the decrease of capital while liquidity buffers declined further.

Table 2.2: Capital and liquidity over time

Period	1900-1920	1920-1940	1940-1960	1960-1980	1980-1990
Liquidity	83	221	593	162	72
Capital	26	24	15	7	4
Correlation	-0.12	0.36	0.30	0.95	-0.07

Note: Liquidity aims at replicating the LCR as precisely as possible. It is calculated as the sum of central and regional government debt, central bank reserves, cash and covered bonds (85%) as percentage of interbank deposits and 10% retail deposits. Capital is calculated as equity in percentage of total assets. Correlation reflects the correlation coefficient of liquidity and capital during the respective period.

2.3.3. Capital and liquidity holdings of Dutch banks from 1982 to 2011

DNB's detailed reporting of capital and liquidity began in 1982. Figure 2.2 presents liquidity buffers and capital levels of Dutch banks from 1982 to 2011. Liquidity is calculated as the sum of cash and government bonds as percentage of retail and wholesale liabilities while capital is calculated as equity in percentage of total assets.

Figure 2.2: Liquidity and capital of Dutch banks from, 1982-2011

a: Liquidity b: Capital

Note: The figure presents capital levels and liquidity buffers of the Dutch banking system from 1982 to 2011. Liquidity is calculated as the sum of cash and government bonds as percentage of retail and wholesale liabilities while capital is calculated as equity in percentage of total assets. In 2003, DNB strengthened its formal Pillar 1 liquidity requirement from 1977, which caused regulatory liquidity to drop. The dashed line is an approximation for the liquidity buffer under the old standard.

While the previous section mainly discussed some general patterns, the focus of this section is the correlation between capital and liquidity after the Basel I (left vertical line, 1988) and Basel II (right vertical line, 2004) Accords.

Figure 2.2a shows that after the Basel I proposal in 1988, banks' liquidity buffers start to decline until the final implementation in 1992 where they seem to stabilize. For capital, the opposite can be observed. Figure 2.2b shows that after a dip, banks' capital ratios continuously rise from 4.2% in 1988 to 5.5% in 1997. Similarly, after Basel II was proposed, liquidity buffers decline from 177% to 165% in 2007 while capital starts once again to rise from 3.9% to 5.1% in 2007.

While Figure 2.1 shows some signs of capital and liquidity being negatively correlated in case only one is regulated, Figure 2.2 provides further evidence supporting this hypothesis. While this pattern is rather clear for the Dutch banking sector, it is useful to complement these findings with a cross-country analysis.

2.3.4. Cross-country capital and liquidity from 1980 to 2009

Figure 2.3 shows capital holdings for four representative countries from 1980 to 2009. Capital describes aggregate equity over total assets. The data stems from the International Financial Statistics (IFS) database. The vertical lines represent the Basel I proposal in 1988. To make numbers fully comparable across countries, all figures are normalized with 1988 being defined as the base value set to 100.

Figure 2.3: Capital levels across countries, 1980-2009 (1988=100)

a: Germany

b: Italy

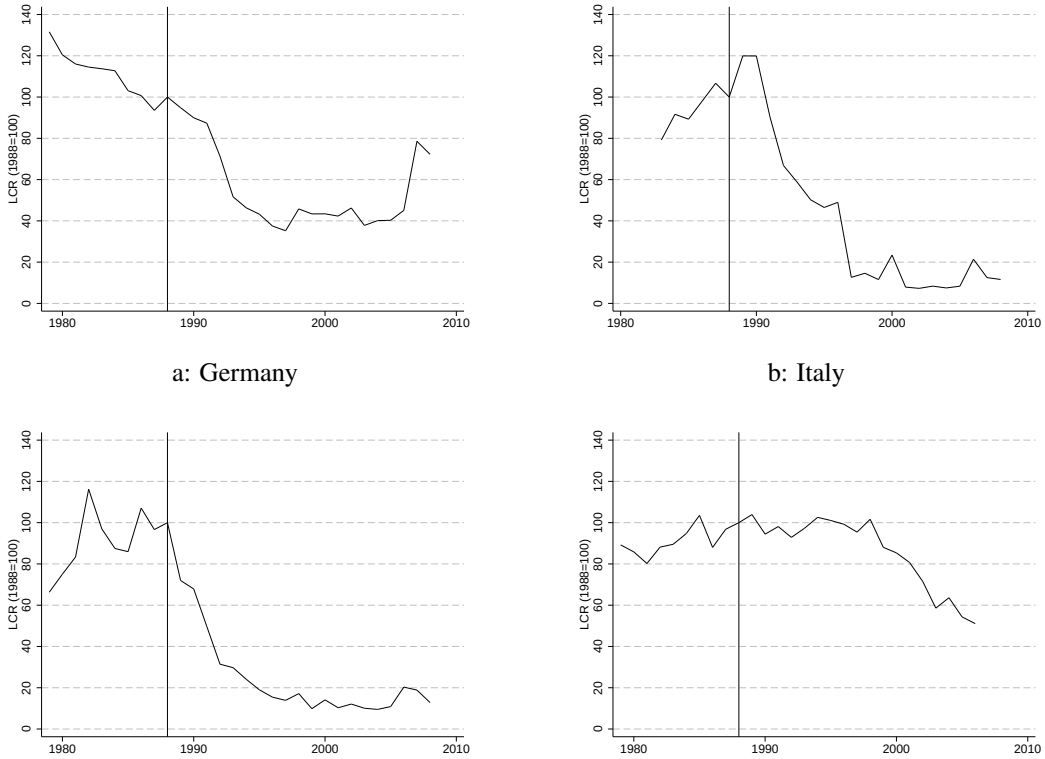
c: Spain

d: United States

Note: The figure presents capital levels of four representative countries from 1980 to 2009. Capital describes aggregate equity over total assets. The vertical line represents the Basel I proposal in 1988. All figures are normalized with 1988 being defined as the base value set to 100.

Starting with Germany, Figure 2.3a shows that capital holdings increase from 100 in 1988 to 110 in 1993 (a relative increase of 10%). Italy's capital ratio (Figure 2.3b) rises by 30% to 130 between 1988 and 1993 and therefore shows significantly larger increases than that of Germany. Figure 2.3c, describing Spain's capital levels, shows more similarities to the developments in Germany. Spain's capital ratio increases by 17% between 1988 and 1990 but then falls again to reach 107 in 1993. Finally, the US capital ratio (Figure 2.3d) shows the largest jump and increases by 50% between 1988 and 1993. Figure 2.3 therefore shows that banks in many countries significantly increased their capital ratios between the Basel I proposal in 1988 and the actual implementation in end-1992.

Figure 2.4: Liquidity buffers across countries, 1980-2009 (1988=100)



a: Germany b: Italy

c: Spain d: United States

Note: The figure presents liquidity buffers of four representative countries from 1980 to 2009. Liquidity is defined as cash and central bank reserves as percentage of the sum of interbank deposits and 10% retail deposits. The vertical line represents the Basel I proposal in 1988. All figures are normalized with 1988 being defined as the base value set to 100.

Turning to liquidity, Figure 2.4 shows liquidity buffers from 1980 to 2009 for the same four countries. Liquidity is defined as cash and central bank reserves as percentage of the sum of interbank deposits and 10% retail deposits. The variable is normalized with the value in 1988 being set equal

to 100. While the pattern is not always fully clear, Figure 2.4 seems to confirm that regulating capital is correlated with declining liquidity buffers.

Figure 2.4a shows that German banks' liquidity buffers decrease by 48% to 52 in 1993. Similarly, Figure 2.4b suggests that Italy's liquidity buffers decrease from 100 to 59, albeit with an increase between 1988 and 1990. Like capital, the pattern for Spain (Figure 2.4c) looks somewhat similar to the one of Germany. Spain's liquidity ratio shows the largest decrease (-70%) from 100 in 1988 to only 30 in 1993. Finally, Figure 2.4d (United States) shows a less clear pattern but still a decrease by 7% between 1988 and 1992.

While the graphic analysis should not be considered fully conclusive, the evidence from the three data sources is rather clear. Both the analysis specifically referring to the Netherlands as well as the cross-country comparison suggest that regulating capital is associated with a decrease in liquidity holdings.

The graphic analysis clearly points to a negative correlation between capital and liquidity as capital was regulated more tightly. To further understand this link, Table 2.3 shows correlation coefficients of liquidity, capital, GDP growth, inflation and long-term interest rates. The data covers 27 countries and the years 1980 to 2008.

Table 2.3: Correlation coefficients over the entire sample and from 1988 to 1992

Entire sample	Liquidity	Capital	Interest rates	GDP growth	Inflation
Liquidity	1				
Capital	0.06	1			
Interest rates	-0.17	-0.22	1		
GDP growth	0.05	0.16	-0.11	1	
Inflation	-0.05	-0.15	0.74	-0.22	1
1988-1992					
Liquidity	1				
Capital	-0.38	1			
Interest rates	-0.12	-0.12	1		
GDP growth	0.09	0.22	-0.24	1	
Inflation	-0.08	-0.03	0.61	-0.25	1

Note: The table shows correlation coefficients of liquidity and capital as well as a number of macroeconomic variables. As in the graphic analysis, liquidity and capital are normalized with 1988 being set equal to 100.

Table 2.3 confirms the conclusions from the graphic analysis. Over the entire sample from 1980 to 2008, capital is somewhat positively correlated with liquidity (0.06). During the implementation period of Basel I from 1988 to 1992, however, the correlation is significantly negative (-0.38). The correlation coefficients of the other variables, however, are fairly similar during the two periods.

The analytical section suggests that regulating capital reduces banks' liquidity buffers. As such, there seem to be arguments to consider them jointly in regulation. With the Basel III proposals, the

BCBS recommends to both tighten capital requirements and to introduce new liquidity standards. The following sections will therefore discuss how the BCBS continued after the publication of BCBS (2008) and which role the financial crisis played in this process.

2.4. Basel III, the financial crisis and supervisory momentum

A few months after the publication of BCBS (2008), the investment bank Lehman Brothers failed. The outbreak of the financial crisis had a direct impact on a number of obstacles which previously hampered the harmonization of liquidity regulation.

Firstly, the financial crisis exposed poor liquidity management and insufficient liquidity buffers which led a number of institutions - despite appropriate capital levels - to fail. While there is a certain degree of interaction, capital itself did not prevent institutions to experience severe losses or failures.[23] The financial crisis showed that capital regulation does not substitute liquidity regulation.

As argued by Goodhart (2011a), another important implication of the 2007-08 financial crisis was that it forced most central banks to rethink their monetary policy frameworks. While the large differences in monetary policy frameworks were a major obstacle in the past, the financial crisis showed that there is probably not one best framework but that the right way of central bank liquidity provision depends on contextual factors. While liquidity regulation should take into account monetary policy frameworks, complete coordination between the two might not be necessary. Related to this, the financial crisis also motivated regulators to reduce the reliance of financial institutions on central banks and therefore harmonizing liquidity regulation might require an agreement on a set of market-liquid assets rather than a more involved harmonization of monetary policy frameworks.

Looking at the discussions of the BCBS during the 1980s and 1990s, it is evident that regulators have been hesitant to additionally burden banks, for instance, with data requests regarding liquidity. The 2007-08 financial crisis clearly led the BCBS to overcome these hesitations. The crisis gave supervisory momentum, making the harmonization of liquidity regulation more likely.

Indeed, about a year after the publication of BCBS (2008) and a few months after the failure of Lehman Brothers, the BCBS started working on the Basel III proposals. There was a fundamental difference between capital and liquidity requirements. With regards to capital, the Committee could build on the existing standards, and make the necessary adjustments in terms of the definition of capital, the formulas for determining risk-weighted assets, and the actual capital ratios. Since it was clear that the definitions had been too loose regarding hybrid forms of capital, and ratios had been too low, this process resulted in a sizeable strengthening of the capital framework, including

[23] See the Introduction as well as the Epilogue for more information.

the establishment of a number of additional capital buffers: the capital conservation buffer, the countercyclical buffer and the systemic risk buffer. In addition, the Committee developed a proposal for a separate leverage ratio.

In order to develop estimates for the new capital requirements, the Top-down Calibration Group (TCG) was established. This group analyzed the financial crisis in detail, with the objective to determine which levels of capital would have prevented the problems that had occurred. Although not an easy exercise, it was at least possible to develop a rough estimate for the level of capital that could be considered sufficient in this context. Together with the results of the first data-driven quantitative impact study (QIS) and the analyses of the Macroeconomic Assessment Group (MAG), the calculations of the TCG became the basis for the new capital requirements.

On the liquidity side, however, things were more complex. To begin with, there was no existing standard and therefore no basis to start with. In addition and in contrast to capital, it is very difficult to conclude from failed institutions how much liquidity they would have needed to withstand the shock they experienced. Once an institution is unable to meet its obligations as they come due, the institution is considered illiquid. However, it is not possible to conclude in this situation how much liquidity the bank would have needed as it is not clear how many additional deposit withdrawals and calls on off-balance sheet commitments the bank would have experienced in the coming days or weeks. Against this background, it was decided to choose a more theoretical approach for liquidity compared to capital. A specialized workstream was mandated to determine outflow rates for banks' liabilities and based on these outflows, how much liquidity banks would need to survive a certain period of extreme liquidity stress without having to resort to the central bank. In light of the funding difficulties experienced by banks, the workstream also developed a framework reflecting banks' structural funding profile. These standards became the basis for the final determination of the Basel III liquidity requirements. Soon after the development of these first standards, the workstream also started working on a QIS for the initial liquidity standards. The goal of the QIS was to assess the impact of the draft liquidity requirements on banks.

The main conclusion from the QIS was that the liquidity standards, included in the July 2009 proposal, would have a large impact on banking activity and financial markets. Although the Committee's intention was to change bank behavior, the report prompted a number of adjustments, which eventually led to the "International framework for liquidity risk management, standards and monitoring" published in December 2010. Specifically, BCBS (2010b) proposed the introduction of the Liquidity Coverage Ratio (LCR) and the Net Stable Funding Ratio (NSFR). The following sections will discuss these two requirements in turn.

2.5. The Liquidity Coverage Ratio

The primary objective of the LCR is to ensure that banks hold sufficient liquid assets, commensurate with their funding liquidity risk, to withstand a stress period of 30 days. This would put banks in a better position to perform their function even during crises and reduce early reliance on central bank facilities.[24] The LCR is based on classic liquidity "coverage" considerations used by banks and some national authorities and is defined as follows:

$$LCR = \frac{High\ Quality\ Liquid\ Assets}{Net\ Cash\ Outflows} \geq 100\% \tag{2.1}$$

High Quality Liquid Assets (HQLA) are comprised of two types of assets. Level 1 assets are of highest liquidity quality and include cash, central bank reserves and a number of marketable securities issued or backed by sovereigns and central banks. Based on BCBS (2010b), Level 2 assets include lower-rated government securities, high quality covered bonds and some corporate debt securities. In contrast to Level 1 assets, Level 2 assets can only be included to a limited extent (40% of total HQLA) and are subject to a haircut of 15%.[25]

Net cash outflows reflect the difference between stressed outflows and assumed inflows. Stressed outflows are calculated by multiplying the size of certain liabilities and off-balance sheet commitments with an assumed outflow percentage. This leads to a moderate outflow of retail and operational corporate deposits as well as substantial losses of most types of wholesale funding. Additionally, the LCR assumes significant calls on off-balance sheet exposures.

Cash inflows are defined as weighted contractual inflows. It is assumed that banks can only rely to 50% on their maturing retail and operational wholesale assets while relative inflows from maturing financial assets are higher. To limit banks' reliance on uncertain inflows, banks need to cover at least 25% of their outflows with HQLA.

As shown by Equation 2.1, banks can meet the LCR standard either by increasing liquid assets or by reducing their exposure to liabilities with higher runoff risks (e.g. short-term wholesale funding). To understand the LCR better, Table 2.4 shows the BCBS (2010b) LCR of a hypothetical bank.[26] It can be clearly seen that the 15% haircut on Level 2 assets compared to the 0% haircut on Level 1 assets reduces a bank's stock of HQLA only to a limited extent. The stronger incentive to hold Level 1 assets is caused by the cap on Level 2 assets (40% of total HQLA), which reduces

[24] There are a number of studies providing overviews of the LCR, e.g. Bech and Keister (2013).

[25] Note that this section refers to the LCR defined in BCBS (2010b). The revised version in BCBS (2013b) includes an additional asset category, called Level 2B.

[26] A similar example for the BCBS (2013b) LCR can be found in the Appendix.

the LCR of the hypothetical bank from 226% to 197%. The rationale behind the cap is to limit banks' reliance on less liquid assets. The weights of banks' in- and outflows, on the other hand, are an important driver of the LCR's denominator. For instance, the hypothetical bank's stable retail outflows are less than its interbank outflows although their total position amounts to a 1,000 and 100 respectively. The cap on inflows reduces the bank's LCR from 226% to 109%. Taking into account all caps, the hypothetical bank does not comply with the LCR requirement of 100%.

Table 2.4: Illustrative BCBS (2010b) LCR example

	Market value	**Weight**	**Weighted value**
Total Level 1 assets			**65**
Cash and central bank reserves	25	100%	25
0% RW government bonds	40	100%	40
Total Level 2 assets			**60**
Covered bonds AA- or higher	25	85%	21.3
20% RW government bonds	25	85%	21.3
Corporate bonds AA- or higher	20	85%	17
Total Inflows			**400**
Retail loans	300	50%	150
Interbank loans	250	100%	250
Total Outflows			**455**
Stable retail deposits	1000	5%	50
Less stable retail deposits	1000	10%	100
Operational corporate deposits	100	40%	40
Non-operational corporate deposits	100	75%	75
Interbank deposits	100	100%	100
Committed undrawn liquidity facilities to banks	50	100%	50
Committed undrawn credit facilities to banks	40	100%	40
Calculation			
LCR without caps	226%		
LCR with Level 2 cap (maximally 40% of total HQLA stock)	197%		
LCR with cap on inflows (inflows cannot exceed 75% of outflows)	109%		
Actual LCR with both caps	**95%**		

Note: The table shows the LCR calculation of a hypothetical bank. For simplicity, it is assumed that all loans and deposits have remaining maturities of less than 30 days so that they fall within the 30 day horizon of the LCR. If remaining maturities exceed 30 days, neither inflows nor outflows emerge. Regarding HQLA, the LCR takes a stock approach and is therefore independent of maturities. The figures are only hypothetical and specifically chosen in such a way that both caps are binding. In practice, the impact of the various caps is likely to be small. For empirical evidence, see EBA (2013c).

2.6. The Net Stable Funding Ratio

After discussing the LCR, this section aims at providing a more detailed description of the second measure, the NSFR. The NSFR has a 1-year horizon and aims at ensuring a sustainable maturity

structure of assets and liabilities. The NSFR is supposed to incentivize banks to fund their activities with more stable sources of funding and is defined as follows:

$$NSFR = \frac{Available\ Stable\ Funding}{Required\ Stable\ Funding} \geq 100\% \tag{2.2}$$

Available Stable Funding (ASF) is funding on which banks are likely able to rely on for a period of one year or longer. Similar to the LCR, ASF is calculated by multiplying balance sheet positions with assumed stability factors. A bank is assumed to be able to rely fully on its regulatory capital and to a large extent on retail deposits. Funding provided by wholesale clients, on the other hand, is assumed to be less stable.
Required Stable Funding (RSF) is the part of a bank's balance sheet that could not be monetized within a year. The funding requirement of a specific asset is determined by its marketability, maturity and duration of encumbrance. Unencumbered high-quality securities and bonds receive therefore very limited funding requirements while institutions' long-term loans have to be funded to a large extent.

Table 2.5: Illustrative BCBS (2010b) NSFR example

	Market value	**Weight**	**Weighted value**
Available Stable Funding			**2195**
Tier 1 and 2 capital	30	100%	30
Stable retail deposits	1200	90%	1080
Less stable deposits	1200	80%	960
Wholesale funding from corporates, PSEs, central banks	250	50%	125
Other liabilities	320	0%	0
Required Stable Funding			**1871**
Cash	25	0%	0
Unsecured actively-traded instruments <1 year	500	0%	0
0% RW Government bonds	25	5%	1.25
20% RW Government bonds	50	20%	10
Residential mortgages with a 35% RW	1000	65%	650
Other retail loans <1 year	1000	85%	850
All other assets	350	100%	350
Undrawn credit and liquidity facilities	200	5%	10
Calculation			
NSFR	**117%**		

Note: The table shows the NSFR calculation of a hypothetical bank.

Similar to Table 2.4, Table 2.5 shows an illustrative example for the BCBS (2010b) NSFR.[27] Although the NSFR takes into account the entire balance sheet, its calculation is less complex compared to the LCR. As can be seen in Table 2.5, the NSFR is simply calculated as the ratio of weighted ASF as percentage of RSF. Again, the weights considerably differ across asset and liability classes. While a bank can take into account 90% of its stable retail deposits, it can only rely on 50% of the funding provided by corporates. Similarly on the asset side, a bank needs to fund government bonds only to 5% while retail lending is assigned a RSF factor of 65%.

2.7. After the first proposal

2.7.1. Public debate

Already during its consultation but certainly after its publication, BCBS (2010b) started an intense public debate about the potential impact of the new reforms.

Taking a more general view, MAG (2010a) and MAG (2010b) analyze the impact of tighter capital and liquidity requirements on an aggregate level. Assuming that the introduction of a liquidity rule leads to an increase of both liquid assets (25%) and maturities of banks' wholesale liabilities, the study finds an increase of 14 basis points in the median lending spread and a fall in lending volumes of 3.2%. BCBS (2010c) follows MAG (2010a) and MAG (2010b) while it additionally takes into account the benefits of the new reform in the form of the emergence of a more stable banking system, leading to a lower probability of banking and financial crises.[28]

Bindseil and Lamoot (2011) discuss the interaction of the LCR with monetary policy implementation. Although the authors acknowledge the rationale behind not drawing a direct link from the LCR to the various monetary policy frameworks, they point out several interactions and argue that care needs to be taken so that the LCR does not hamper monetary policy implementation. While also analyzing the same interaction, Bech and Keister (2013) specifically focus on the impact of the LCR on money market rates and hence on monetary policy transmission. Increasing banks' demand for long-term funding, the LCR might lead to a steepening of the yield curve, potentially making the overnight rate a less useful target rate for monetary policy implementation. To account for this, Bech and Keister (2013) argue that central banks should use long-term interest rates as additional target when implementing monetary policy.[29]

[27] Note that although the BCBS published a consultation paper for the NSFR in January 2014 (BCBS (2014a)), the final NSFR definition is only expected by the end of 2014 and therefore the chapter refers to the 2010 NSFR.

[28] For completeness it needs to be mentioned that MAG (2010a) and MAG (2010b) focus on the transition phase while BCBS (2010c) assumes that the economy is in its steady state.

[29] See Chapter 4, which empirically analyzes the impact of the Dutch quantitative liquidity requirement on interbank money markets.

Using country-specific datasets, De Haan and Van den End (2013), Schertler (2010) and Banerjee and Hio (2014) analyze the impact of a liquidity requirement on banks in the Netherlands, Germany and the UK, respectively. While all studies find some evidence of banks changing their behavior, the introduction of liquidity requirements does not seem to have had a detrimental impact on lending to the real economy or monetary policy transmission.

Apart from these analytical studies, several key monetary policymakers held speeches on the subject.[30] ECB Board member Coeuré (2012) highlighted that the LCR should *"not hamper the functioning of funding markets. This applies in particular to the calibration of the run-off rates for interbank funding and to the asymmetrical treatment of liquidity facilities extended to financial firms."* Governor Noyer (2010) from the Banque de France was more explicit when stating that *"the new liquidity ratios (...) cannot be applied as they stand as they do not take into account all their consequences and interactions beyond the prudential objectives themselves, which include in particular the functioning of the interbank market, the level of intermediation or the conditions of monetary policy implementation."*

In the public debate, which developed after BCBS (2010b), old patterns can be recognized. While most studies found little evidence of liquidity regulation hampering the real economy or monetary policy, monetary policymakers were very concerned about the implications of the LCR. It is likely that the then still recent memories of the events during the 2007-08 financial crisis are the main reason why this sharp rhetoric did not lead to abandoning the LCR.

2.7.2. Developments in Basel

Figure 2.5: Overview BCBS publications regarding liquidity

[30] Also see Schmitz (2012).

Parallel to the public debate, soon after BCBS (2010b) a workshop took place in Basel in which several issues around the LCR and NSFR were discussed. Attendants to this meeting included representatives from 18 central banks as well as the co-chairs of the WGL. The main purpose of the workshop was to understand how banks in the various jurisdictions react to the implementation of Basel III. The general impression was that banks already started to shift towards more stable funding and more liquid assets. At the same time, however, some participants expressed concerns that banks further increased their government bond holdings and also started to issue innovative products, which resembled ABCP. Regarding implementation, regulators were concerned that there was very little explicit guidance. Two interesting questions raised were how to design an appropriate penalty regime, and how to handle issues such as measurement, reporting and transparency in order to avoid liquidity hoarding.[31]

To further analyze the issues raised during the workshop and to observe banks' migration to the new requirements, a second QIS was carried out in late 2011. The main conclusion drawn from this exercise was that banks had improved their LCR while the NFSR remained stable. The Committee pointed out that further analysis was required to assess the impact of excluded assets, the 40% cap on Level 2 assets, and the differences between those banks that already meet the requirements and those that do not.

In light of this, the WGL prepared several notes regarding different features of the Basel III agreement. Specifically, the WGL aimed to clarify issues around the treatment and usability of HQLA. The group recommended to expand the current language regarding the qualitative criteria, to provide additional guidance on the diversification of the HQLA buffer as well as to include language that the LCR requirement has some degree of flexibility, allowing banks to temporarily breach the requirement in times of stress. The rationale behind the latter proposal was to avoid self-fulfilling prophecies and to ensure that banks are actually able to use their HQLA buffer in times of stress.[32]

During the remainder of 2012, the WGL worked mainly on recalibrating the standards as well as to solve issues regarding their practical implementation. Particular attention was given to the interaction of the LCR with monetary policy and a potential widening of the HQLA buffer.

After several months of negotiations within the WGL, the Committee discussed the final package of policy proposals regarding the LCR in September 2012. Apart from the softening of a number of outflow assumptions, the most significant change was the introduction of a new asset category,

[31] In the early stages of the discussions, some policymakers were concerned that the LCR will decrease rather than increase available liquidity in the system. The argument was that strictly requiring banks to maintain a minimum liquidity ratio at all times would prohibit banks to actually use their liquid assets when needed. Also see Goodhart (2011b).

[32] During that time, the WGL also worked on LCR disclosure requirements. See BCBS (2014b).

called Level 2B. The rationale behind the inclusion of Level 2B assets was to address concerns regarding the observed tendency of banks to hoard liquidity, especially in markets with less liquid assets. Level 2B assets include corporate bonds rated A+ to BBB-, listed equities of non-financial corporations and high quality RMBS. Level 2B assets are subject to a 15% cap and also count towards the 40% of the overall Level 2 cap. Apart from RMBS, which receive a 25% haircut, Level 2B assets are subject to a haircut of 50%.

Finally, although monetary policy concerns did not lead to abandoning the LCR, the Committee recognized the issue and included a Restricted Committed Liquidity Facility (RCLF) as Level 2B asset. Initially, the RCLF was designed for countries with a structural insufficiency of liquid assets, like for instance Australia. Eventually, however, it was decided to include two different central bank facilities in the LCR standard: 1) A central bank facility specifically designed for countries with a structural insufficiency of liquid assets. It is the intention that banks in countries that fall under the Alternative Liquidity Approach (ALA) can structurally rely on the central bank facility, while 2) the RCLF is intended to address cyclical shortages. The purpose of the RCLF is to allow central banks to support the LCR during stress. Due to restrictive conditions of this facility, including punitive pricing, it can expected that drawing on the RCLF is only efficient in case banks are not able to attract other HQLA. The RCLF balances the intention to reduce banks' dependence on central bank support during normal times while still recognizing central banks' role as liquidity providers during stress.

In January 2013, the Committee published a final document with the new Basel III Liquidity Coverage Ratio. The final definition of the NSFR is expected by the end of 2014. With the publication of BCBS (2013b), the expected finalization of the NSFR as well as the additional guidance for additional monitoring metrics and intraday liquidity risks, the BCBS has set a milestone for global liquidity regulation. As has been seen in the case of capital standards, the biggest challenge is the development and implementation of a completely new set of standards. Further adjustments are usually less cumbersome.

2.7.3. Remaining issues - Home-Host supervision

The first discussions on liquidity in 1975 focused on who would be responsible to supervise the risk as opposed to ways of measuring it. For liquidity, the accepted regulatory position was that host authorities - familiar with local market conditions and discount facilities - could judge the liquidity position of a bank. Additionally, there was the presumption that each host central bank can create liquidity in its own currency.

Goodhart (2011a) argues that in the absence of harmonized liquidity regulation, most international banks have started to manage their liquidity in a single pool. While this might be more efficient and less costly, there is the risk that liquidity gets trapped at one place and is therefore not available where it is needed.

As Goodhart (2009) states, with large banks being international in life but national in death, harmonized liquidity regulation is likely to lead regulators in host countries requiring banks to hold local liquidity buffers. The tensions between banks managing their liquidity in a centralized manner and the likely intention of host-regulators to require local liquidity buffers is a remaining open issue. BCBS (2014c) provides clear guidance for effective supervisory colleges, intended to improve home-host coordination. The practical implementation of this guidance is now in the hands of regulators in the individual countries.

2.8. Conclusion

This chapter analyzes the development of global liquidity standards, their objectives as well as their interaction with capital standards. Starting with the Committee's first meeting in 1975, this chapter presents the discussions of the BCBS regarding liquidity and specifically focuses on the question of why earlier attempts regarding the harmonization of liquidity regulation failed. The chapter also discusses the potential impact of harmonizing capital regulation on banks' liquidity buffers and assesses which role the 2007-08 financial crisis played in overcoming previous obstacles regarding liquidity regulation.

The analysis suggests that regulating capital was associated with declining liquidity buffers. The fact that capital and liquidity are very costly for banks is a potential reason for this effect. Another potential explanation is that under the pressure of reaching capital adequacy, both banks and regulators neglected liquidity risks. Finally, declining liquidity buffers might partially be caused by banks' rational choices. While capital alone does not address liquidity risks, it does improve banks' opportunities to fund themselves in the market and makes bank runs less likely. However, the financial crisis showed that, independent of the specific reasons, banks' liquidity buffers were too low. Even high capital levels were not a substitute for prudent liquidity risk management and buffers.

While there were a number of reasons, there are three factors which seem to have significantly hampered the harmonization of liquidity regulation. The first stumbling block was the view that central bank eligibility is the most important determinant of an asset's liquidity. As such, it was thought that harmonizing liquidity regulation would require a harmonization of collateral frameworks as well. Since banks and regulators were already under pressure to enhance capital adequacy, an additional harmonization of collateral frameworks was considered unfeasible. Another important point was the view that regulating capital would also address liquidity risks since it incentivizes banks to hold assets with lower risk-weights, which often coincide with high liquidity quality. On top of that, better capitalized banks are better able to refund themselves in the market. Finally, and related to the previous two issues, was the lack of supervisory momentum. For many years, regulators were hesitant to burden banks with additional work regarding liquidity.

Throughout its history, the BCBS has been on the verge of harmonizing liquidity regulation a few times. With many different interests around the table, it seems to be that supervisory momentum is needed to truly succeed in introducing completely new regulatory frameworks. The Latin American debt crisis had a major impact on capital adequacy while the 2007-08 financial crisis has given enough supervisory momentum to reach harmonized liquidity regulation. The proposal for the LCR and NSFR was a major step for the BCBS in terms of enhancing the effectiveness of supervision. Their practical implementation by banks and supervisory authorities is one of the big challenges for the coming years.

For an effective implementation of the liquidity standards, it is important to account for the fact that the need for and the reaction to liquidity regulation differs across jurisdictions. Against this background, Chapter 3 provides an analysis regarding the impact of banks' operating environment on their liquidity risk management and how this interaction is affected by the presence of liquidity regulation.

Appendix

The Basel I, II and III capital Accords

Despite the initial objective to harmonize both liquidity and capital regulation, capital adequacy (specifically in relation to credit risk) soon became the main focus of the Committee's work after its establishment in 1975. Eventually this led to the adoption of Basel I in 1988.

BCBS (2013a) argues that since it raised concerns that the capital ratios of the main international banks were deteriorating at a time of growing international risks, the onset of the Latin American debt crisis was the main reason for the Committee to shift its focus towards capital. Looking at the events during this crisis, the Committee's bias towards capital seems justified. When oil prices sharply increased, petroleum-exporting countries - then rich in cash - invested their money in international banks, which in turn issued short-term loans to Latin American governments. When interest rates increased in 1979 the respective countries struggled to repay their debt, eventually leading to Mexico declaring default in August 1982.

After Mexico's default, most commercial banks stopped rolling over their assets to Latin American governments. Since these loans were typically short-term, several Latin-American countries ran out of funding very quickly. A borrower not being able to repay its loan, like Mexico, is a classic case of credit risk, which in turn calls for sufficient levels of capital to absorb these losses. Increased attention to capital adequacy caused by the Latin-American debt crisis seems therefore justified. From a liquidity perspective, it is notable that banks have issued short-term loans, allowing them to stop lending and therefore to avoid major losses on non-performing loans. Liquidity supervision usually incentivizes banks to issue more short-term loans.

After several years of negotiations and public consultation, the BCBS issued the Basel Capital Accord in July 1988 that was supported by its 11 member countries and Luxembourg.[33]

Basel I proposed a minimum capital ratio (capital to risk-weighted assets) of 8%. With a view on swift regulatory convergence, national authorities were expected to prepare frameworks allowing a final implementation by the end of 1992. Right before the implementation in national frameworks, however, the Capital Accord was amended aiming at improving the definition of loan loss provisions.

In 1995 and 1997, the Accord was subject to further changes, which focused on the recognition of the effects of netting agreements in derivative contracts as well as a widening of the initially narrow focus on credit risk, reflected by the Market Risk Amendment.

In June 2004, the Committee released the Revised Capital Framework, commonly referred to as

[33] Belgium, Canada, France, Germany, Italy, Japan, Netherlands, Sweden, Switzerland, United Kingdom and United States.

"Basel II". The new framework consisted of three pillars: Pillar 1) The minimum standards from Basel I; Pillar 2) Supervisory review of an institution's capital adequacy and assessment processes, and Pillar 3) disclosure requirements.[34]
The new framework aimed at addressing financial innovation but also by encouraging continued improvements in banks' own risk measurement and control processes. In June 2006, the BCBS extended the initial Basel II framework - which focused on the banking book - by a trading book perspective.
In December 2010, the BCBS proposed a new capital framework "Basel III: A global regulatory framework for more resilient banks and banking systems", which was updated in June 2011. Apart from raising the required capital levels (e.g. with an increase of the common equity ratio to 4.5%), Basel III aims at increasing the quality of banks' capital. Against this background, BCBS (2010a) specifies that the predominant form of Tier 1 capital must consist of common shares and retained earnings. The remainder of Tier 1 capital can be comprised of subordinated instruments with simple coupons. Hybrid capital instruments (previously limited to 15% of the Tier 1 base) and Tier 3 capital instruments will be phased out.
Finally, Basel III also includes a non risk-based leverage ratio that is calculated as capital in percentage of total exposure (includes off-balance sheet exposures). The minimum Leverage ratio is set to 3%.

Sound Practices for Managing Liquidity in Banking Organisations

BCBS (2000) outlines 14 principles providing guidance on how banks can improve their internal liquidity risk management as well as principles on public disclosure and the role of supervisors.
The focus of the paper is laid on incentivizing banks to develop internal structures and processes for managing liquidity risk, measuring and monitoring net funding requirements, managing market access, contingency planning and foreign currency risks.
In developing a structure for liquidity management, the BCBS stressed the importance of an agreed strategy outlined by banks and adequately communicated throughout the organization. A board of directors ought to approve this strategy and ensure its implementation. The specifically appointed individuals in charge of managing the liquidity strategy should set liquidity risk limits in accordance with the bank's size and complexity, which in turn should be reviewed by supervisors. Banks should analyze their stress resistance under different scenarios and are expected to have information systems in place, which should be used to check whether the bank complies with its own policies.

[34] Labeling these three components of the regulatory framework as Pillar 1, Pillar 2 and Pillar 3 became general supervisory practice.

Regarding the measurement and monitoring of net funding requirements, the BCBS urged banks to carefully assess cash inflows against outflows to identify potential shortfalls. Banks should make sound assumptions about future funding needs. The BCBS suggested a maturity ladder as a device to compare cash inflows and outflows within different time horizons. Moreover, banks should use several scenarios in order to evaluate the behavior of cash flows under different conditions. For this task, the BCBS outlined some guidelines as to how to treat different assumptions made about different parts of the bank's balance sheet. An important remark made by the BCBS is the careful assessment of off-balance sheet activities, which can constitute a significant drain on liquidity in times of stress.

With respect to managing market access, the BCBS stressed the importance of maintaining sound relationships with liability holders, and to appropriately diversify liabilities, as to provide the bank with a line of defense against liquidity problems.

Banks were also expected to develop contingency plans outlining a strategy of action in case of emergency situations. The contingency plan should set out clear responsibilities and identify ways to attract funding in adverse situations. Secondary sources of funding should be outlined and the bank should calculate as accurately as possible the amount of funds that could be drawn from these sources. However, the BCBS warned banks not to rely too much on these secondary sources of funding.

In addition to ongoing liquidity management, and in light of the currency market problems of the 1990s, the BCBS pointed out the importance of foreign currency liquidity management. The paper suggested that banks should appropriately measure and monitor its positions in the currencies in which they operate. Exchange rate risk can be a significant threat on the bank's liquidity. The BCBS recommended that banks target lower foreign currency mismatches compared to domestic currencies.

After having outlined the general principles of liquidity risk management, the BCBS suggested that banks place internal control systems to ensure the liquidity risk management process is being executed flawlessly. Such internal controls should promote reporting to the relevant authorities and compliance with laws and regulations. Additionally, banks should have a mechanism for the appropriate disclosure of information, both to the general public and to particular creditors and counterparties. Dealing with the press and media broadcast in times of stress is of utmost importance to manage market perceptions of the bank.

BCBS (2000) concludes by outlining the role of supervisors. Supervisors should evaluate banks' strategies and policies independently, and verify that the 13 principles are followed. In addition to assessing liquidity risk, the supervisor must examine the capital adequacy of the bank. Finally, the BCBS recommended that the supervisors also have their own contingency plans in case of stressful situations being experienced by a particular bank or by the market as a whole.

Principles for Sound Liquidity Risk Management and Supervision

BCBS (2008) is based on the same principles as BCBS (2000) but includes a few additions. First, BCBS (2008) recommends the inclusion of liquidity costs and risks in the process of product pricing, performance measurement, and new product approval. This ought to be done for all significant business activities, including those that may not have an immediate effect on the balance sheet. The analytical framework should be reviewed in line with changing market conditions.
Second, regarding the measurement and management of liquidity risk, BCBS (2008) gives a more detailed outline on how to manage liquidity risk for positions held on specific items. These items are: all future cash flows of assets and liabilities, off-balance sheet positions, all currencies in which the bank is active, and correspondent, custody and settlement activities.
Another addition to the original text is the guidance on how to assess the health of banks. Suggested measures include both static ratios as well as forward-looking instruments. Such measurements should be adapted to the size, risk profile and business strategy of the bank. Additionally, BCBS (2008) outlined a few early warning indicators of liquidity risk. A few examples are rapid asset growth, increase in currency mismatches, a decrease in the average maturity of liabilities, negative publicity, credit downgrades, or increasing retail deposit outflows.
A very important augmentation compared to BCBS (2000) is the suggestion that banks should not only manage liquidity risk at the individual entity level, but also aggregate data to give a group-wide view of liquidity risk. Banks with branches and subsidiaries in third countries face additional contagion risks across borders. Banks should be aware of country-specific circumstances and set internal limits on intragroup liquidity risk.
Additionally, banks are prompted to differentiate between encumbered and unencumbered assets in order to manage their collateral positions. Banks should assess the central bank eligibility of each asset class and have a thorough understanding of the amount of time it would take to liquidate certain assets.
BCBS (2008) also provided some more detail with respect to stress tests and contingency plans. It was recommended that stress tests are performed regularly, and that the results are actively integrated in banks' liquidity risk management strategies. Stress tests should take into account several time horizons and banks should use a range of assumptions adequate to the size and business structure of the bank. Banks should also consider the potential behavioral response of counterparties under the assumed stress situations, and be aware of the fact that a stress event could affect their customers' use of intraday liquidity, threatening the liquidity position of the bank.
Regarding public disclosure, BCBS (2008) extends BCBS (2000) by outlining some suggestions on the qualitative information to be disclosed by banks, such as the aspects of liquidity risk in which the bank is involved, the assumptions used in the measurement of risk and the limits imposed on liquidity positions.

Finally, with respect to the role of supervisors, BCBS (2000) is augmented in three main pillars. First, supervisors are required to not only perform independent evaluations, but also to supplement their assessments using banks' internal and prudential reports as well as market information. Second, supervisors are prompted to intervene, demanding that the bank carries out remedial action if necessary. And third, supervisors should communicate regularly with each other but also with other public authorities, such as central banks. This communication ought not to be restricted to their own borders, but also performed cross-nationally.

Table A2.1: Illustrative BCBS (2013b) LCR example

	Market value	**Weight**	**Weighted value**
Level 1 assets			
Cash and central bank reserves	25	100%	25
0% RW government bonds	40	100%	40
Level 2A assets			
Covered bonds AA- or higher	25	85%	21.3
20% RW government bonds	25	85%	21.3
Corporate bonds AA- or higher	20	85%	17
Level 2B assets			
RMBS AAA	10	75%	7.5
Corporate bonds between A+ and BBB-	10	50%	5
Inflows			
Retail loans	300	50%	150
Interbank loans	120	100%	120
Outflows			
Stable retail deposits	1000	3%	50
Less stable retail deposits	1000	10%	100
Operational corporate deposits	100	20%	20
Non-operational corporate deposits	100	40%	40
Interbank deposits	50	100%	50
Committed undrawn liquidity facilities to banks	50	100%	50
Committed undrawn credit facilities to banks	100	40%	40
Calculation			
LCR	**122%**		

Note: The table shows the LCR calculation of a hypothetical bank. For simplicity, it is assumed that all loans and deposits have remaining maturities of less than 30 days so that they fall within the 30 day horizon of the LCR. If remaining maturities exceed 30 days, neither inflows nor outflows emerge. Regarding HQLA, the LCR takes a stock approach and is therefore independent of maturities.

CHAPTER 3

Banks' liquidity buffers and the role of liquidity regulation

The LCR and NSFR are likely to affect banks' liquidity risk management in a number of ways. To ensure a successful and efficient implementation, it is important to understand the fundamental determinants of banks' incentives to hold liquid assets and whether these determinants are affected by liquidity regulation. Focusing on banks' operating environment, the purpose of this chapter is to provide the first global analysis of the determinants of banks' liquid asset holdings across countries. At the very heart of the analysis lies the question of whether or not the presence of liquidity regulation substitutes banks' internal incentives to hold liquid assets.

Closest to this chapter are the papers by Aspachs et al. (2005) and Delechat et al. (2012). However, both studies use limited datasets; the former a panel of 57 UK-resident banks and the latter a sample of Central American banks, and focus solely on the determinants of banks' liquidity holdings rather than the additional impact of liquidity regulation.[1]

The analysis is based on yearly balance sheet data for nearly 7000 banks from 25 OECD countries over a ten-year period.[2] While the analysis includes bank-specific, macroeconomic and financial development variables, this chapter's focus is laid on the impact of banks' operating environment, described by the strength of existing deposit insurance systems, the concentration of the banking sector and banks' disclosure practices. All three variables have recently received considerable attention from policymakers and academics in the context of reform proposals to strengthen the

[1] Dinger (2009) and Gennaioli et al. (2013) are other recent studies dealing with banks' liquidity holdings. The former analyzes the impact of transnational banks on system-wide liquidity risks while the latter analyzes the holdings of public bonds and the role of these bonds during sovereign debt crises.

[2] Note that the usual trade-off between broad country coverage and data granularity applies. While this chapter draws on data with broad country coverage, Chapters 4 and 5 are examples of using more granular data.

resilience of banks to liquidity risks.[3]

The Generalized Methods of Moments (GMM) estimation reveals that without liquidity regulation, banks' liquidity buffers are determined by a combination of bank-specific and country-specific factors. The presence of liquidity regulation substitutes most of these factors, making them insignificant determinants of liquidity buffers. An institution's disclosure requirements and the concentration of the banking sector, on the other hand, are important factors in the presence of liquidity regulation.

There is also suggestive evidence that while the presence of liquidity regulation is not associated with generally higher liquidity buffers, it reduces the volatility of banks' liquidity holdings. On top of that, banks subject to liquidity regulation seem to have maintained higher liquidity buffers during the 2007-08 crisis but also reduced their lending volumes. The results can be interpreted as being supportive of liquidity regulation itself but also regarding the BCBS' decision to allow banks to fall below a 100% LCR during stress, making potential unintended consequences regarding lending to the real economy less likely.

A key take away from this chapter is that when implementing the LCR as well as Pillar 2 liquidity frameworks in national legislation, policymakers need to take into account that the need for and the reaction to liquidity regulation differs across banks as well as jurisdictions. Therefore care needs to be taken in tailoring the new liquidity requirements to fit the context in which they will take their effect.[4] Especially the European Union with its mixture of national and union-wide rules and responsibilities seems to face a challenge of appropriately balancing union-wide harmonization with allowing some national discretion.

Specifically, regulators should pay attention to disclosure requirements when specifying Pillar 2 liquidity frameworks as well as the accompanying guidelines to the Basel III liquidity rules. The reciprocity of disclosure and liquidity requirements provides strong arguments for regulators to jointly harmonize disclosure and Basel III liquidity requirements across countries.

The remainder of this chapter is organized as follows: Section 3.1 provides background regarding liquidity regulation in various countries and also introduces the key variables. Section 3.2 presents the data, to be followed by the results and corresponding discussions in Sections 3.3, 3.4 and 3.5. Section 3.6 concludes.

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[3] See BCBS (2014b) for disclosure, Demirgüç-Kunt and Detragiache (2002) for deposit insurance coverage and Aspachs et al. (2005) for concentration.

[4] See, for instance, Chapter 4 which shows that jurisdictions which implement monetary policy using the overnight interest rate face different challenges when implementing the LCR than jurisdictions for which this is not the case.

3.1. Conceptual background

3.1.1. Liquidity regulation across countries

Since liquidity regulation is not harmonized globally, the banks in this chapter's cross-country sample face different liquidity requirements. In the sample used in this chapter, regulators in France, Germany, Ireland, Korea, Luxembourg, the Netherlands and the United Kingdom, apply quantitative liquidity requirements.[5]

The French and German requirements are very similar. Already introduced in 1969, the German liquidity requirement has been subject to major updates in 1997 and 2006. Since the update in 1997, German institutions are required to hold liquid assets at least equal to total liabilities coming due within one month. Liquid assets are defined as the sum of expected cash inflows from assets coming due within one month and marketable securities. Marketable securities are, for instance, government bonds and high quality covered bonds. The calculation of the requirement as well as the underlying assumptions are very similar to the LCR. Analyzing the behavior of German banks subject to the liquidity requirement, Schertler (2010) finds that commercial banks purchase significantly more liquid assets and somewhat reduce lending once they get close to their regulatory threshold. Given that - depending on size and type - between 22% and 53% of banks are close to the threshold, the German requirement seems to be regularly binding for a significant number of banks. In France, banks have to maintain a "Liquidity Ratio" at least equal to 1 at all times. Similar to the German requirement, the ratio is calculated as the sum of market liquid assets and assumed cash inflows as share of assumed cash outflows over one month.

The Irish requirement was introduced in 1995 and updated in 2009. The original requirement expected institutions to maintain a minimum ratio of liquid assets to total borrowing of at least 25%. The definition of liquid assets is in line with the requirements in other countries and therefore includes cash, government securities as well as balances with central banks.

The Korean requirement was introduced just before 1997 with updates in 1999 and 2002. The requirement is formulated as a ratio, expecting banks to have enough liquid assets to cover liabilities within a 3 month horizon. Liquid assets include the stock of marketable securities as well as assumed inflows from maturing assets. According to Lee (2013), the regulatory liquidity ratio in Korea has been raised in 2002 and 2004. The rule was usually revised to send warning signals in case a large number of banks fell below regulatory or precautionary levels. This behavior by the regulator and the underlying rationale suggests that the Korean rule has been binding several times both on the individual and the aggregate level.

[5] See Bundesbank (2006), BDF (1988), CBI (2009), Lee (2013), CSSF (2007), DNB (2003), BOE (2013) for more information regarding the requirements in the individual countries. See Algorithmics (2007) for an overview.

The liquidity requirement of the Luxembourgian supervisory authority CSSF dates back to 1993 and was updated in 2007. The requirement is also reflected by a ratio, which reflects liquid assets as percentage of current liabilities. Banks have to maintain a ratio of at least 30%.

De Nederlandsche Bank (DNB) introduced its first liquidity requirement in 1977, which was revised in July 2003. The requirement is calculated as the difference between banks' Actual Liquidity (AL) and Required Liquidity (RL) over a 7 and a 30 day stress horizon. AL is defined as the sum of liquid assets and assumed inflows. RL is comprised of moderate retail and substantial wholesale outflows as well as significant calls on contingent liquidity lines. Apart from cash, government bonds and highly rated covered bonds, the Dutch requirement also includes most central bank eligible securitizations as liquid assets. At introduction, a significant number of institutions were non-compliant with the requirement. But, while individual shortages still occur, there has not been an aggregate shortage since 2004. De Haan and Van den End (2013) argue that Dutch banks seem to hold precautionary liquidity buffers above the levels strictly required by the regulation.[6]

Finally, the liquidity requirement in the United Kingdom mainly aims at limiting maturity mismatches. Specifically, the Prudential Regulatory Authority (PRA) sets institution-specific limits for the maximum net-cumulative mismatch as percentage of total deposits over a 8 and a 30 day horizon. On top of that, banks are required to hold a minimum amount of high quality liquid assets, which includes, for instance, cash, central bank reserves or UK government bonds. According to recent work by Banerjee and Hio (2014), UK banks seem to have significantly increased their holdings of liquid assets once they became subject to the requirement. Further, banks seem to have reduced their share of financial assets and short-term wholesale funding. BOE (2013) further suggests that at least individual institutions seem to become non-compliant from time to time, forcing them to use their liquid asset buffer but also to return to compliance in a timely manner.

In conclusion, most liquidity requirements follow the same logic, but also have some differences. Importantly, however, cash, government securities and short-term assets are considered as liquid assets in all requirements.[7] As such, these assets are considered liquid for the purpose of this analysis. Central bank reserves are specifically excluded because, although they are - apart from Korea - included in all regimes, their treatment is very different in the various countries.[8] For the denominator, total assets are considered most appropriate.[9]

[6] See Chapters 4 and 5 for more information on the Dutch liquidity requirement.

[7] See Gennaioli et al. (2014) who provide a similar argumentation for banks' reserve requirements.

[8] The largest difference regarding central bank reserves stems from the treatment of the minimum reserves banks are required to deposit at the central bank. While some jurisdictions allow banks to add minimum reserves in full to their liquidity buffer, other jurisdictions only allow reserves in excess of the reserve requirement. Since the dataset does not distinguishing the two types of reserves, central bank reserves are not considered part of banks' liquidity buffers.

[9] Denominator definitions differ substantially across the various requirements. Requirements either do not include any weighting or show large differences regarding the treatment of institutions' liabilities.

3.1.2. Key variables - Contextual determinants

This section discusses the likely impact of the three key contextual factors on banks' liquid assets holdings and how the role of these factors might change due to the presence liquidity regulation.

Concentration and size

There is a vast literature on bank concentration and bank size. The empirical evidence presented in this literature shows conflicting predictions. Beck et al. (2006) and Beck (2007) show, for instance, that concentrated banking systems tend to have larger, better-diversified banks. A more concentrated banking system therefore implies that banks have more opportunities to fund themselves. This, in turn, would be expected to reduce the need for large liquidity buffers. On the other hand, a more concentrated banking system might also imply less competition and therefore higher franchise values and less incentives for excessive risk taking, which can be assumed to increase banks' liquidity buffers.[10]

Depending on the measure of concentration, there is a link between concentration and bank size. Most theories regarding bank concentration assume that higher concentration implies a smaller number of large banks as opposed to a larger number of small banks. In fact, however, many concentrated banking systems are characterized by a few large banks and many small banks.[11] Since this chapter uses the concentration measure of Beck et al. (2008), reflecting the share of the largest three banks' assets in total banking system assets, it is necessary to additionally account for banks' size. Similar to concentration, bank size involves conflicting theoretical predictions. Boyd and Runkle (1993) and Mishkin (1999) argue that large banks are more likely to receive public support during stress, thus reducing the effective liquidity risk faced by these institutions. Repullo (2003) confirms this, when showing that the strength of the financial safety net lowers the incentives for banks to hold liquid assets. Using a panel of 57 UK resident banks, Aspachs et al. (2005) confirm this result when arguing that the likelihood of receiving support by the Lender of Last Resort reduces banks' liquidity holdings. A bank's size can also have a negative effect on liquidity holdings because large banks can be expected to have less volatile cash flows (due to offsetting flows) and better access to different funding sources. On the other hand, given their special role in the economy, large banks might be particularly prone to peer and supervisory monitoring.

Liquidity regulation is likely to make concentration and size less important determinants of banks' liquidity buffers.[12]

[10] See Allen and Gale (2000, 2003).

[11] From a macroeconomic perspective, it seems justifiable to assume that concentration implies a small number of large banks. However, since this chapter uses bank-level data, it is important to take into account that higher concentration could imply a large number of very small banks, which react in the opposite way than the few large banks.

[12] Also see Farag et al. (2013).

Disclosure

The banking literature frequently associates disclosure practices with market discipline. Greater transparency allows market participants to price institutional strategies more accurately and therefore deter socially excessive risk taking by financial institutions.[13] In a market environment characterized by low transparency, financial institutions may find it profitable to adopt riskier strategies off the back of uninformed customers or investors. By similar reasoning, it is expected that a bank, which is subject to low disclosure requirements to manage liquidity risk less prudently, thus reducing the size of its liquidity buffer. With a liquidity requirement in place, disclosure might become more important. A quantitative liquidity requirement gives investors a clear indication whether a bank's liquidity holdings are sufficient, which is likely to enforce liquidity requirements.

Deposit insurance

One would expect the reliability and coverage of the deposit insurance system to lower banks' liquidity risk exposure and, hence, their liquidity buffers. As argued by Beck et al. (2006), a large literature indicates that deposit insurance creates incentives for banks to increase risk taking.[14] Ceteris paribus, increasing deposit insurance coverage should reduce the likelihood of retail bank runs, an extreme form of liquidity shock. The presence of liquidity regulation is likely to substitute the role of deposit insurance coverage, thus reducing its importance.

Additional bank-specific and macroeconomic variables

Along with the "contextual" factors, the analysis includes several bank-specific, macroeconomic and financial development control variables. Regarding profits, Delechat et al. (2012) find a negative impact on banks' liquid asset holdings while Aspachs et al. (2005) do not find significant effects. Delechat et al. (2012) argue that it is easier for more profitable banks to fund themselves, which makes them less liquidity constrained, thus reducing the incentives to hold liquid assets. A similar result is likely to hold for capital, as more solvent banks can be expected to have market access (at least to a point) even during stress.

Banks face a trade-off between self-insurance against liquidity risks and opportunity costs of holding liquid assets. The macroeconomic situation can help explaining how this trade-off is solved. Delechat et al. (2012), for instance, discuss the cyclical behavior of liquidity demand. The authors argue that liquidity buffers should be negatively related to real GDP growth, the credit cycle and policy interest rates. Such counter-cyclicality would limit the effectiveness of monetary policy: if

[13] See for instance Jordan et al. (2000) or Nier and Baumann (2006).

[14] See, for instance, Sharpe (1978), Flannery (1989), Chan et al. (1992) or Demirgüç-Kunt and Detragiache (2002).

central banks inject liquidity to stimulate the economy, liquidity buffers would increase but credit would not necessarily pick up. This discussion is in line with Aspachs et al. (2005) who find that liquidity buffers are negatively related to GDP growth and the policy rate. Similarly, Agénor et al. (2004) find that excess reserves are negatively related to the output gap.
The stronger the presence of capital market frictions, the stronger the counter-cyclicality of liquidity buffers. Thus, Delechat et al. (2012) find that financial development and the quality of institutions have a significant effect on banks' holdings of liquidity. A further argument for the importance of financial development for liquidity buffers can be found in Almeida et al. (2004) who show that financially constrained firms have a higher propensity to save cash. Hence, one could argue that lower levels of financial development imposes financial constraints on banks, which presumably increases banks' liquidity holdings.

3.1.3. Institutional liquidity risk versus systemic risk

There is no direct mapping between this chapter's findings concerning banks' individual liquidity management and aggregate financial risk. The observation that "variable *x* reduces banks' liquidity buffers" is not synonymous to "variable *x* increases aggregate liquidity risk". A bank's choice to reduce the size of its liquidity holdings may be an *individually* optimal response to a *reduction* in economy-wide liquidity risk, proxied by a variable such as the coverage of deposit insurance. The net effect of both on the aggregate risk in the domestic financial system may be positive or negative and therefore this individually rational behavior may not be socially optimal. This chapter focuses, however, exclusively on documenting the ways in which banks respond to features of their business and policy environment and therefore an empirical characterization of the deviation of banks' liquidity management from the social optimum is beyond the scope of this chapter.

3.2. The data

3.2.1. Data sources and variable construction

The analysis in this chapter includes bank-specific, annual balance sheet data for all reporting banks from Bureau van Dijk's *BankScope* database in current local-currency units for the period from 1998 until 2007 for 25 OECD countries. The end date of the sample is set to capture the period before the global financial crisis which started in mid-2007.[15] Considering this period reduces the risk of unobserved underlying heterogeneity in domestic banking regulation across OECD

[15] There are arguments in favor of incorporating the recent crisis period. However, this chapter focuses on banks' incentives to hold liquid assets during normal times. Additionally taking into account a crisis period would weaken the explanatory power of the results as the "clean" incentive effect would be distorted by crisis related factors.

countries, which was at least partially harmonized by Basel I, while being able to analyze banks' liquidity management in "normal" times.

The data is checked for errors, inconsistencies and changes in definitions and converted values into constant (2005) US dollars, using the appropriate exchange rates and the US GDP Deflator. The analysis only includes banks for which at least 5 bank-year observations are available, which ensures sufficient intra-institutional variation. Wherever possible, the analysis uses data recorded under the IFRS accounting standard.[16] The majority of banks are located in Germany followed by France. To limit the dependence on a particular country, however, only the 600 largest institutions of both countries are considered.

The contextual factors are collected by the World Bank and the IMF – combining quantitative and qualitative data. Deposit insurance coverage is measured as the ratio of state-underwritten deposits to average savings.[17] Bank concentration is measured as the share of the three largest banks' assets in economy-wide bank assets, based on Beck et al. (2008). An index of bank disclosure requirements is provided by the World Bank, and discussed in Huang (2006).

Information on country-specific regulatory liquidity requirements is taken from the World Bank's *Bank Regulation and Supervision* database.[18] Based on this survey, a dummy variable, which is 1 in case a quantitative liquidity requirement is in place and 0 otherwise, is calculated. Qualitative liquidity requirements or average reserve requirements do not qualify as liquidity regulation.[19] Additional control variables, capturing macroeconomic conditions as well as domestic financial development, are obtained from the WDI and the IMF's *International Financial Statistics*.

3.2.2. A first look at the data

Figure 3.1 illustrates the difference between the distribution of liquidity holdings (pooled over time) in different OECD countries through a cross-country comparison of Box-Whisker diagrams. The average liquidity buffer in the sample is 6.4% of total assets with a median of only 4.5%. As the figure shows, country means and distributions vary substantially. Notably, a liquidity requirement does not automatically imply higher liquidity buffers. Banks in countries with liquidity regulation have average (median) liquidity holdings of 4.5% (3.4%) while the average (median) liquidity buffer for banks in jurisdictions without a liquidity requirement amounts to 8.1% (4.5%).

On top of that, banks operating in countries with smaller financial sectors or less used currencies,

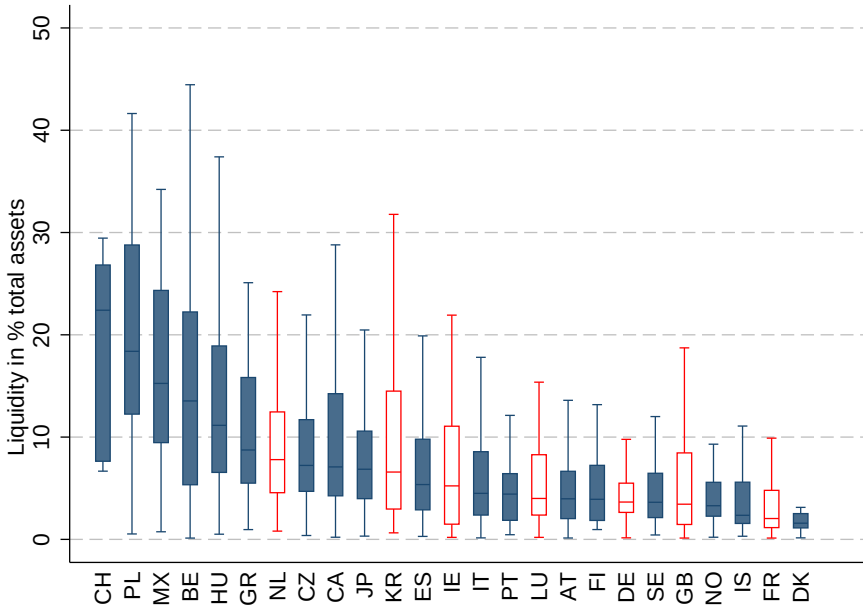
[16] Please note that all findings reported below are robust to using the alternative Local GAAP accounting standard.

[17] The variable's source is the World Bank's *World Development Indicators* (WDI). See also Demirgüç-Kunt et al. (2005).

[18] This chapter uses the survey from 2007. An earlier version is described in depth in Barth et al. (2008).

[19] Given that some of the classifications might be arbitrary, an alternative measure of liquidity regulation, which is based on the answers to a survey circulated in the BCBS Working Group on Liquidity (WGL), is used. The results are qualitatively similar.

Figure 3.1: Cross-country distribution of liquidity, 1998-2007



Note: The figure presents the distribution of cross-country liquidity buffers from 1998 to 2007. Liquidity is defined as the sum of cash, government securities and short-term assets as percentage of total assets. Countries with (without) are represented by unfilled (filled) bars.

like Poland or Mexico, seem to have larger liquidity buffers and larger variations across banks. This observation is consistent with the discussion in Section 3.1. Banks in smaller financial markets face higher individual liquidity risks because there are fewer options for cross-institutional risk sharing through interbank markets, and smaller stock markets imply more financial volatility. Moreover, financial frictions lower returns from alternative, less liquid investments in the domestic economy. In this case, the opportunity costs of holding liquidity buffers are lower.

3.3. Analysis

3.3.1. The GMM model

The baseline regression takes the form:

$$Liquidity_{bct} = \alpha + \beta_1 Bank_{bt} + \beta_2 Context_{ct} + \beta_3 Macro_{ct} + \beta_4 FinDep_{ct} + \varepsilon_{bt} \tag{3.1}$$

where $Liquidity_{bct}$ measures the liquidity buffer of bank b in country c and year t. $Bank_{bt}$ is a set of bank- and time-varying controls, which include a bank's capital, size and profitability as well as the share of its total deposits in total assets. $Context_{ct}$ refers to country- and time-varying aspects of banks' operating environment. Specifically, $Context_{ct}$ describes disclosure, concentration

and deposit insurance coverage. $Macro_{ct}$ and $FinDep_{ct}$ control for the current macroeconomic conditions as well as the level of financial development of the country a bank is operating in.
The analysis includes two estimation methods: OLS with bank dummies and lagged bank-specific variables as well as a dynamic GMM panel estimator. The choice to include bank dummies into the estimations is based on Hausman tests, which indicate that fixed effects are preferred over random effects as the independent variables and bank-specific effects are correlated. Since lagged liquidity buffers may be correlated with the panel-level effects and the time dimension is relatively limited, there is a risk that the estimator is inconsistent (Nickell (1981)). The results of a GMM difference estimator, where the instruments consist of lags of the levels of the explanatory and dependent variables, are therefore reported as well (Arellano and Bond (1991)).[20]
To test whether the instruments are valid, Hansen's J test for overidentifying restrictions are performed. If the null cannot be rejected, the model is supported. The reported p-values are sufficiently but not exceptionally high (i.e. not above 0.9), which gives some comfort that the instruments are not weak (Roodman (2009)). The outcomes of the Arellano and Bond (1991) test for autocorrelation of order 1 and 2 were checked as well. These consistently show that the null hypothesis of no second-order autocorrelation cannot be rejected (since the estimator is in first differences, first-order autocorrelation does not imply inconsistent estimates). Robust estimators are used to correct for heteroscedasticity.
Finally, the GMM estimations additionally include the lagged dependent variable while ε_{bt} is a robust standard error in case of the OLS estimations or the usual GMM error term.

3.3.2. Findings

Table 3.1 shows that most bank-specific and contextual variables have an economically and statistically significant impact on banks' liquidity holdings. The effects of most factors, however, are substituted by liquidity regulation. Only *Disclosure* and *Concentration* are important determinants of banks' liquidity holdings in presence of a liquidity requirement.
In absence of liquidity regulation, *Disclosure* and *DGS* have a negative impact on banks' liquidity holdings, while *Concentration* does not show a significant effect. An increase of *Disclosure* from the 25th to the 75th percentile (henceforth "increase") reduces banks' liquidity holdings by 1.61%. With a decrease of liquid assets by 1.82%, an increase of *DGS* has a similar effect.[21] While the effect of *DGS* is in line with theory, the negative sign of *Disclosure* appears somewhat counterintuitive. A likely explanation for this result is that in absence of a specific minimum requirement,

[20] Additionally regressions using the Arellano and Bover (1995) and the Hausman and Taylor (1981) estimator were conducted. As the results are very similar to those obtained with the other estimators they are not reported for reasons of brevity.
[21] Note that in case both methods lead to significant results, the discussion refers to the GMM estimations.

corresponding disclosure requirements are often relatively general or only prescribe the provision of qualitative information and therefore leave room for window dressing. When facing tight disclosure requirements, banks are therefore increasingly likely to improve their positions of clearly-defined minimum requirements (i.e. capital) at the cost of other non-regulated risks (i.e. liquidity).

An increase of *Profit* and *Deposits* increases liquidity holdings by 0.60% and 1.03%, respectively. An increase of an institution's *Capital ratio* increases its liquidity holdings by 0.21%. Hence, while an institution's *Profit* and *Capital ratio* have moderate effects on the size of its liquidity buffer, its *Deposits* from clients have a large impact. The positive effect of *Deposits* is also found by De Haan and Van den End (2013) and is likely attributable to a lack of funding diversification. Banks with large amounts of *Deposits* are very concentrated in a single funding source and therefore specifically prone to liquidity risks.[22] With an increase of banks' liquidity buffers by 0.007%, *Size* has a statistically but not economically significant impact. The results with respect to *Profit* and *Capital* are likely driven by these banks having higher franchise values and therefore less incentives to take excessive risks. Banks with higher capital levels are regularly found to be more conservative.[23]

The presence of liquidity regulation reduces the economic and statistical significance of several factors. While most factors are substituted by a liquidity requirement, the results suggest that *Disclosure* and *Concentration* are important determinants of banks' liquidity holdings in the presence of liquidity regulation.

Profit, *Deposits* and *DGS* have a significant impact on liquidity holdings without liquidity regulation but not in presence thereof. *Disclosure* and *Concentration*, on the other hand, are important determinants of banks' liquidity buffers under a liquidity requirement. The intuition behind this result is that in absence of liquidity regulation it is difficult for market participants, especially retail clients, to observe institutions' risks. However, with liquidity regulation and strict disclosure requirements in place, investors have a very clear view on institutions' risks, which presumably increases liquidity buffers. *Disclosure* can therefore be viewed as reciprocal to regulation while the role of most other factors is substituted by a liquidity requirement.

Summarizing, the analysis shows that without liquidity regulation, a combination of bank-specific and country-specific variables determine the size of banks' liquidity buffers. The presence of liquidity regulation, however, substitutes most of these bank- and country-specific factors. An institution's disclosure requirements and the concentration of the banking sector, on the other hand, are significant factors in presence of liquidity regulation.

[22] Please note that this argument holds despite the fact that retail deposits are considered to be one of the most stable sources of funding.

[23] See for instance De Haas and Van Lelyveld (2010, 2014).

Table 3.1: Banks' liquidity holdings under different regulatory regimes

	All		No Regulation		Regulation	
VARIABLES	OLS	GMM	OLS	GMM	OLS	GMM
Disclosure	0.05***	0.13**	-0.23***	-0.09**	0.39***	0.34***
	(0.014)	(0.059)	(0.023)	(0.040)	(0.044)	(0.050)
Concentration	-0.03***	-0.08***	-0.00	0.01	-0.12***	-0.27***
	(0.005)	(0.022)	(0.007)	(0.023)	(0.018)	(0.027)
DGS	0.01***	-0.01**	-0.01***	-0.00	-0.00	-0.02
	(0.001)	(0.004)	(0.001)	(0.002)	(0.002)	(0.012)
Profit (lagged)	0.28**	0.45***	0.01	0.88***	0.18	-0.08
	(0.131)	(0.139)	(0.181)	(0.178)	(0.170)	(0.095)
Capital ratio (lagged)	0.00	-0.06	0.07**	-0.06	-0.01	-0.05
	(0.017)	(0.052)	(0.026)	(0.037)	(0.018)	(0.037)
Deposits (lagged)	0.01**	0.01	0.02***	0.08**	-0.02	-0.02
	(0.005)	(0.040)	(0.006)	(0.032)	(0.017)	(0.018)
Total assets (ln, lagged)	2.36***	1.01***	3.35***	0.86***	0.85	2.20
	(0.252)	(0.293)	(0.365)	(0.130)	(0.993)	(2.202)
Real GDP growth (%)	0.72***	-0.13*	0.46***	-0.07	0.18***	-0.04
	(0.042)	(0.067)	(0.065)	(0.056)	(0.055)	(0.054)
Government debt (% GDP)	0.06***	0.01	0.07***	0.16***	-0.05***	-0.03**
	(0.004)	(0.017)	(0.006)	(0.027)	(0.010)	(0.011)
Financial openness	-0.05*	-0.06	0.18***	-0.41***	-0.16***	-0.05
	(0.025)	(0.072)	(0.046)	(0.104)	(0.029)	(0.041)
Constant	-1.85	0.00	16.46***	0.00	-12.65***	0.00
	(1.262)	(0.000)	(2.101)	(0.000)	(2.710)	(0.000)
Observations	10,760	8,772	6,124	4,687	4,636	4,085
Adjusted R-squared	0.096		0.099		0.055	
AB AR1 pval		0.320		0.312		0.0464
AB AR2 pval		0.251		0.998		0.687
Hansen pval		0.0174		0.319		0.427

Note: The table shows GMM as well as OLS estimations with bank dummies and lagged bank-specific variables. The dependent variable is reflected by the sum of cash, government bonds and due from banks as percentage of total assets (TA). The regression includes $Profit$ defined as net income over TA while a bank's $Capital\ ratio$ is reflected by equity as percentage of TA. $Deposits$ are defined as total retail deposits over TA while $Disclosure$ is an index describing countries' disclosure requirements. $Concentration$ is measured as the share of the three largest banks' assets in economy-wide bank assets. DGS is measured as the ratio of state-underwritten deposits to average savings. $Financial\ openess$ is defined as total international financial flows as percentage of GDP. Finally, the model includes several additional controls. Specifically, the analysis includes the lagged dependent (only in GMM), country and time dummies, as well as real GDP growth.

3.3.3. Robustness checks

This section provides a number of robustness checks for the baseline regression results. In particular, the section discusses results with 1) a different measure for liquidity regulation and 2) another measure for banks' risk bearing capacity.

First, given that the liquidity regulation variable is based on a survey, some of the answers might be noisy due to different interpretations of the questions. In order to check the robustness of the results in this respect, the outcome of another survey is used as basis for the assessment of liquidity regulation. This confidential survey was circulated in the BCBS' Working Group on Liquidity (WGL) in 2007 and asked banking supervisors to describe their current liquidity supervision while specifically distinguishing between qualitative and quantitative requirements. The results indicate that the baseline results are robust to using another measure for liquidity regulation. While there are some differences with respect to economic and statistical significance, the pattern of the impact of liquidity regulation is consistent across all specifications.

Second, the robustness checks include two different measures for banks' liquidity holdings, namely a) cash, government bonds and due from banks over total deposits instead of assets and b) cash and due from banks over total assets. While the former does not lead to any significant changes, defining liquidity only as cash changes the determinants of banks' liquidity holdings. The incentives for banks to hold cash are different from the incentives to hold other liquid assets. It is very likely that banks with high cash holdings do so because of a lack of other investment opportunities as opposed to incentives related to liquidity risk.

3.3.4. Shortcomings

Although several robustness checks were conducted, some caveats are in order. First, this chapter's focus is the relationship between a bank's liquidity risk exposure and its liquidity risk bearing capacity. While it is possible to obtain data for the second, the measures of profitability, deposit holdings and regulatory environment are only proxies for banks' actual liquidity risk exposure and thus subject to a measurement error. However, the purpose of this study is to analyze the impact of banks' policy environment on their liquidity holdings and, therefore, by definition, these proxies need to be used.

Second, when measuring the impact of liquidity regulation, binding and non-binding liquidity requirements cannot be exactly distinguished. However, the discussion in Section 3.1.1 shows that the liquidity requirements have been binding at some point in all countries. On top of that, even when requirements were less binding they seem to have caused banks to change their behavior. The analysis is likely to capture the impact of all liquidity requirements at some point while potentially overestimating the impact of regularly non-binding requirements while underestimating the impact of regularly binding ones.

Third, the data does not allow the distinction between local and globally active banks.[24] Given that the main aim of the chapter is to understand the impact of banks' operating environment such a distinction would enrich the analysis. At the same time, however, also global banks are significantly influenced by the regulation in their home country and, as a result, the findings might underestimate the impact of the contextual variables but are unlikely to be heavily biased.

3.4. Liquidity regulation and holdings after 2007

Although the main purpose of this chapter is to analyze the determinants of banks' liquidity holdings during normal times, it is also useful to understand how these liquidity holdings have developed between 2007 and 2013 and more specifically during the financial crisis.

Figure 3.2: Average liquidity holdings in % total assets, 2000-2013

Note: The figure presents average liquidity buffers of 24 countries from 2000 to 2013. Liquidity is defined as the sum of cash, government securities and short-term assets as percentage of total assets.

[24] See De Haas and Van Lelyveld (2010, 2014) and the literature cited therein for an analysis of how local and global shocks affect internationally active banks.

Figure 3.2 shows that, when looking at the entire time-series, liquidity buffers in countries with and without regulation are closely related. The average liquidity buffer over the entire sample in countries with regulation is 7.92%. In countries without liquidity regulation, the average buffer amounts to 8.66%. Only the significantly lower standard deviation of 1.92 compared to 2.29 shows that liquidity regulation seems to be associated with less volatility in banks' liquidity holdings. For the period after 2007, liquidity buffers in countries with and without regulation are 9.64% and 9.35% respectively. Also the correlation coefficient of 0.46 points towards parallels between the two types of countries.

Particularly evident, however, are the differences when only looking at the period of the financial crisis. Figure 3.2 shows that average liquidity holdings for banks subject to liquidity regulation increase while there is a sharp decline in countries without regulation. The average liquidity buffers in 2007 and 2008 for banks in countries with regulation is 7.46% and therefore not significantly different from the average over the entire sample. For banks not subject to regulation, on the other hand, liquidity buffers are only 4.20% and therefore less than half of the average over the entire sample. Between 2008 and 2009 liquidity buffers increase sharply, probably due to central bank interventions.[25]

It can be seen that liquidity regulation does not lead to generally higher liquidity buffers. It does, however, reduce volatility and, most importantly, banks in countries with liquidity regulation seem to have maintained significantly higher liquidity buffers during the 2007-08 financial crisis.

3.5. Does it matter?

3.5.1. Liquidity regulation and the occurrence of banking crises

The analysis shows that without liquidity regulation, banks' liquidity buffers are determined by a combination of bank-specific and country-specific factors. Liquidity regulation seems to substitute most of these factors while disclosure and concentration remain significant. The analysis also provides suggestive evidence that liquidity regulation is associated with less volatile liquidity buffers and higher buffers during crises. While these results provide interesting insights from a microprudential perspective, it is useful to briefly analyze the impact of liquidity regulation on the aggregate financial system.

In a recent IMF paper, Laeven and Valencia (2013) present a new database on banking crises across the globe. The authors develop indicators of systemic banking crises for various countries. Specifically, Laeven and Valencia (2013) consider 1) the presence of extensive central bank liquidity

[25] These distorting effects of government interventions during crises justify our approach to not consider this period for our econometric analysis.

support; 2) significant bank restructuring costs relative to GDP; 3) the number of nationalizations; 4) extensive guarantee schemes by the central bank or the government; 5) significant asset purchases, and 6) large deposit freezes as crisis indicators. If three of these indicators are triggered, Laeven and Valencia (2013) consider the country to have suffered from a systemic banking crisis during the 2007-2008 financial crisis.[26]

Table 3.2: Correlation of liquidity regulation and banking crises

Sample	Laeven and Valencia (2013)	Restructuring	Nationalizations	Guarantees	Asset purchases
Regulation	-0.12	-0.03	0.28	-0.10	-0.12

Note: The table shows the correlation coefficients of liquidity regulation with the crisis indicators defined by Laeven and Valencia (2013).

Table 3.2 shows the correlation coefficients of liquidity regulation and both the individual indicators as well as the combined indicator defined by Laeven and Valencia (2013). There seems to be some negative correlation between systemic banking crises and the presence of liquidity regulation. Liquidity regulation seems to be less associated with extensive asset purchases, significant government guarantees and also the joint indicator shows a negative correlation coefficient. However, all correlation coefficients are rather low and therefore the conclusion that banking crises are significantly less likely in countries with liquidity regulation cannot be drawn.

3.5.2. Liquidity regulation and banks' behavior during crises

Although the analysis does not provide evidence that the presence of liquidity regulation is less associated with the occurrence of banking crises, banks subject to liquidity regulation might still remain more effective during stress.

Collecting lending data from the International Financial Statistics of the IMF, this final step investigates whether banks subject to liquidity regulation were better able to maintain their private sector credit supply and corresponding interest rates (average short-term interbank market rate and average private sector lending rate per country).

Table 3.3 shows that the presence of liquidity regulation is positively associated with the growth of bank claims, short-term interest rates as well as lending rates to the private sector. The presence of liquidity regulation is associated with a 6.16% higher growth in total bank claims as well as 1.70% and 1.82% higher interest rates.

Interestingly, during crises all three previously significant factors change their sign and are therefore negatively associated with liquidity regulation. Specifically, the presence of liquidity regulation coincides with 4.86% lower growth rates of bank claims as well as 1.62% and 2.68% lower interest rates.

[26] Note that Table 3.2 does not include the first indicator because there was extensive central bank support in all countries under analysis and therefore correlation coefficients cannot be calculated.

Table 3.3: Liquidity regulation and lending during crises

Sample	Bank claims	Lending	Short-term rate	Lending rate
Regulation	6.16***	-2.61	1.70***	1.82***
	(1.48)	(2.13)	(0.38)	(0.52)
Crisis	0.56	-2.02	-0.57**	-0.58
	(1.07)	(1.55)	(0.26)	(0.42)
Crisis*Regulation	-4.86**	1.90	-1.62***	-2.68***
	(1.92)	(2.69)	(0.48)	(0.82)
	.	.	.	.
	Controls	*Controls*	*Controls*	*Controls*
	.	.	.	.
Observations	284	164	343	197
R^2	0.383	0.280	0.857	0.656

Note: The table shows pooled OLS regressions with the dependent variables being the growth rate of aggregate claims of banks on residents, the growth of aggregate bank lending, the OECD short-term interest rates as well as the average lending rate to the private sector. The table only points out certain patterns but does not establish causality. As key explanatory variables, the analysis includes the dummies *Regulation* (1 if liquidity regulation is present) and *Crisis* (1 during the years 2007-2013) as well as an interaction term of these two dummies. The additional control variables capture net government debt, government revenue, government expenditure, GDP growth, inflation as well as aggregate investment. A more detailed version of this table can be found in the Appendix. The sample comprises the years 1999 to 2013 and covers 24 countries.

Liquidity regulation requires banks to permanently hold liquid, lower-yielding assets, presumably increasing institutions' marginal costs of funds. Since banks will try to pass on these increased costs to their clients, higher interest rates in countries with liquidity regulation seem a logical consequence. At the same time, higher liquidity buffers - although consuming assets - function as an insurance against liquidity shocks, making banks potentially more comfortable to issue credit. On top of that, some banks might increase their loan issuance to raise income in order to compensate the increased costs from holding more liquid assets.

As discussed in Section 3.4, liquidity regulation is associated with higher liquidity buffers during stress. At the same time, crises make it more difficult for banks to obtain funding in the market. This interplay of banks having to maintain higher liquidity buffers while funding gets scarce is likely to be the reason for the negative relationship of liquidity regulation and lending during stress. This argument, however, makes the negative sign on the interest rates counterintuitive. A possible explanation for this can be that banks in countries with liquidity regulation are still considered less risky and therefore, if funding is available, these banks can attract it on relatively better conditions, allowing them to charge lower interest rates.

3.6. Conclusions

This chapter analyzes the determinants of banks' liquid asset holdings and their interaction with liquidity regulation. It highlights the role of several bank-specific and institutional variables in shaping banks' liquidity risk management. This chapter's main purpose is to analyze whether or not the presence of liquidity regulation substitutes banks' incentives to hold liquid assets.

The results reveal that without liquidity regulation, banks' liquidity buffers are determined by a combination of bank-specific and country-specific factors. As most factors turn insignificant with a liquidity requirement in place, the analysis suggests that regulation substitutes most incentives to hold liquid assets. A bank's disclosure requirement, however, is likely to enforce liquidity regulation, thus becoming more important in the presence thereof. There is also suggestive evidence for liquidity regulation to be associated with higher lending volumes and higher interest rates. During stress, however, liquidity regulation coincides with higher liquidity buffers but lower lending volumes.

A takeaway from this chapter is that the reciprocal features of disclosure and liquidity requirements provide strong incentives for regulators to jointly harmonize disclosure and Basel III liquidity requirements across countries. One could interpret the analytical results as being supportive of implementing a liquidity requirement with some flexibility temporarily allowing banks to fall below the regulatory threshold, presumably reducing potential unintended consequences during stress. Both of these recommendations are in line with the BCBS' current efforts.

Apart from these wider considerations regarding the impact of liquidity regulation, the interaction of the LCR and monetary policy transmission has also been subject to discussions. Against this background, the next chapter analyzes the impact of the LCR on interbank money markets and real economy interest rates.

Appendix

Table A3.1: Summary statistics

Variable		N	Mean	Median	sd	Min	Max
Liquidity	All	8781	6.40	4.53	5.88	0.13	44.62
	No Regulation	3765	8.57	6.80	6.98	0.14	44.62
	Liquidity Regulation	5016	4.77	3.55	4.22	0.13	44.43
Profit	All	8577	0.28	0.23	0.48	-2.33	3.85
	No Regulation	3605	0.28	0.23	0.61	-2.33	3.85
	Liquidity Regulation	4972	0.29	0.24	0.35	-2.10	3.74
Deposits	All	8531	85.75	90.04	12.16	15.12	96.10
	No Regulation	3568	84.11	91.18	15.09	15.12	96.10
	Liquidity Regulation	4963	86.93	89.47	9.34	15.51	96.07
Disclosure	All	8781	76.36	74.00	4.74	61.00	90.00
	No Regulation	3765	79.90	81.00	3.96	65.00	90.00
	Liquidity Regulation	5016	73.71	74.00	3.34	61.00	90.00
Concentration	All	8781	57.44	63.32	15.35	24.89	98.37
	No Regulation	3765	49.22	38.91	16.86	30.46	98.37
	Liquidity Regulation	5016	63.61	68.27	10.51	24.89	95.74
DGS	All	8781	133.30	81.68	88.39	36.83	719.35
	No Regulation	3765	187.22	248.10	98.08	45.39	606.89
	Liquidity Regulation	5016	92.83	77.11	51.36	36.83	719.35
Government Debt (% GDP)	All	8781	59.74	59.40	15.74	2.67	105.21
	No Regulation	3765	68.97	72.63	17.94	7.88	105.21
	Liquidity Regulation	5016	52.80	53.83	8.93	2.67	65.22

Table A3.2: Liquidity regulation and lending during crises

Sample	Bank claims	Lending	Short-term rate	Lending rate
Regulation	6.16***	-2.61	1.70***	1.82***
	(1.48)	(2.13)	(0.38)	(0.52)
Crisis	0.56	-2.02	-0.57**	-0.58
	(1.07)	(1.55)	(0.26)	(0.42)
Crisis*Regulation	-4.86**	1.90	-1.62***	-2.68***
	(1.92)	(2.69)	(0.48)	(0.82)
Net government debt over GDP	-0.04***	-0.08***	-0.00	-0.00
	(0.01)	(0.02)	(0.00)	(0.01)
Government revenue over GDP	-0.07	-0.82***	0.07*	0.05
	(0.14)	(0.22)	(0.03)	(0.05)
Government expenditure over GDP	0.13	0.70***	-0.13***	0.03
	(0.16)	(0.26)	(0.04)	(0.06)
GDP growth	0.74***	-0.51*	0.08*	-0.01
	(0.19)	(0.28)	(0.05)	(0.09)
Inflation	0.45***	1.12**	1.30***	1.36***
	(0.13)	(0.51)	(0.03)	(0.09)
Investment over GDP	0.98***	0.65**	0.01	0.26***
	(0.16)	(0.27)	(0.04)	(0.07)
Constant	-17.93***	1.56	3.15**	-5.54***
	(4.95)	(11.44)	(1.22)	(1.95)
Observations	284	164	343	197
R^2	0.383	0.280	0.857	0.656

Note: The table is the full version of Table 3.3.

CHAPTER 4

The impact of liquidity regulation on bank intermediation

As laid out in Chapter 2, the interaction of liquidity regulation and monetary policy was one of the key stumbling blocks hampering the harmonization of liquidity regulation. In recent years, policymakers paid particular attention to the impact of the LCR on interbank money markets and monetary policy transmission.

According to Bech and Keister (2013), the LCR might impact monetary policy implementation. In many jurisdictions, the central bank relies on the overnight rate in interbank money markets as operating targets for monetary policy implementation. As the LCR incentivizes banks to attract longer-term funding, it is likely to reduce the demand for overnight loans. This lower need to access overnight markets may drive down the corresponding interest rate, whereas the increased demand for long-term funding is likely to steepen the short end of the yield curve. In such a situation, central banks may be required to adjust their monetary policy frameworks and use the long-term interbank rate as additional target for monetary policy implementation.

Apart from these relative changes between short-term and long-term loans, a liquidity requirement may also directly impact an institution's profits and losses. A bank facing liquidity regulation is required to either increase its liquidity buffer or to attract longer-term funding, which come at high costs, presumably increasing an institution's marginal costs of funds. As institutions will try to pass on these increased costs, a general increase in interest rates might be a consequence.[1] Depending how binding the requirement is, this effect can be permanent or short-term.

Anecdotal evidence also suggests that institutions use quantitative liquidity requirements as a risk management tool. Banks with a lower regulatory liquidity position might therefore not only increase their long-term loans but improve their overall liquidity position, potentially including

[1] See Blundell-Wignall and Atkinson (2010).

short-term loans although they do not count towards the regulatory requirement.

Most important, however, is the question how these potential movements in the interbank money market are transmitted to the real economy. The rationale for central banks to target overnight interest rates is the view that price movements in the interbank money market are transmitted to other interest rates in the economy, including corporate lending rates. To draw the right policy conclusions it needs to be understood how specific developments in the interbank money market are transmitted to the real economy.

Against this background, this chapter empirically analyzes the impact of the LCR on the bank lending channel. Specifically, this chapter first assesses the impact of a quantitative liquidity requirement on volumes and interest rates in the unsecured interbank money market and second how potential developments in the interbank market are transmitted to real economy interest rates. The analysis is based on unique data on the Dutch quantitative liquidity requirement 8028 (henceforth DLCR) in combination with data on banks' lending and borrowing behavior in the Dutch unsecured interbank money market and banks' lending to non-financial institutions.[2]

The analysis suggests that the DLCR causes banks to both pay (when borrowing) and charge (when lending) higher interest rates for long-term interbank loans. With respect to volumes, the results show that a liquidity deficiency increases banks' net demand of long-term loans while demand for short-term loans seems unaffected. While the analysis suggests that most banks already react to their own targets above the regulatory threshold, banks below the regulatory threshold react particularly strong to long-term loans. The fact that short-term rates increase as well can be interpreted as evidence for banks using the liquidity requirement as internal risk management tool and the liquidity requirement leading to increased marginal costs of funds.

Finally, this analysis finds no evidence of a liquidity requirement affecting corporate lending rates. Rather, a binding liquidity requirement seems to lower banks' interest margins, suggesting that banks cannot pass on their increased funding costs to their private sector clients.

A key takeaway from this chapter's analysis is that liquidity regulation does not seem to affect monetary policy transmission itself. Rather, it seems to create situations in which the interbank market rate is a less useful target for reaching the desired interest rate level in the real economy. In presence of liquidity shortages, interbank market rates seem to increase, affecting banks' interest margins but not real economy lending rates. As such, central banks are advised to closely monitor the LCR of the banking system and potentially use a representative real economy interest rate as additional target for monetary policy implementation. A potential option would be to target the price of certain securities, such as for instance corporate bonds or securitizations.

[2] See DNB (2003).

The remainder of this chapter is organized as follows: Sections 4.1 and 4.2 provide some conceptual background as well as details regarding the data, respectively. Section 4.3 explains the background of the econometric approach, followed by the econometric model and results in Sections 4.4, 4.5 and 4.6. Section 4.7 shows sensitivity analyses while Section 4.8 concludes.

4.1. A primer on the DLCR

Similar to the LCR, the DLCR requires banks to hold an amount of liquid assets at least equal to their net outflows over a 30 day stress period:[3]

$$DLCR = (Actual\ Liquidity) - (Required\ Liquidity\ within\ 30\ days) \geq 0 \tag{4.1}$$

Actual Liquidity (*AL*) is defined as the stock of liquid assets minus haircuts plus recognized cash inflows weighted by degree of liquidity. Required Liquidity (*RL*) comprises of assumed calls on contingent liquidity lines, assumed withdrawals of deposits as well as assumed drying up of wholesale and derivative funding. Apart from cash, government bonds as well as highly rated covered bonds, the DLCR additionally allows banks to include most central bank eligible securitizations as part of their liquidity buffer while the LCR allows structured products only to a limited extent. With respect to deposits and contrary to the LCR, the DLCR does not distinguish between "stable" and "less stable" retail deposits, which have different run-off rates under stress and are classified according to a set of predefined conditions. Importantly, however, maturing unsecured interbank loans have the same treatment (100% runoff assumption) under both regimes. Suppose that a non-compliant bank obtains an overnight loan in the unsecured interbank money market:

$$DLCR = (AL + Overnight\ Loan) - (RL + 100\% * Overnight\ Loan) \geq 0 \tag{4.2}$$

As can be seen from equation 4.2, interbank loans with maturities shorter than 30 days do not help banks to eliminate a DLCR deficiency. The reason for this is that any loan with a corresponding maturity shorter than 30 days comes due within the DLCR horizon and therefore not only increases a bank's *AL* but also its *RL*.

By contrast, interbank loans with maturities longer than 30 days can help a bank to reach its regulatory threshold, as the repayment occurs outside the 30 day horizon. In equation 4.2, this

[3] Note that for the purpose of this analysis, ratios of Actual over Required Liquidity are calculated.

means that only *AL* increases while *RL* remains unchanged. In light of this special feature, Bech and Keister (2013) argue that the introduction of such a liquidity requirement makes interbank loans with maturities longer than 30 days relatively more valuable.

On an aggregate level, the differences between the DLCR and the LCR are insignificant. Given that the LCR is stricter with regard to the definition of liquid assets, while the DLCR applies considerably higher outflow rates and haircuts, the differences between the two regimes are negligible.[4] In 94% of the cases, banks are jointly (non-)compliant with the LCR and the DLCR while the correlation coefficient of the two ratios is almost 87%.[5]

4.1.1. A liquidity requirement and monetary policy implementation

Many central banks have adopted frameworks using overnight interest rates as operating targets for monetary policy implementation. As laid out by Bech and Keister (2013), most central banks offer deposit and lending facilities that allow banks to deposit or borrow reserves. Theoretically, these two facilities constitute the upper and lower bound for the interbank market rate. Central banks aim to adjust reserves in such a way that interbank lending takes place at a target rate lying within these boundaries.

In the canonical model of monetary policy implementation, banks hold reserves primarily to satisfy their average reserve requirements.[6] When deciding on their borrowing and lending volumes in the interbank money market, banks have to balance two concerns: If they borrow too little and experience a large payment outflow, banks have to draw on the central bank's lending facility, which comes at a higher cost than borrowing in the market. However, borrowing too much is also inefficient as it means the bank holds reserves that could have been lent out in the market at a rate higher than the central bank deposit rate.

With the (D)LCR in place, banks need to fulfil a second requirement. When deciding on their borrowing and lending volumes in the interbank money market, banks have to take into account the risk of falling below the (D)LCR threshold.

Banks not complying with their liquidity requirement will take into account the possibility of being forced to borrow from the central bank in order to remedy a (D)LCR deficiency. As argued by Bech and Keister (2013), in this case a considerable term premium arises: loans with maturities longer than 30 days become relatively more valuable. Bech and Keister (2013) further argue that overnight interest rates will fall, given that longer-term loans perform a double duty: as well as

[4] This is especially true since the revised LCR, described in BCBS (2013b).

[5] The entire spectrum of banks reporting the DLCR includes only a few banks with large differences between the LCR and DLCR. These banks are niche banks without access to money markets and are therefore not included in the analysis.

[6] See Poole (1968).

counting towards the (D)LCR, they also help to fulfill the average reserve requirement. It therefore becomes increasingly likely that banks will end up holding higher reserves, which presumably reduces the marginal value of overnight funding.
In this situation, the central bank cannot follow the standard procedure for monetary policy implementation. That is, using the overnight interest rate as operating target. In a situation with term premiums on loans with maturities longer than 30 days and lower overnight interest rates, Bech and Keister (2013) argue that there is no amount of reserve supply that will yield an overnight rate equaling the target rate.[7] In such a situation, central banks may need to adjust their frameworks for monetary policy implementation.

4.1.2. A liquidity requirement and lending

The rationale for central banks to use the overnight interest rate as target for monetary policy implementation is the view that price movements in the interbank money market are transmitted to other interest rates in the economy.
Banks' role as financial intermediaries exposes them to a reinvestment risk.[8] As pointed out by Maudos and de Guevara (2004), demand for loans and supply of deposits reach the bank at different points in time, which forces them to temporarily turn to the interbank money market in case of excessive demand for loans or insufficient supply of deposits.[9] In order to compensate for the risk of refinancing interest rate increases in the money market, institutions set their interest rates to corporates as margin relative to money market interest rates.
When analyzing the impact of a liquidity requirement on monetary policy transmission, it is therefore important to investigate how potential movements in the interbank market get transmitted to the real economy and whether banks are able to pass on their individually higher rates to clients.

4.1.3. A liquidity requirement as risk management tool

Apart from its actual purpose to require banks to hold sufficient liquid assets, a key advantage of liquidity regulation is that it helps banks and regulators to quantify liquidity risks. The documentation submitted by banks to DNB within the Internal Liquidity Adequacy Assessment Process

[7] According to Bech and Keister (2013), a binding LCR increases banks' demand for long-term loans and central bank funding because they can be used to satisfy both the reserve requirement and the liquidity requirement while overnight funding cannot. As a consequence, banks will likely hold excess reserves, and the marginal value of overnight funding reduces, causing the overnight rate to be approximately equal to the deposit facility rate as opposed to the target rate lying in the middle of the corridor.

[8] See Ho and Saunders (1981), Lerner (1981), Pong Wong (1997) or Saunders and Schumacher (2000).

[9] In the end, the interplay between corporate lending and interbank markets is similar to the one between interbank markets and central bank reserves. As one functions as a backup for the other, developments in the backup market are likely to affect the pricing in the other market.

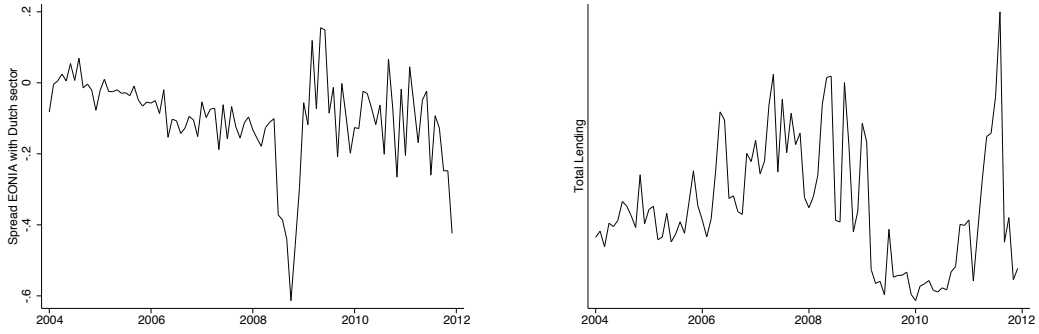
(ILAAP) suggests that instead of only viewing the DLCR as regulatory requirement, most banks use it as daily liquidity risk monitoring tool.[10] It is therefore likely that banks view a low DLCR not only as regulatory but rather as general liquidity deficiency. Consequently, potential actions to correct such a deficiency might not only aim at correcting the regulatory deficiency but also incentivize banks to attract more short-term loans or other types of funding as potential backup, even though these do not count towards the regulatory standard.

4.2. Data

4.2.1. The Dutch interbank market

The interbank market works as an over-the-counter (OTC) market so prices and volumes are not publicly known.[11] Financial institutions settle various types of payments in TARGET 2 (the interbank payment system of cross-border transfers within the EU), such as payments on behalf of customers, bank-to-bank payments, payment of the cash leg of a security trade, and pay-ins for the CLS system (continuous linked settlement) to settle foreign exchange transactions.

Figure 4.1: Dutch interbank market over time



a: Interest rates b: Total lending

Note: The figure presents the spread of the average interest rate in the unsecured Dutch interbank market with the EONIA interest rate as well as the average total turnover.

[10] See DNB (2012).

[11] An exception to this rule is e-MID, which is the only electronic market for interbank deposits in the Euro Area and US.

In 2010, the Dutch part of TARGET 2 had 61 direct participants, including a few large British banks, a daily average of 34.000 transactions and a daily turnover of 295 billion euro. The Dutch part of TARGET 2 (Target 2-NL) constitutes roughly 13% (10%) of the complete TARGET system in terms of volume (transactions).[12]

Heijmans et al. (2010) analyze the Dutch interbank market, based on four periods: 1) January 2004 to June 2007: financial markets were smooth and well-functioning; 2) July 2007 to August 2008: first turmoil; 3) September 2008 to June 2009: failure of Lehman Brothers, followed by a severe period of stress, and 4) July 2009 until December 2011: Unconventional monetary policy measures by the ECB. Although the analysis includes a period-specific dummy in all regressions, it is important to understand the different periods in the Dutch unsecured interbank money market.

Comparing the average interest rates paid in TARGET 2-NL with EONIA (see Figure 4.1a), it becomes evident that before the failure of Lehman Brothers, Dutch interest rates are highly correlated with the Euro-area average. After the collapse of Lehman Brothers, however, the interest rates in the Dutch interbank market have increased less sharply than EONIA, suggesting that the effect of Lehman Brothers' failure is somewhat smaller for Dutch banks compared to other European banks. According to Heijmans et al. (2010), the average total turnover fell by roughly 25% after the failure of Lehman Brothers. Although the credit crunch after the failure of Lehman Brothers led to higher interest rates and lower volumes, the Dutch interbank market remained sufficiently active and diversified for the purpose of this analysis.

4.2.2. Data sources

To analyze the effects of a quantitative liquidity requirement on banks' behavior, this chapter brings together data on 1) DNB's monthly prudential liquidity reporting; 2) bilateral transactions in the interbank market for different maturities (volumes and prices); 3) new loan issuances and the respective interest rates of Dutch banks to the private sector; 4) the Eurosystem's Bank Lending Survey (BLS), and 5) risk indicators and other measures calculated from the balance sheet.

For the DLCR, data for 18 Dutch banks from January 2004 to December 2011 from DNB's regulatory liquidity reporting is used. With respect to the unsecured interbank money market, this chapter uses the same raw data as Heijmans et al. (2010). Heijmans et al. (2010) describe how loans can be identified and thus volumes and prices extracted, from the observable flows between banks. The authors build on the seminal paper by Furfine (1999) and improve the algorithm to include durations of up to one year.[13] The algorithm has been applied in the US using Fedwire (Demiralp

[12] From a technical perspective, TARGET 2 is a centralized system offering one platform for all participants to settle their payments. Legally, however, it is a decentralized system with each country having its own legal documentation.

[13] For a more detailed description of the functioning of the algorithm, see Heijmans et al. (2010).

et al. (2006), Hendry and Kamhi (2009)), in Norway (Akram and Christophersen (2010)), and Germany (Braeuning and Fecht (2012)). The algorithm returns information on the borrowing and lending institution, paid interest rates, total value as well as maturity of the loan.
The data on lending comes from DNB's socio-economic reporting and is collected for the monetary statistics of the Eurosystem. The data covers the period from January 2004 to December 2011 and carries information on 26 Dutch banks. The dataset distinguishes granted loans, larger and smaller than 1 million as well as with maturities shorter and longer than 1 year and contains information on new issuances (flows but not stocks) and the respective interest rates. Total lending does not include lending which occurred due to the drawdown of committed credit lines, overdrafts or open debit or credit card deficits.
The BLS includes 8 Dutch banks, covering roughly 65% of the Dutch sector's total lending. Monthly data from 2004 to 2011 is used.[14] The BLS contains information on how the banks' credit standards, as applied to the approval of loans or credit lines to enterprises, have changed over the past three months or expectations of changes over the next three months and what factors contribute to these changes. The answers regarding the development of lending standards range from 1 ("tightened considerably") to 5 ("eased considerably"). The BLS also includes banks' perception of demand for loans.
As additional control variables the analysis includes a large number of bank-specific controls, such as institutions' capital holdings, profits or fulfilment of the central bank reserve requirement. For all balance sheet measures this chapter uses monthly data per bank from January 2004 to December 2011 from DNB's prudential reporting.

4.3. Methodology - Regression Discontinuity Design (RDD)

In order to analyze the impact of a liquidity requirement on banks' behavior in the interbank money market, this chapter applies Regression Discontinuity Designs (RDD). The application of RDD goes back to the classic work of Thistlethwaite and Campbell (1960) as a way of estimating treatment effects in a nonexperimental setting where treatment is determined by whether an observed *assignment variable* exceeds a known cutoff point. In this dataset, the continuous DLCR ratio is the assignment variable while the cutoff determining treatment varies per institution.
In a RDD setting, the assignment to treatment and control groups is not random but rather caused by imprecise control over a known assignment variable. While other comparable approaches, such as IV estimations, require exogenous assignment, in RDD randomized variation is a consequence

[14] Note that the BLS is only reported quarterly. Given, however, that banks are required to report their experience of the last 3 months as well as a forecast for the following 3 months, an extrapolation of the data to a monthly frequency should not cause any problems.

of agents' inability to precisely control the variable near the known cutoff.[15] As stated by Hahn et al. (2001), the main advantage of RDD is that it requires less strict assumptions regarding the assignment of treatment compared to other non-experimental approaches.

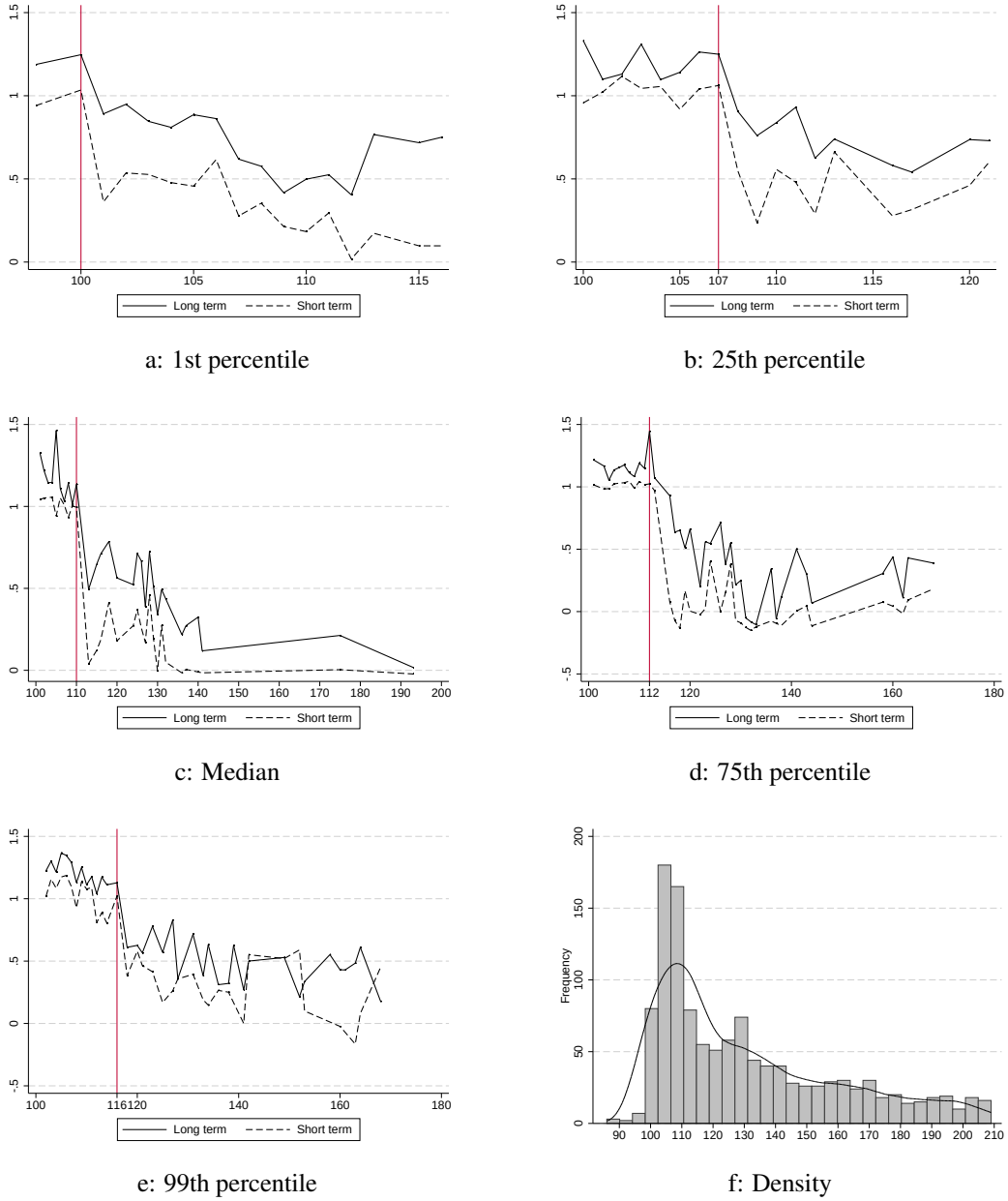
4.3.1. Fuzzy vs. Sharp - Discontinuity cutoff

An essential part of establishing the validity of RDD is to define the cutoff point of the *assignment variable*. Since it is the regulatory threshold, a DLCR of 100% is a natural starting point. At the same time, however, empirical as well as anecdotal evidence suggests that banks tend to hold additional precautionary liquidity buffers, reducing the likelihood of becoming non-compliant.
It is likely that both observable and unobservable bank characteristics determine at what cutoff an institution reacts to the liquidity requirement. Using similar data, De Haan and Van den End (2013), for instance, find that smaller banks, foreign branches and less capitalized banks tend to hold more liquid assets, suggesting that these banks target a DLCR above 100%.[16] The rationale for these banks to hold precautionary buffers is that they are likely to have less good market access, making them less flexible compared to larger or better capitalized banks.
Apart from these observable balance sheet variables, banks' cutoff is likely to also be affected by unobservable factors or factors like governance structures which are difficult to measure. To overcome this problem, an advantageous feature applicable to this dataset can be used. In contrast to most other RDD settings, this dataset includes several observations per institution allowing to observe both cutoff and discontinuity at the individual level.[17]
Determining the cutoff per institution and its determinants proceeds in two steps: First, the relationship between the DLCR and the variables of interest (short-term and long-term borrowing and lending rates as well as short-term and long-term net demand) is plotted. However, instead of conducting this graphical analysis at the aggregate level, this chapter analyzes discontinuity at the individual level.[18] Based on these figures, the institution-specific cutoffs are determined. The second step attempts to analyze the determinants of these "discontinuity-thresholds".
Figure 4.2 shows the institution-specific cutoffs and the graphs of the respective institutions. Three things become evident: First, the figures show clear discontinuities, allowing the determination of cutoffs based on these figures (reflected by the vertical lines). Second, the value of the DLCR on which discontinuity can be observed and where the cutoff is set significantly differs across

[15] See Lee (2008).
[16] Also see Chapter 3 for a more in depth analysis regarding the determinants of banks' liquid asset holdings.
[17] In order to ensure the feasibility of this approach only banks with at least 10 observations with distinct DLCRs are kept in the sample.
[18] Note that the figures only present banks' borrowing rates. The individual cutoffs, however, are consistent across borrowing and lending rates.

institutions, and third, there appears to be no significant difference between short-term and long-term loans.

Figure 4.2: Distribution of institution-specific cutoffs



a: 1st percentile

b: 25th percentile

c: Median

d: 75th percentile

e: 99th percentile

f: Density

Note: The figure presents the distribution of institutions according to their institution-specific cutoffs, which are reflected by the vertical lines. The cutoffs presented above were confirmed by plotting the same graphs with banks' lending rates and net demand as well as via additional documentation.

Looking at the distribution of the individual cutoffs, it can be seen that the cutoff of the lowest percentile of institutions coincides with the regulatory threshold of 100%.[19] Half of the institutions have cutoffs between 107% and 112%. The 99th percentile is at 116% with one institution having a cutoff at 130%.[20] After obtaining these institution-specific cutoffs, they were verified either via additional documentation or via direct contact with the respective bank. With the exception of one bank, all institution-specific cutoffs could be verified.[21]

The presence of different institution-specific cutoffs points towards the presence of some form of "fuzzy" treatment. A "fuzzy" design usually refers to a situation when there are individuals in the treatment group which do not receive treatment or vice versa. Formally, Lee and Lemieux (2010) state that in a sharp design, probability of treatment jumps from 0 to 1 at the cutoff while in a fuzzy design this jump is smaller than 1. However, since it seems quite certain whether an institution has received treatment or not, the analysis can follow the standard procedure of sharp RDD while using different cutoffs per institution.

The second step attempts to understand why institutions target different precautionary buffers. The pooled OLS model takes the following form:

$$Cutoff_i = \beta_0 + \beta_1 Size_{i,t} + \beta_2 Risk\ profile_{i,t} + \beta_3 Profit_{i,t} + \beta_4 Business\ model_{i,t} + \varepsilon_{i,t} \tag{4.3}$$

where $Cutoff_i$ reflects the institution-specific cutoff identified by the graphical analysis. $Size_{i,t}$ describes a number of variables referring to an institution's size. Specifically, $Size_{i,t}$ includes the natural logarithm of an institution's total assets and total borrowing volume in the interbank market as well as the institution's total assets in percentage of total banking sector assets.

$Risk\ profile_{i,t}$ includes variables describing an institution's risk profile which are either market based or balance sheet based. The market based factors are reflected by an institution's rating and CDS spreads while an institution's capital (capital in % of RWA) and leverage (capital in % of total assets) describe the balance sheet based factors.

$Profit_{i,t}$ describes an institution's profitability (net income in % of total assets) and return on equity (net income in % of total capital) while $Business\ model_{i,t}$ indicates how international an institution's business model is and whether it relies on a liquidity facility from another institution.

[19] To understand whether there is a specific reaction of banks below the regulatory threshold, an additional step performs the same analysis only considering institutions with individual cutoffs at the regulatory threshold of 100% and at least one non-compliant observation.

[20] Highest cutoff in this regard means highest observable cutoff. There are institutions with DLCRs lying constantly above 150 for which no reaction can be observed. These institutions are not included in the analysis.

[21] While this bank was generally kept in the sample, it was excluded from the sensitivity analyses, which did not lead to significantly different results.

The internationality of an institution's business model is measured by the share of banks' interbank borrowing from international counterparts in total borrowing. $\varepsilon_{i,t}$ is a bank-clustered robust standard error.

The econometric model does not allow to claim causality. However, the main purpose of this analytical step is twofold: 1) Point out general patterns explaining the difference in institutions' cutoffs, and 2) predict the institution-specific cutoff as precisely as possible, as reflected by a high R-squared.

Table 4.1: Determinants of individual cutoffs

Size	Total assets	5.04***	-14.07***	-13.65***	-14.60***
		(0.07)	(0.19)	(0.19)	(0.19)
	Borrowing volume	-1.82***	-0.59***	-0.54***	-0.38***
		(0.04)	(0.03)	(0.03)	(0.03)
	Relative size	-87.69***	-10.10***	-13.31***	-3.42**
		(1.38)	(1.44)	(1.43)	(1.38)
Risk profile	Capital		-0.36***	-0.57***	-0.53***
			(0.04)	(0.04)	(0.05)
	Leverage		-0.46***	-0.49***	-0.58***
			(0.07)	(0.08)	(0.09)
	Rating		-1.16***	-0.86***	-0.99***
			(0.06)	(0.06)	(0.07)
	CDS spreads		0.01***	0.01***	0.01***
			(0.00)	(0.00)	(0.00)
Profits	Profitability			-13.40***	-10.44***
				(2.90)	(3.17)
	Return on Equity			-0.69***	-0.27***
				(0.08)	(0.10)
Business	International				0.16
					(0.15)
	Standby facility				-0.31***
					(0.01)
	Constant	65.86***	412.41***	405.42***	417.84***
		(1.27)	(3.39)	(3.39)	(3.39)
	Observations	14925	6103	6103	5282
	R^2	0.42	0.97	0.97	0.97

Note: The table shows pooled OLS estimations with the dependent variable being the institution-specific DLCR cutoffs. The regression includes 4 groups of explanatory variables, referring to an institution's size, risk profile, profitability and business model respectively. Specifically, the analysis includes the natural logarithm of both *Total assets* and total *Borrowing volume* in the interbank market as well as an institution's *Relative size* (individual assets as share of aggregate assets). The regressions further account for *Capital* in percentage of RWA and capital in percentage of total assets (*Leverage*) as well as an institution's numeric *Rating* and *CDS spreads*. Finally, the analysis includes *Profitability* (net income in percentage of total assets), *Return on Equity*, how *International* (borrowing from international counterparts in total borrowing) the institution's business model is and whether the institution relies on a *Standby facility* (natural logarithm). Statistical significance is indicated by *** p<0.01, ** p<0.05, * p<0.1 while robust standard errors are in parentheses.

Table 4.1 points very clearly to a number of patterns. Larger, better capitalized and better rated institutions have lower cutoffs. These results suggest that higher cutoffs are an explicit intention to hold precautionary liquidity buffers. It is likely that smaller and more risky institutions have less precise control over their DLCR and therefore aim at values above the regulatory minimum of 100%. The results on banks' profitability suggest that more profitable banks tend to have lower cutoff values, supporting the hypothesis that larger liquidity buffers imply higher costs.

4.3.2. Establishing the internal validity of applying RDD

After defining the institution-specific cutoffs, the analysis follows the standard procedure to establish the internal validity of RDD. According to Lee and Lemieux (2010), the key condition for RDD to be valid is that individuals are not able to *precisely* manipulate the assignment variable. Lee and Lemieux (2010) state that when individuals have imprecise control over the assignment variable, even if some are especially likely to have values near the cutoff, every individual will have approximately the same probability of having a value that is just above or just below the cutoff. The reason why RDD allows for more relaxed assumptions is that, in contrast to other comparable setups, the assignment variable can be directly observed.

For RDD to be valid for this sample, banks should not be able to precisely choose whether they will be above their individual cutoff or not but rather have imprecise control. The fact that all banks in the sample have values below their cutoff is already a very strong indication that unexpected actions of other market participants make it impossible for a bank to precisely determine its liquidity ratio.[22]

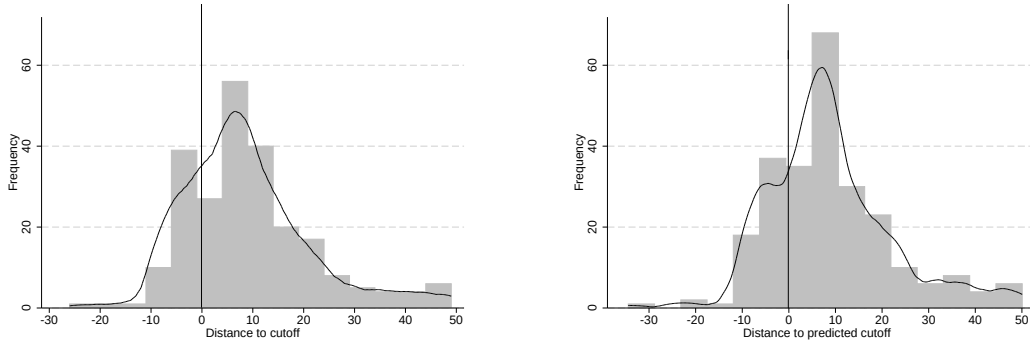
Banks' control over their DLCR is similar to the example provided by Van der Klaauw (2002) regarding students' capability to manipulate their high school grades and SAT scores. As argued by the author, even if students have perfect knowledge about the threshold determining the assignment of scholarships, it seems implausible that students can perfectly control their grades.

Although the assumption of imprecise control is intuitively plausible for this sample and it cannot be directly tested, Lee and Lemieux (2010) point towards the discontinuity of the assignment variable's aggregate distribution as potential test for imprecise control. As McCrary (2008) argues, if the density of the assignment variable is continuous for each individual, then the marginal density over the population should be continuous as well. However, as pointed out by the author, the density test is only appropriate to confirm the validity of RDD while it is neither necessary nor sufficient for identification.

[22] Such actions can, for instance, be drawdowns of committed credit and liquidity facilities, interest rate changes and the subsequent movements in assets' market values, large deposit withdrawals, exchange rate movements, changes in central bank policies, defaults of important counterparts and even simple measurement or interpretation errors.

To conduct this test, a new variable reflecting the distance of a bank's DLCR to its individual cutoff is generated. For the individual cutoff, both the one determined by the graphical analysis and the predicted cutoff based on the regression coefficients in Table 4.1 are used.

Figure 4.3: Distribution of banks' distance to (predicted) cutoff



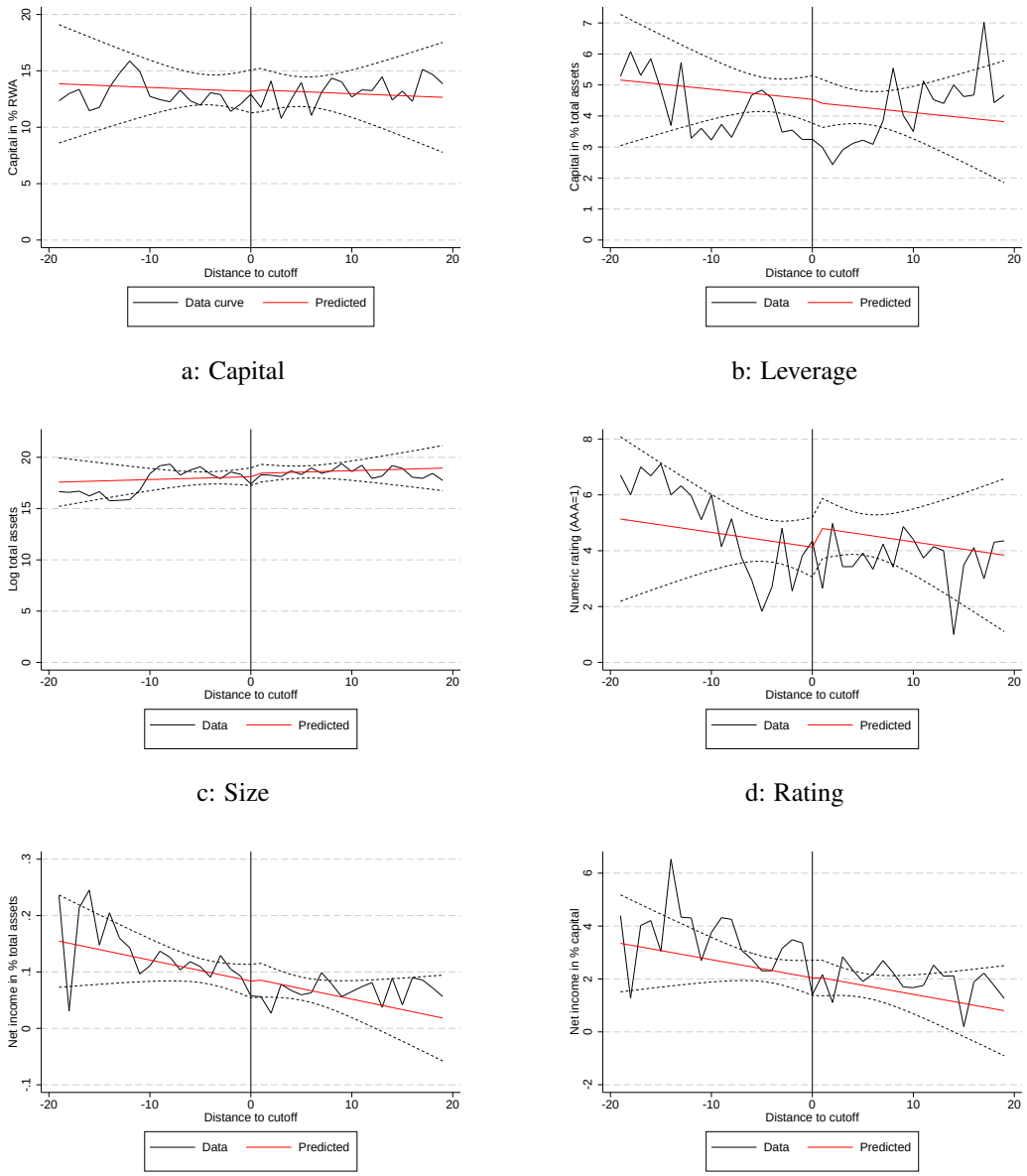
a: Set cutoff b: Predicted cutoff

Note: The figure presents the distribution of banks' distance to their individual cutoff. The value of 5, for instance, shows the number of observations for which banks have a DLCR that is 5 above their institution-specific cutoffs. Both, the cutoffs determined by the graphical analysis and the predicted cutoffs are used.

As can be seen in Figure 4.3, there is no discontinuity in aggregate density.[23] According to McCrary (2008), in case of precise control one would expect surprisingly few observations just below and surprisingly many observations just above the cutoff. Clearly this is not the case in Figure 4.3.
As argued by Lee and Lemieux (2010), an alternative approach for testing the validity of RDD is to analyze whether the baseline covariates are balanced on both sides of the cutoff. An intuitive way of doing this is to conduct both a graphical as well as a formal estimation analysis to show that other predetermined bank-specific characteristics are smooth around the cutoff.
The fact that the institution-specific cutoffs are determined by bank characteristics is likely to reduce the risk of discontinuity with respect to the covariates. Following Lee and Lemieux (2010), Seemingly Unrelated Regressions (SUR) with each equation representing a different bank-specific variable are performed.[24] As dependent variable the analysis includes banks' distance to their individual cutoff as well as a dummy describing whether an institution's DLCR is above its individual cutoff. SUR allows testing whether the coefficients for banks' deviation from their individual cutoff are jointly insignificant for all lagged bank-specific characteristics. Figure 4.4 and Table 4.2 present the impact of being above the cutoff on a set of lagged bank-specific variables.

[23] Note that this analysis has also been conducted on the individual level which also did not point to discontinuity around the threshold.
[24] The application of SUR is standard in this context. See Lee and Lemieux (2010) for further details.

Figure 4.4: Smoothness of lagged covariates around cutoff



Note: The figure presents graphs of several bank-specific variables on the y-axis and banks' distance to their cutoffs on the x-axis. All variables are represented by their lagged values. Additionally the graphs show parametric curves predicted with the results from Table 4.2 as well as the respective 95% confidence interval.

Observing Figure 4.4 and Table 4.2, it becomes evident that the covariates do not show discontinuities around the institution-specific cutoffs. The coefficients of both the distance of a bank's DLCR to its cutoff as well as the dummy describing whether a bank's DLCR is above the cutoff

are insignificant for all covariates. This insignificance can be observed in Figure 4.4, which shows that the parametric and the data curves significantly deviate. Finally, the data curves do not show discontinuities around the threshold. While it is not possible to prove the validity of RDD, the combined evidence in this section does not give any reason to doubt it.

Table 4.2: Seemingly Unrelated Regressions of the lagged covariates

VARIABLES (lags)	Capital	Profit	Rating	Size	RoE	Leverage
Cutoff	0.16	0.01	0.72	0.32	0.06	-0.10
	(1.85)	(0.03)	(1.04)	(0.83)	(0.65)	(0.75)
DLCR-Cutoff	-0.04	-0.00	-0.05	0.03	-0.07	-0.03
	(0.17)	(0.00)	(0.10)	(0.08)	(0.06)	(0.07)
Constant	13.17***	0.08***	4.13***	18.11***	2.04***	4.54***
	(0.97)	(0.02)	(0.54)	(0.44)	(0.34)	(0.39)
Observations	179	179	179	179	179	179
R^2	0.001	0.068	0.006	0.023	0.051	0.016

Note: The table shows regressions with the dependent variables being lagged *Capital* (capital as % of RWA), $Profit$ (income as % of total assets), numeric *Rating*, *Size* (natural logarithm of total assets), *RoE* (return on equity) and *Leverage* (capital as % of total assets). $Cutoff$ is a dummy which is 1 in case an institution's DLCR is above its individual cutoff and 0 otherwise. $DLCR - Cutoff$ is the difference between an institution's DLCR and its cutoff. Statistical significance is indicated by *** p<0.01, ** p<0.05, * p<0.1 while robust standard errors are in parentheses.

4.4. Estimation

The RDD literature typically distinguishes parametric and non-parametric analyses. As pointed out by Roberts and Whited (2012), when deciding between the two approaches one faces the usual trade-off between precision and bias. Starting with Hahn et al. (2001), nonparametric approaches are more common. A likely reason for this practice is the increased risk of misspecification in case of parametric analyses. Misspecification is a general problem but it is particularly severe in RDD. As specification errors are minimized globally, linear regression models can - despite misspecification - be interpreted as linear predictors. RDD, on the other hand, depends on small *local* specification around the cutoff and therefore does not gain from global minimization. Following Hahn et al. (2001) as well as McCrary and Royer (2011), all models are estimated using both approaches while focussing on non-parametric estimations. The regression is defines as follows:

$$Y_{i,t,d} = \beta_0 + \beta_1 DCutoff_{i,t} + \beta_2 (DLCR - Cutoff)_{i,t} + \beta_3 (DCutoff * DLCR)_{i,t} + \beta_4 Controls_{i,t(-1)} + \varepsilon_{i,t} \quad (4.4)$$

where $Y_{i,t,d}$ describes six distinct dependent variables. The pattern of the classifications is straightforward: Four variables relating to an institution's interest rates are defined while the remaining

two refer to its net demand. Interest rates are defined as the spread between institution i's volume and maturity-weighted average borrowing (lending) rate in month t and day d with the respective ECB rate while volumes refer to institution i's net borrowing on day d as share of its average net borrowing during the entire sample. Given the different treatment between loans with maturities longer and shorter than 30 days, the analysis further classifies the dependent variables referring to prices and volumes into these two categories.

The right hand side is in line with Roberts and Whited (2012) as well as Lee and Lemieux (2010), reflecting common practice when estimating an RDD model with a pooled nonparametric approach. It includes the dummy variable $DCutoff_{i,t}$, which gives insight into whether a bank below its individual cutoff behaves differently. The variable is 1 in case a bank's liquidity ratio is above its cutoff and 0 otherwise.

To avoid the results being driven by an institution's liquidity holdings rather than the liquidity requirement, the variable $(DLCR-Cutoff)_{i,t}$, reflecting the distance of a bank's DLCR from the cutoff, is included. As argued by Roberts and Whited (2012), subtracting the cutoff value from the assignment variable ensures that the intercepts reflect the value of the regression functions at the cutoff. To allow the regression function to differ on both sides of the cutoff, the analysis additionally includes the interaction term $(DCutoff*DLCR)_{i,t}$.

In a valid RDD, the main argument for still including covariates is to reduce the sampling variety. Especially when experimenting with different bandwidths and polynomials, the inclusion of covariates can be useful.

For each bandwidth, the regression model is run with and without $Controls_{i,t(-1)}$. $Controls_{i,t(-1)}$ includes an institution's lagged capital (capital in percentage of RWA), profitability (net income in percentage of total assets), fulfilment of the average reserve requirement, a variable reflecting the relationships of an institution in the interbank money market as well as a variable describing the average solvency of an institution's counterparts.[25] $Controls_{i,t(-1)}$ also includes bank and period-specific dummies. All regressions include robust standard errors.

Finally, it is important to choose the optimal bandwidth. While there are several different approaches used in the literature, none of these approaches provides a clear answer and the selection of bandwidths remains a subjective judgment call.[26] As pointed out by Roberts and Whited (2012), it is best to choose a bandwidth and experiment with a variety of other bandwidths to illustrate the robustness of results. Following the earlier argumentation, an upper limit seems appropriate for this sample. Given this, a rectangular kernel between -100 and 100 seems intuitively plausible, which is therefore used as baseline scenario.

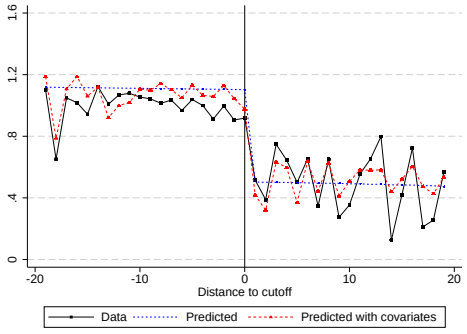
[25] See Cocco et al. (2009). Note that the analysis alternately includes capital or leverage as well as RoE or profitability.

[26] See, for instance, McCrary and Royer (2011) who use a rule-of-thumb bandwidth or Ludwig and Miller (2007) applying cross-validation techniques.

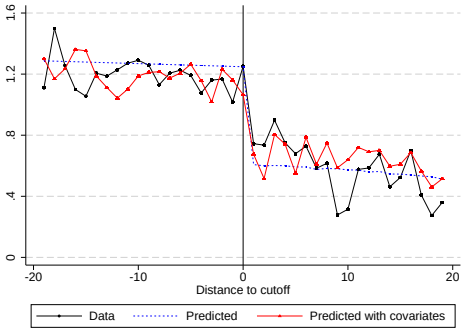
4.5. Results - data and parametric

4.5.1. Institution-specific cutoffs greater or equal to 100%

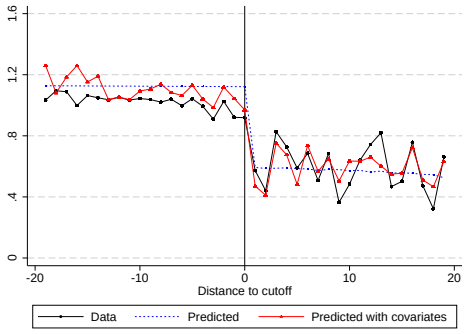
Figure 4.5: Interbank market and liquidity regulation - all banks



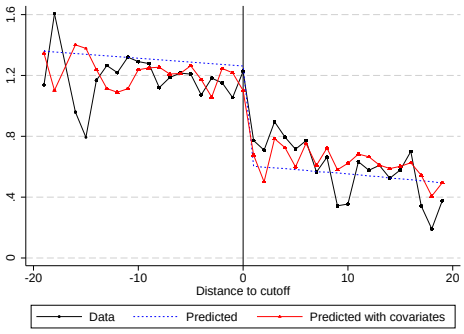
a: Short-term borrowing rate



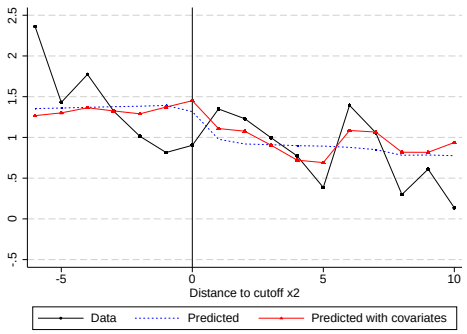
b: Long-term borrowing rate



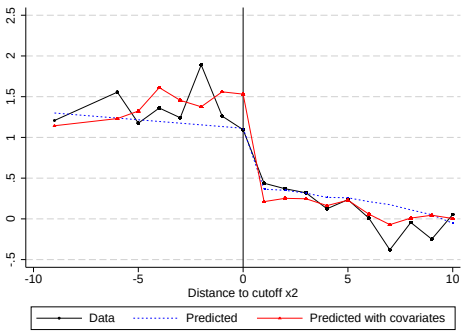
c: Short-term lending rate



d: Long-term lending rate



e: Short-term net demand



f: Long-term net demand

Note: The figure shows parametric and data curves describing the relationship between institutions' distance to their individual DLCR cutoff and the short-term and long-term interest rates as well as volumes in the interbank money market.

Based on Tables A4.2 and A4.3, Figure 4.5 shows parametric and data curves describing the relationship between institutions' distance to their individual DLCR cutoff and the short-term and long-term interest rates as well as volumes in the interbank money market.

Figure 4.5 shows that banks below their individual cutoff pay (when borrowing) and charge (when lending) significantly higher interest rates for unsecured interbank loans with maturities shorter and longer than 30 days. On top of that, banks' net demand for loans with maturities longer than 30 days is significantly higher for banks below their cutoff while net demand for short-term loans seems unaffected.

Looking at Figures 4.5a and 4.5b, it can be seen that banks' interbank borrowing rates show a clear discontinuity around the cutoff, suggesting that banks with DLCRs below the cutoff pay higher interest rates for short-term and long-term loans in the interbank money market.

Specifically, institutions below their cutoff pay between 33 basis points (bp) and 56bp more for short-term loans and between 28bp and 44bp for long-term loans. Both results are statistically significant at the 1% confidence level. The results for lending rates look very similar, suggesting that banks below their cutoff charge between 19bp and 35bp more for short-term loans and between 46bp and 59bp higher interest rates when issuing loans with maturities longer than 30 days.

Figures 4.5a to 4.5d show that including covariates significantly improves the precision of the results. Given this, the regressions with covariates can be considered more accurate and therefore the impact of being below the cutoff varies between 19bp and 33bp for short-term loans and between 28bp and 46bp for long-term loans. The results from the regressions including covariates are also more in line with the theory of long-term loans being relatively more attractive for banks below the cutoff. With covariates included, the impact of $DCutoff_{i,t}$ is consistently larger for long-term loans. The reason why this effect is clearer for lending rates is likely caused by institutions having more precise control over their lending rates.

For banks' net demand, Figure 4.5f shows a clear discontinuity around the cutoff for long-term loans while the evidence for short-term loans is less clear. Net demand is defined as the share of a bank's net borrowing (difference of borrowing and lending) on day d as share of its average daily net borrowing over the entire sample.

Institutions below their cutoff borrow between 60% and 72% more long-term loans than their peers above the cutoff. Although the precision of the estimates seems generally better when covariates are included, the discontinuity jump at the threshold is more accurately predicted by the regression without covariates. However, independent of the bandwidth and the inclusion of covariates the analysis suggests that being below their individual cutoff causes banks to increase their net demand for long-term loans between 60% and 70% of their average net demand.

The evidence regarding banks' demand for short-term loans is less clear. While the regression results show a significant impact of being below the cutoff across all specifications, Figure 4.5e does not show a discontinuity around the cutoff. The econometric results suggest that the net

demand of banks below the cutoff is approximately 35% higher than their average net demand. However, since there is no discontinuity at the threshold, it can be concluded that this effect is driven by a general risk management process within the bank rather than regulation.

4.5.2. Institution-specific cutoffs equal to 100%

The analysis so far suggests that there is discontinuity around institutions' individual cutoff, even if these cutoffs are significantly above the regulatory threshold. However, it might still be the case that institutions react differently in case they do not only drop below their individual cutoff but also below the regulatory threshold of 100%.

In total, the sample includes 9 banks and 111 observations with values below the regulatory threshold of 100%. To understand whether there is a significant difference between the regulatory and the individual threshold well above 100%, the same analysis, as shown in Figure 4.5, is conducted only considering those banks with individual cutoffs of 100% and at least one non-compliant observation.

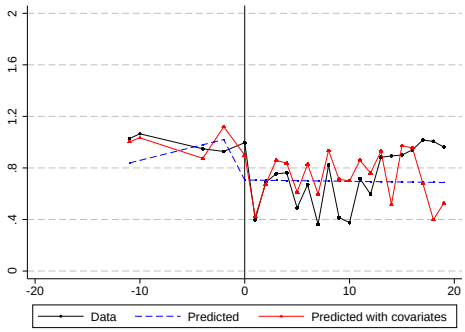
Illustrating the results of Tables A4.4 and A4.5, Figure 4.6 shows parametric and data curves describing the relationship between institutions' distance to the regulatory threshold of 100% and the short-term and long-term interest rates as well as volumes in the interbank money market. Figure 4.6 shows similar results as Figure 4.5 but also suggests that banks' reaction regarding long-term loans is significantly stronger when falling below the regulatory minimum.

Figures 4.6a and 4.6b show rather clear discontinuities around the regulatory threshold of 100% and are therefore in line with the results also including the individual cutoffs above 100%. Looking at the individual coefficients, however, one can see that banks' reaction regarding long-term interest rates is significantly stronger when they fall below the regulatory threshold of 100%.

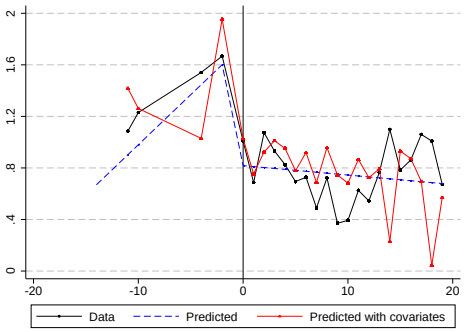
Specifically, when being below the threshold of 100%, banks pay 96bp more for long-term loans. To recall, banks below their individual threshold above 100% pay only 38bp more for long-term loans. To make the two samples comparable, being below the regulatory threshold causes banks' long-term borrowing rates to increase by almost 2 standard deviations (sd) while banks below their individual threshold above 100% pay only 0.74sd more. Regarding short-term loans, banks below the regulatory threshold react less strong (0.7sd compared to 0.3sd). The results for banks' lending rates are similar to the ones for borrowing rates.

Also regarding banks' net demand, Figure 4.6f is very similar to Figure 4.5f. Again, however, the coefficients are significantly larger for long-term loans. While banks' below their individual cutoffs above 100% borrow 72% more, being below the regulatory threshold causes banks to borrow twice as much as their compliant peers.

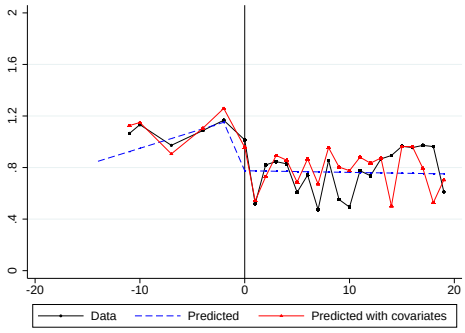
Figure 4.6: Interbank market and liquidity regulation - cutoff 100%



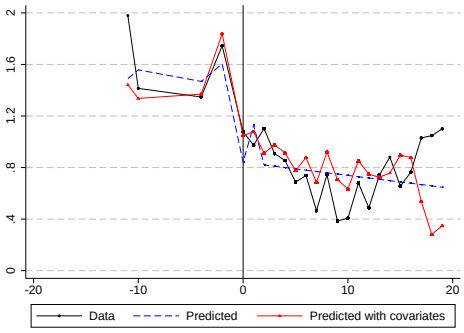
a: Short-term borrowing rate



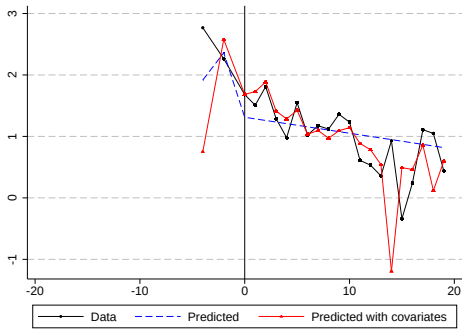
b: Long-term borrowing rate



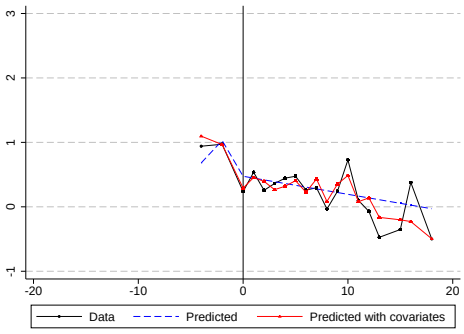
c: Short-term lending rate



d: Long-term lending rate



e: Short-term net demand



f: Long-term net demand

Note: The figure shows parametric and data curves describing the relationship between institutions' distance to the regulatory threshold of 100% and the short-term and long-term interest rates as well as volumes in the interbank money market.

Summarizing, the results suggest that a liquidity requirement affects banks' behavior in the interbank market. Banks below their cutoff pay and charge significantly higher interest rates for all loans and borrow larger volumes of unsecured interbank loans with maturities longer than 30 days. While the results with respect to banks' net demand are in line with the theory suggesting that banks below their cutoff demand more long-term loans, the results regarding interest rates are somewhat counterintuitive. Usually, one would expect that - since banks below the cutoff are incentivized to attract more long-term loans- only interest rates of long-term loans increase. There are two reasons which are likely to explain the increase of short-term interest rates: 1) Once a bank falls below its cutoff and is forced to borrow more costly long-term loans, it will try to pass on these increased marginal costs of funds to other banks, presumably increasing short-term lending rates as well, and 2) The sharp discontinuity of short-term interest rates around the cutoff suggests that banks view the DLCR not only as regulatory requirement but also as liquidity managing tool. Once a bank falls below its individual cutoff, it is likely to not only view this as regulatory shortage but as general liquidity shortage, presumably also raising short-term interest rates. This is additionally confirmed by the fact that the impact of being below the cutoff on long-term loans is significantly larger if this cutoff coincides with the regulatory threshold of 100%. The combined evidence suggests that when banks fall below their individual cutoff above 100% they view it as a general liquidity shortage and therefore also address it with short-term borrowing while a regulatory shortage causes a relatively stronger reaction regarding long-term loans.

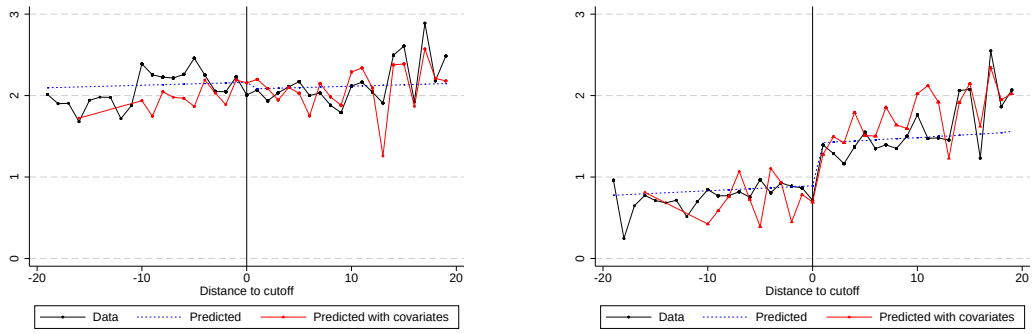
4.6. Transmission to the real economy

When central banks use the overnight interest rate as tool for monetary policy implementation, it is assumed that interest rate movements in the interbank market are transmitted to the real economy. Since the key objective of most central banks is price stability, real economy interest rates are eventually more important than the overnight rate. Hence, to understand how policymakers can react to the changes of banks' behavior, suggested by the results, it is important to look at the transmission channel between the interbank interest rates and banks' lending rates to corporates.
This step also applies RDD. Although the covariates are somewhat different, the overall structure of the right hand side of the regression is identical to Equation 5.2. Two different dependent variables are used: The spread between an institution's corporate lending rate with 1) the ECB interest rate, or 2) its borrowing rate in the interbank market. The first variable gives insight in whether being below the cutoff has a direct impact on institution's corporate lending rates while the latter spread shows whether $DCutoff_{i,t}$ can explain the interest margin banks charge on top of their interbank market rate.
The additionally included $Controls_{i,t}$ are motivated by the literature on corporate lending, which typically considers banks' funding costs, expected losses on lending activities and the extent of

equity funding as key determinants of corporate lending.[27] As proxies for the expected default risk on an institution's lending activities, the analysis includes an institution's lending standards measured by its response to the BLS. The analysis also includes the lag of an institution's capital in percentage of RWA, a bank's perception of credit demand, the growth rate of the industrial sectors an institution is lending to as well as GDP and two loan-specific factors. As earlier, $Controls_{i,t}$ also includes bank dummies.

Illustrating the results of Table A4.6, Figure 4.7 shows that banks below their cutoff do not seem to charge higher interest rates for corporate lending. Banks below the cutoff charge, however, lower interest margins when lending to corporates. These results suggest that banks are not able to pass on their increased funding costs to non-financial corporates.

Figure 4.7: Corporate lending spreads



a: Spread corporate ECB

b: Spread corporate interbank

Note: The figure shows parametric and data curves describing the relationship between institutions' distance to their individual DLCR cutoff and the spread of institutions' corporate lending rates with either the ECB interest rate or the bank's funding rate in the interbank market.

Figure 4.7a shows that being below the cutoff does not impact banks' corporate lending rates. The figure does not show a discontinuity around the threshold and also the regressions do not show significant effects of $DCutoff_{i,t}$ on banks' corporate lending rates. Figure 4.7b, on the other hand, shows a clear discontinuity around the threshold. Table A4.6 suggests that banks below the cutoff charge between 44bp and 69bp less on top of their interbank borrowing rates when issuing loans to corporates. Again, the precision of the estimates is better with covariates.

Summarizing, the results suggest that the DLCR does not affect corporate lending rates. It does, however, reduce the interest margins banks can charge on top of their funding costs. It is important to point out though that the dataset does not include an aggregate liquidity shortage. In most months

[27] See Brown et al. (2010), Fabbro and Hack (2011) or Deans and Stewart (2012).

about 80% of the banks in this sample are above their cutoff. Competitive pressure limits banks' opportunities to pass on increased costs. In case of an aggregate shortage, competitive pressure to maintain current interest rates is likely to decrease.

4.7. Sensitivity analysis

In order to check the robustness of the results, a number of sensitivity tests are conducted. Given the high importance of choosing the correct functional form as well as bandwidth in an RDD, the sensitivity analysis mainly aims at confirming the chosen RDD approach.
The results in Figures 4.5 and 4.7 are robust to changes in the bandwidth. While the coefficients decrease with wider bandwidths, their statistical and economic significance remains generally stable.[28] An exception to this observation are some coefficients in the 20 and 40 bandwidths referring to interest rates. When no covariates are included some regressions in those two bandwidths show coefficients above 100bp. Although this is possible, the coefficients seem unrealistically high. A likely explanation for these results is that only certain banks lie in these particular bandwidths, additionally suggesting the inclusion of covariates. The previous results are also robust to using the predicted institution-specific cutoffs based on the coefficients from Table 4.1.
Apart from this RDD specific exercises, the analysis includes different covariates. Specifically, risk-weighted capital is substituted for leverage, ratings for CDS spreads and different measures describing a bank's size are used. The impact of these changes is insignificant.
To exclude the possibility of liquidity regulation having a particular effect on overnight interest rates, the analysis additionally includes a dummy which is 1 in case of overnight loans and 0 otherwise. The dummy is insignificant in all specifications which is intuitively straightforward, given that the calculation of the dependent variables controls for a loan's maturity. The split between large and small banks does not result in any major differences. The results are also robust to adding more macroeconomic variables, namely inflation and other ECB interest rates.

4.8. Interpretation and conclusion

The aim of this chapter is to show the impact of a quantitative liquidity requirement on banks' role as financial intermediaries. Specifically, this chapter analyzes whether the Dutch quantitative liquidity requirement changes banks' behavior in the unsecured interbank money market and whether these changes have an impact on private sector lending and monetary policy implementation.

[28] See Table A4.7 in the Appendix.

This chapter's analysis suggests that a quantitative liquidity requirement increases banks' demand for long-term loans, making them more expensive. While increased demand for long-term loans could decrease the relative value of short-term funding, the analysis does not show evidence confirming this theory. Rather, an increase of short-term borrowing and lending rates can be observed. The increase of short-term rates is likely to be caused by increased marginal costs of funds as well as banks' tendency to use the liquidity requirement as general risk management tool. Having said this, the impact of being below the cutoff on long-term loans is significantly larger if this cutoff coincides with the regulatory threshold of 100%. The combined evidence suggests that, when banks fall below their individual cutoff above 100%, they view it as a general liquidity shortage and therefore also address it with short-term borrowing while a regulatory shortage causes a relatively stronger reaction regarding long-term loans.

While a liquidity requirement does not seem to have a direct impact on corporate lending rates, the analysis in this chapter suggests that it reduces banks' interest margins on private sector lending. However, the absence of an aggregate liquidity shortage and the implied competitive pressure might be a key reason for banks not being able to pass on their increased funding costs.

Generally, the potential impact of the LCR depends crucially on the extent of non-compliance as it determines how many banks will adjust their behavior. An important insight from this analysis is that the LCR is unlikely to affect monetary policy transmission itself. Rather, it might make the overnight interest rate a less useful tool for monetary policy implementation. Central banks are advised to closely monitor the aggregate LCR and potentially use a representative real economy interest rate as additional target for monetary policy implementation. Whether or not further measures are needed (such as the recognition of committed central bank facilities in the LCR), crucially depends on the economic and legal context in which they take their effect. Answering this question, however, is beyond the scope of this chapter.

While the period after the financial crisis was characterized by discussions around Basel III, the European sovereign debt crisis raised interest in other topics related to financial regulation. Being one of the key issues during that time, the next chapter analyzes the impact of financial regulation on banks' demand for government.

Appendix

Table A4.1: Summary statistics

Variable	#Obs.	Mean	Std.Dev.	Min	Max
Short-term borrowing spread	12597	.70	.48	-1.33	2.34
Long-term borrowing spread	11591	.81	.52	-1.30	2.30
Short-term lending spread	14248	.74	.45	-1.60	2.29
Long-term lending spread	9956	.82	.51	-1.28	2.48
Short-term net demand	4433	1	1.22	-1.58	4.61
Long-term net demand	4433	1	1.73	-2.12	6.01
DLCR	15176	135.80	57.52	49	669
Capital	13797	13.41	4.22	4.83	46.02
Profit	15176	.08	.10	-.48	.36
RoE	15176	2.13	3.15	-26.80	11.56
Relationships borrower	14549	.27	.238	.00	1
Relationships lender	14676	.20	.20	.00	1
Rating	8364	4.23	2.26	1	9
Corporate ECB spread	786	2.25	.59	.88	4.63
Corporate IB spread	734	1.47	.76	-.18	4.09
Lending standards	454	2.82	.65	1	4
BLS demand	457	2.86	.79	1	5
Borrower health	782	0.32	2.63	-3.74	3.45
Large	786	25.99	41.22	.33	399
Short	777	.60	.33	.01	1.99
GDP growth rate	1200	1.73	2.03	-3.48	3.92

Note: The above table shows summary statistics for all relevant variables.

Table A4.2: Interest rates

	Borrowing rates				Lending rates			
VARIABLES	< 30days	< 30days	> 30days	> 30days	< 30days	< 30days	> 30days	> 30days
Cutoff	-0.556***	-0.331***	-0.440***	-0.381***	-0.351***	-0.191***	-0.587***	-0.460***
	(0.020)	(0.017)	(0.023)	(0.022)	(0.016)	(0.014)	(0.025)	(0.025)
DLCR-Cutoff	-0.001**	0.000	-0.002***	-0.001	-0.000	-0.000	-0.005***	-0.003***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Cutoff*DLCR	-0.000**	-0.000***	-0.002***	-0.002***	-0.002***	-0.001***	-0.001***	-0.000*
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Reserve requirement		-0.003***		-0.001***		-0.003***		-0.001***
		(0.000)		(0.000)		(0.000)		(0.000)
Capital in % RWA		-0.035***		-0.060***		-0.031***		-0.053***
		(0.002)		(0.002)		(0.001)		(0.002)
Relationships		0.049***		-0.121***		-0.064***		-0.107***
		(0.018)		(0.024)		(0.021)		(0.029)
Profit		0.594***		0.195***		0.773***		0.311***
		(0.037)		(0.045)		(0.031)		(0.047)
Counterparty capital						-0.114***		0.141***
						(0.027)		(0.037)
Constant	1.103***	1.511***	1.248***	2.017***	1.122***	1.518***	1.262***	1.889***
	(0.007)	(0.022)	(0.007)	(0.030)	(0.006)	(0.017)	(0.007)	(0.029)
Observations	12391	9445	11548	9052	14030	11338	9909	7985
R^2	0.315	0.595	0.377	0.490	0.302	0.584	0.419	0.526

Note: The table presents results estimated with RDD. The dependent variable is the spread between an institution's daily average borrowing or lending rate and the respective ECB interest rate. The analysis additionally distinguishes between maturities shorter and longer than 30 days. The purpose of the regressions is to show whether banks below and above their individual $Cutoff$ (dummy 1 if above) behave differently. The analysis includes the distance of an institution's DLCR to the cutoff ($DLCR-Cutoff$) as well as an interaction term ($Cutoff*DLCR$). Additionally, the analysis includes an institution's daily fulfilment of its central bank *Reserve*;*requirement*, lagged *Capital in % RWA*, an institution's *Relationships*, *Profit* (net income in % total assets) and the average capital ratio of the counterparts an institution is lending to (*Counterparty capital*). When covariates are included, the regressions also include bank dummies. Statistical significance is indicated by *** p<0.01, ** p<0.05, * p<0.1 while standard errors are in parentheses.

Table A4.3: Volumes

	< 30days		> 30days	
Cutoff	-0.336*	-0.372**	-0.611***	-0.723**
	(0.198)	(0.183)	(0.252)	(0.351)
DLCR-Cutoff	0.004	-0.001	-0.010**	-0.002
	(0.003)	(0.003)	(0.005)	(0.005)
Cutoff*DLCR	-0.008***	-0.004**	-0.007**	-0.005
	(0.002)	(0.002)	(0.003)	(0.003)
Reserve requirement		0.005***		0.001***
		(0.000)		(0.000)
Capital in % RWA		0.040		0.031
		(0.025)		(0.022)
Relationships		1.552***		1.033***
		(0.141)		(0.190)
Profit		-0.699		0.175
		(0.492)		(0.461)
Counterparty capital		-0.043		-0.192
		(0.160)		(0.231)
Constant	1.405***	0.295	1.102***	0.643**
	(0.058)	(0.272)	(0.050)	(0.276)
Observations	3076	3072	4495	3705
R^2	0.038	0.209	0.071	0.109

Note: The table presents results estimated with RDD. The dependent variable is an institution's net daily borrowing over average net daily borrowing over the entire sample. The analysis additionally distinguishes between maturities shorter and longer than 30 days. The purpose of the regressions is to show whether banks below and above their individual $Cutoff$ (dummy 1 if above) behave differently. The analysis includes the distance of an institution's DLCR to the cutoff ($DLCR-Cutoff$) as well as an interaction term ($CutoffS*DLCR$). Additionally, the analysis includes an institution's daily fulfilment of its central bank *Reserve*;*requirement*, lagged *Capital in % RWA*, an institution's *Relationships*, *Profit* (net income in % total assets) and the average capital ratio of the counterparts an institution is lending to (*Counterparty capital*). When covariates are included, the regressions also include bank dummies. Statistical significance is indicated by *** p<0.01, ** p<0.05, * p<0.1 while standard errors are in parentheses.

Table A4.4: Interest rates with 100% cutoff

	Borrowing rates				Lending rates			
VARIABLES	< 30days	< 30days	> 30days	> 30days	< 30days	< 30days	> 30days	> 30days
Cutoff (100%)	-0.354***	-0.142**	-0.939***	-0.962***	-0.426***	-0.257***	-0.901***	-0.810***
	(0.070)	(0.058)	(0.092)	(0.081)	(0.062)	(0.054)	(0.108)	(0.087)
DLCR-100%	0.020***	0.012**	0.078***	0.092***	0.025***	0.015***	0.068***	0.083***
	(0.007)	(0.005)	(0.011)	(0.009)	(0.006)	(0.005)	(0.017)	(0.013)
Cutoff*DLCR	-0.021***	-0.012**	-0.085***	-0.096***	-0.027***	-0.016***	-0.079***	-0.090***
	(0.007)	(0.005)	(0.011)	(0.009)	(0.006)	(0.005)	(0.018)	(0.014)
Reserve requirement		-0.003***		-0.001***		-0.003***		-0.001***
		(0.000)		(0.000)		(0.000)		(0.000)
Capital in % RWA		-0.046***		-0.149***		-0.023***		-0.144***
		(0.003)		(0.006)		(0.002)		(0.006)
Relationships		0.121***		0.308***		-0.064		0.107*
		(040)		(0.056)		(0.041)		(0.063)
Profit		0.847***		0.834***		0.728***		1.242***
		(0.063)		(0.090)		(0.054)		(0.102)
Counterparty capital						0.345***		0.578***
						(0.068)		(0.117)
Constant	1.061***	1.561***	1.757***	3.477***	1.202***	1.442***	1.742***	3.221***
	(0.070)	(0.070)	(0.092)	(0.107)	(0.062)	(0.063)	(0.108)	(0.115)
Observations	4942	3587	4104	3030	5648	4247	3045	2480
R^2	0.007	0.458	0.057	0.345	0.012	0.378	0.065	0.387

Note: The table presents results estimated with RDD. The dependent variable is the spread between an institution's daily average borrowing or lending rate and the respective ECB interest rate. The analysis additionally distinguishes between maturities shorter and longer than 30 days. The purpose of the regressions is to show whether banks below and above the regulatory $Cutoff(100\%)$ (dummy 1 if above) behave differently. The analysis includes the distance of an institution's DLCR to the cutoff ($DLCR-100\%$) as well as an interaction term ($CutoffS*DLCR$). Additionally, the analysis includes an institution's daily fulfilment of its central bank *Reserve*;*requirement*, lagged *Capital in % RWA*, an institution's *Relationships*, *Profit* (net income in % total assets) and the average capital ratio of the counterparts an institution is lending to (*Counterparty capital*). When covariates are included, the regressions also include bank dummies. Statistical significance is indicated by *** p<0.01, ** p<0.05, * p<0.1 while standard errors are in parentheses.

Table A4.5: Volumes with 100% cutoff

	< 30days		> 30days	
Cutoff (100%)	-0.440***	-0.384***	-0.902**	-1.053**
	(0.085)	(0.079)	(0.438)	(0.441)
DLCR-100%	0.329***	0.165***	0.174*	0.112
	(0.073)	(0.061)	(0.092)	(0.092)
Cutoff*DLCR	-0.391***	-0.199***	-0.202**	-0.144
	(0.075)	(0.062)	(0.095)	(0.095)
Reserve requirement		0.005***		0.001***
		(0.000)		(0.000)
Capital in % RWA		0.203***		0.197***
		(0.028)		(0.043)
Relationships		1.958***		0.554*
		(0.188)		(0.287)
Profit		-0.958*		-0.630
		(0.493)		(0.753)
Counterparty capital		1.963***		-0.640
		(0.390)		(0.595)
Constant	2.940***	-1.014**	1.376***	-0.875
	(0.349)	(0.432)	(0.440)	(0.659)
Observations	1768	1753	1768	1753
R^2	0.056	0.238509	0.009	0.046

Note: The table presents results estimated with RDD. The dependent variable is an institution's net daily borrowing over average net daily borrowing over the entire sample. The analysis additionally distinguishes between maturities shorter and longer than 30 days. The purpose of the regressions is to show whether banks below and above the regulatory $Cutoff(100\%)$ (dummy 1 if above) behave differently. The analysis includes the distance of an institution's DLCR to the cutoff ($DLCR-100\%$) as well as an interaction term ($CutoffS*DLCR$). Additionally, the analysis includes an institution's daily fulfilment of its central bank *Reserve*;*requirement*, lagged *Capital in % RWA*, an institution's *Relationships*, *Profit* (net income in % total assets) and the average capital ratio of the counterparts an institution is lending to (*Counterparty capital*). When covariates are included, the regressions also include bank dummies. Statistical significance is indicated by *** p<0.01, ** p<0.05, * p<0.1 while standard errors are in parentheses.

Table A4.6: Corporate lending

	Spread ECB		Spread Interbank	
Cutoff	-0.085	0.145	0.444***	0.687***
	(0.066)	(0.184)	(0.082)	(0.186)
DLCR-Cutoff	0.003***	0.015***	0.006***	0.016***
	(0.001)	(0.003)	(0.002)	(0.003)
Cutoff*DLCR	0.000	-0.001	0.001	-0.002
	(0.000)	(0.001)	(0.001)	(0.001)
Lending standards		0.041		-0.031
		(0.064)		(0.064)
BLS demand		0.235***		0.177***
		(0.049)		(0.050)
Capital in % RWA		0.032		0.019
		(0.022)		(0.022)
Large		-0.022***		-0.021***
		(0.003)		(0.003)
Short		-0.468**		-0.366*
		(0.202)		(0.212)
Profit		1.125**		1.001**
		(0.494)		(0.496)
GDP		-0.038		0.270***
		(0.059)		(0.059)
Demand sector		0.027		-0.312***
		(0.051)		(0.051)
Constant	2.162***	1.368***	0.893***	0.929**
	(0.124)	(0.380)	(0.147)	(0.382)
Observations	785	218	733	215
R^2	0.097	0.491	0.283	0.619

Note: The table presents results estimated with RDD. The dependent variable is the spread between an institution's monthly corporate lending rate with either the ECB interest rate or an institution's borrowing rate in the interbank market. The purpose of the above regressions is to show whether banks below and above their individual $Cutoff$ (dummy 1 if above) behave differently. The analysis includes the distance of an institution's DLCR to the cutoff ($DLCR - Cutoff$) as well as an interaction term ($Cutoff * DLCR$). Additional control variables include an institution's *Lending standards* measured by its response to the BLS, its perception of credit demand (*BLS demand*), lagged $Capital\ in\ \%\ RWA$ as well as *Large* (share of loans larger than 1 million in loans smaller than 1 million) and *Short* (share of loans with maturities shorter than 1 year in loans longer than 1 year). Finally, the analysis include $Profit$ (net income in % total assets), *GDP* growth and the average growth rate of the sectors an institutions is lending to (*Demand sector*). If covariates are included, the regressions also include bank dummies. Statistical significance is indicated by *** p<0.01, ** p<0.05, * p<0.1 while standard errors are in parentheses.

Table A4.7: Different bandwidths with set institution-specific cutoffs

	Bandwidth (+/-)	10	15	20	40	60	80	100
Bor. rate <30d	No covariates	-0.883***	-0.957***	-1.175***	-1.163***	-1.247***	-0.548***	-0.556***
		(0.164)	(0.141)	(0.129)	(0.112)	(0.109)	(0.023)	(0.020)
	Covariates	-0.340***	-0.385***	-0.303***	-0.305***	-0.335***	-0.363***	-0.331***
		(0.150)	(0.131)	(0.117)	(0.096)	(0.092)	(0.019)	(0.017)
Bor. rate >30d	No covariates	-0.675***	-0.805***	-0.889***	-0.625***	-0.906***	-0.419***	-0.440***
		(0.172)	(0.153)	(0.145)	(0.128)	(0.124)	(0.024)	(0.023)
	Covariates	-0.468**	-0.460***	-0.452***	-0.453***	0.213*	-0.380***	-0.381***
		(0.187)	(0.169)	(0.157)	(0.132)	(0.125)	(0.023)	(0.022)
Len. rate <30d	No covariates	-0.884***	-1.111***	-1.287***	-1.120***	-1.185***	-0.290***	-0.351***
		(0.138)	(0.120)	(0.111)	(0.095)	(0.092)	(0.018)	(0.016)
	Covariates	0.140	-0.134	-0.324***	-0.214***	-0.237***	-0.167***	-0.191***
		(0.132)	(0.113)	(0.102)	(0.082)	(0.078)	(0.015)	(0.014)
Len. rate >30d	No covariates	-0.487**	-0.703***	-0.960***	-1.063***	-1.420***	-0.572***	-0.587***
		(0.198)	(0.175)	(0.164)	(0.149)	(0.147)	(0.027)	(0.025)
	Covariates	0.853***	0.754***	0.489***	0.159	-0.102	-0.455***	-0.460***
		(0.197)	(0.178)	(0.167)	(0.150)	(0.147)	(0.026)	(0.025)
Volume <30d	No covariates	-0.494***	-0.430***	-0.436***	-0.448***	-0.380***	-0.336*	-0.336*
		(0.173)	(0.165)	(0.161)	(0.146)	(0.136)	(0.198)	(0.198)
	Covariates	-0.467***	-0.497***	-0.503***	-0.523***	-0.431**	-0.372**	-0.372**
		(0.149)	(0.137)	(0.235)	(0.222)	(0.214)	(0.183)	(0.183)
Volume >30d	No covariates	-0.572***	-0.645***	-0.597***	-0.781***	-0.835***	-0.692***	-0.611***
		(0.258)	(0.248)	(0.231)	(0.183)	(0.297)	(0.241)	(0.252)
	Covariates	-0.584***	-0.648***	-0.593***	-0.597***	-0.586***	-0.725***	-0.723**
		(0.249)	(0.298)	(0.246)	(0.211)	(0.202)	(0.301)	(0.351)

Note: The table shows the same regressions as Table A4.2 and Table A4.3 with different bandwidths.

Table A4.8: Different bandwidths with predicted institution-specific cutoffs

	Bandwidth (+/-)	10	15	20	40	60	80	100
Bor. rate <30d	No covariates	-0.264***	-0.189***	-0.227***	-0.423***	-0.547***	-0.678***	-0.678***
		(0.052)	(0.052)	(0.051)	(0.047)	(0.045)	(0.037)	(0.037)
	Covariates	-0.158***	-0.148***	-0.155***	-0.207***	-0.236***	-0.421***	-0.422***
		(0.034)	(0.035)	(0.034)	(0.033)	(0.032)	(0.027)	(0.026)
Bor. rate >30d	No covariates	0.120**	0.185***	0.170***	-0.013	-0.226***	-0.374***	-0.375***
		(0.051)	(0.052)	(0.052)	(0.049)	(0.048)	(0.034)	(0.034)
	Covariates	0.106***	0.094**	0.111***	0.065*	0.006	-0.317***	-0.316***
		(0.039)	(0.039)	(0.039)	(0.039)	(0.038)	(0.029)	(0.029)
Len. rate <30d	No covariates	-0.147***	-0.072	-0.099**	-0.266***	-0.347***	-0.291***	-0.290***
		(0.051)	(0.051)	(0.050)	(0.047)	(0.045)	(0.031)	(0.031)
	Covariates	-0.078**	-0.079**	-0.078**	-0.078**	-0.092***	-0.257***	-0.255***
		(0.035)	(0.035)	(0.035)	(0.035)	(0.033)	(0.025)	(0.025)
Len. rate >30d	No covariates	0.126**	0.179***	0.180***	0.074	-0.133***	-0.314***	-0.316***
		(0.052)	(0.052)	(0.052)	(0.050)	(0.049)	(0.037)	(0.037)
	Covariates	0.085**	0.066	0.073*	0.078*	0.040	-0.267***	-0.268***
		(0.041)	(0.042)	(0.042)	(0.042)	(0.041)	(0.032)	(0.032)
Volume <30d	No covariates	-0.471***	-0.481***	-0.434***	-0.430***	-0.478***	-0.555***	-0.456***
		(0.209)	(0.173)	(0.180)	(0.112)	(0.188)	(0.167)	(0.160)
	Covariates	-0.828***	-0.463***	-0.581***	-0.382***	-0.563***	-0.433***	-0.418***
		(0.266)	(0.184)	(0.180)	(0.102)	(0.177)	(0.153)	(0.146)
Volume >30d	No covariates	-0.584***	-0.632***	-0.598***	-0.776**	-0.842***	-0.692***	-0.692***
		(0.258)	(0.246)	(0.242)	(0.325)	(0.314)	(0.261)	(0.261)
	Covariates	-0.606*	-0.620*	-0.594*	-0.847***	-0.921***	-0.844***	-0.844***
		(0.358)	(0.344)	(0.341)	(0.323)	(0.314)	(0.263)	(0.263)

Note: The table shows the same regressions as Table A4.2 and Table A4.3 but with different bandwidths and predicted institution-specific cutoffs.

Table A4.9: Different bandwidths for corporations

	Bandwidth (+/-)	10	15	20	40	60	80	100
Corp-ECB	No covariates	-0.499	-0.669	-0.747*	-0.643	-0.823	0.011	-0.085
		(0.452)	(0.437)	(0.410)	(0.659)	(0.767)	(0.074)	(0.066)
	Covariates	1.609*	0.308	0.374	0.492	0.061	0.137	0.145
		(0.874)	(0.876)	(0.852)	(0.743)	(0.716)	(0.183)	(0.184)
Corp-IB	No covariates	-0.444***	0.423***	0.441***	0.493***	0.441***	0.543***	0.444***
		(0.135)	(0.139)	(0.110)	(0.140)	(0.140)	(0.191)	(0.182)
	Covariates	0.605***	0.577***	0.609***	1.103***	0.601***	0.678***	0.687***
		(0.283)	(0.130)	(0.192)	(0.189)	(0.244)	(0.184)	(0.186)

Note: The table shows the same regressions as Table A4.6 with different bandwidths.

CHAPTER 5

Regulatory treatment and banks' demand for government bonds

European banks hold sizeable shares of government debt securities.[1] Popov and Van Horen (2013) argue that the 0% risk-weight in the context of capital regulation is a key driver of banks' holdings of government bonds. Besides capital regulation, government debt securities also receive preferential treatment in the newly proposed Basel III liquidity requirements as well as in the context of regulatory efforts to limit large exposures to individual countries and counterparts.[2] While they also bring forward the argument of preferential regulatory treatment, Gennaioli et al. (2013) formulate two more hypotheses explaining banks' holdings of government bonds. The first one follows a large stream of literature arguing that banks hold government bonds as source of liquidity and collateral making them operating more effectively during normal times but not necessarily during stress.[3] The second hypothesis follows Acharya and Steffen (2013) and is based on the idea that banks hold lower quality government bonds, allowing them to both gain from preferential regulatory treatment and to chase high returns.

Especially the sovereign debt crisis in Europe raised interest in the interaction of banks' holdings of government bonds, government defaults and lending to the real economy. Gennaioli et al. (2014), for instance, show that government defaults shrink the net worth of banks with large holdings of government bonds, causing private credit to decline. Brutti and Saure (2013) analyze the demand of European banks for government bonds during the recent sovereign debt crisis while Acharya and Steffen (2013) assess German banks' stock market returns to draw conclusions on banks' returns for government bonds during the recent crisis.

[1] See, for instance, EBA (2013a).

[2] See BCBS (2010b,a, 2013b) as well as EU No 575/2013 ("CRD IV").

[3] See, for instance, Gennaioli et al. (2014) or Holmstroem and Tirole (1993).

The evidence presented in these studies raises the question of whether the relatively favorable treatment of government bonds in financial regulation is justified or whether there are arguments to treat government bonds in a more risk-sensitive way and therefore similar to other bonds.[4] However, there is very little evidence of whether regulatory treatment is truly the main driver of banks' large holdings of government bonds or whether this is not rather caused by banks' own targets and risk management processes.

The correlation between banks' funding and liquidity needs and their compliance with regulatory requirements poses a challenge to establishing a causal link from the various incentives for banks to hold government bonds and their actual holdings. To distinguish whether a change in banks' government bond holdings is caused by regulation or by its funding and liquidity needs, one would need detailed information on banks' targets used in their internal risk management frameworks.

Since such data is not available in a structural form, an alternative approach is to distinguish whether the proximity of a bank to its regulatory liquidity and capital threshold changes its demand for government bonds during the entire following month or only around the reporting date. The hypothesis is that if banks' regulatory capital and liquidity position changes their demand for government bonds over the entire month, it cannot be established whether this is caused by regulation (henceforth *regulatory effect*) or internal risk management targets (henceforth *internal effect*). However, a change of demand only around the reporting date would point towards the presence of a *regulatory effect*. Finally, if banks do not rebalance and increase their supply right after reporting, it can be hypothesized that there is at least a somewhat longer-term effect as opposed to regulatory arbitrage.

Using unique transaction-level data obtained from the Markets in Financial Instruments Directive (MiFID) database, this chapter attempts to distinguish *regulatory* from *internal* effects and aims to answer the question of whether financial regulation increases banks' demand for government bonds beyond their own risk appetite.

Due to the presence of long-running liquidity and capital requirements in the Netherlands, it is possible to assess the impact of both requirements, allowing to draw the link to Basel III. Along with other control variables, the analysis also includes banks' proximity to fulfilling their minimum central bank reserve requirement.

The Seemingly Unrelated Regressions (SUR) suggest that liquidity and capital requirements cause banks' demand for government bonds to increase beyond their internal risk management targets. The relative preferential treatment seems to cause a substitution effect with banks buying more government bonds while selling more other bonds. The analysis also shows that these dynamics

[4] The main criticism on the current regulatory treatment of government bonds is that government bonds of an institution's home jurisdiction get the most favorable treatment across most regulatory frameworks, independent of their riskiness. See also Weidmann (2013) and Buch et al. (2013).

are likely to cause a longer-term increase of government bond holdings.[5]
Further, suggestive evidence points to holdings of high quality government bonds being positively associated with banks' lending to the real economy but negatively with their profits. During both sovereign and liquidity stress, however, the negative impact on banks' profitability diminishes while high government bond holdings seem to have a negative impact on private sector lending.[6]
When drawing policy implications from these results, it is important to note that the purpose of this chapter is to analyze whether financial regulation increases banks' demand for government bonds and whether increased government bond holdings have an adverse impact on the real economy and banks' profitability. While the chapter provides new insights into these dynamics, it does not comprehensively answer the question whether increased government bond holdings are desirable. However, since the analysis suggests that even high quality government bond holdings have a negative impact on banks' lending during stress, the analysis can be interpreted as giving reason to at least consider treating exposures to governments in a more risk-sensitive way and therefore similar to other bonds. The fact that even high rated government bonds had a negative impact on lending suggests that there are additional factors, such as price volatility, which should be taken into consideration when estimating the risk of government exposure.

5.1. The regulatory environment

5.1.1. The MiFID database

The primary data source of this chapter are the MiFID transaction reports obtained from the Netherlands Authority for the Financial Markets (AFM). MiFID was implemented as part of the EU financial market integration in November 2007 with the purpose to regulate the provision of financial instruments and to clarify the responsibilities and powers of national competent authorities regarding these activities.[7] Articles 25(3) and (4) of the MiFID Directive require financial institutions to report trading activities for any instrument admitted to trading on a regulated market. As such, the MiFID database is the most comprehensive dataset on bond transactions in the EU.[8]

[5] It could also be that banks not rebalancing their increased holdings right after reporting is a lagged holding effect with banks waiting for good opportunities to sell. However, with checking the correlation coefficients of banks' demand in one month with the following 6 months this possibility is excluded. If banks rebalance at some point during the next months, one would expect a negative correlation coefficient. However, the coefficient of the current month with the following month is 0.43 and steadily decreases to 0.22 during the next 5 months.

[6] Although there is no structural data on this, available information suggests that the banks in this sample mainly hold Dutch and German government bonds. This is additionally confirmed by the negative impact of government bond holdings on profitability. In case of peripheral European countries, one would expect a positive impact on profit as found by Acharya and Steffen (2013).

[7] Directive 2004/39/EC.

[8] See EBA (2013b), which provides evidence for the comprehensive coverage of the database.

Along with a large amount of other information, each transaction in the dataset includes the international securities identification number (ISIN) of the traded security, the two trading counterparts, volume, time to maturity, the exact time as well as whether the reporting institution acted as a buyer or a seller.

5.1.2. Government bonds in regulatory frameworks

While national capital requirements date back even further, the implementation of Basel I in 1992 harmonized capital regulation across the globe. Since then, both the definition of eligible capital and the risk-weights (RW) of an institution's assets have been subject to a number changes. The most recent development is the Basel III accord and its implementation in national legislation.[9] To understand the interaction of capital requirements and government bond holdings, it is useful to begin with a closer look at the calculation of regulatory capital ratios:

$$Capital\ requirement = \frac{Total\ capital}{Risk-weighted\ assets(RWA)} \geq 8\% \tag{5.1}$$

Since the dataset covers June 2009 to December 2012, the definition of capital under Basel 2.5 is applicable. Total capital therefore consists of at least 50% Tier 1 capital (equity capital and disclosed reserves) complemented by undisclosed reserves, revaluation reserves, general provisions and loan-loss reserves, hybrid debt capital instruments as well as some subordinated debt (Tier 2). As can be seen, the denominator of the capital requirement is determined by multiplying the notional amounts of an institution's assets by their respective RW. Thus, if an institution holds an asset with a 20% RW, it needs to hold capital amounting to at least 8% (the minimum capital ratio) of the notional amount of the respective asset multiplied by 20%. Due to their 0% RW, foreign government bonds rated AAA to AA- or any domestic government bond do not require banks to hold any capital, making government bonds relatively more attractive.[10]
To increase its capital ratio, a bank can therefore either raise capital or reduce its RWA. While banks are able to raise capital in the long run, it is not a feasible way to correct a short-term capital shortfall. As institutions need sufficient assets for funding purposes, only selling large amounts of assets with high RW is not realistic either. As such, the seemingly easiest way to address a capital shortcoming is to substitute bonds with high RW by government bonds.

[9] See BCBS (2010b) and EU No 575/2013 ("CRD IV").

[10] Usually government bonds have lower yields than other securities. Under normal circumstances institutions balance the gains from holding government bonds (safe asset, preferential regulatory treatment) with the opportunity costs of doing so (lower return). During the sovereign debt crisis, bonds issued by European peripheral countries had very high yields while banks could still gain from the preferential regulatory treatment.

Turning to liquidity regulation, the same dynamics can be observed. As in Chapter 4, the Dutch liquidity requirement DLCR is used as proxy for the LCR. Similar to capital, an institution can steer its DLCR by either increasing its Available Liquidity (AL) or by reducing its Required Liquidity (RL). Again, however, reducing liabilities seems to be a less feasible option than increasing liquid assets. Buying government bonds appears to be the most efficient strategy to correct a DLCR deficiency.

5.1.3. The average reserve requirement

Apart from liquidity and capital requirements, banks usually also face a minimum central bank reserve requirement. Most central banks - among which the European Central Bank (ECB) - require credit institutions to hold a minimum amount of reserves with them. An institution's reserve requirement is determined by multiplying the reserve base with the reserve ratio. The reserve base includes retail deposits and a selection of short-term liabilities while the ECB's reserve ratio is currently set at 1%.[11] Compliance with minimum reserve requirements is determined on the basis of banks' average daily balances on the central bank reserve accounts over one reserve maintenance period.

Since it is an average requirement, the reserve requirement can be subject to "frontloading" or "backloading". This means that a bank can fulfil this requirement by holding very large reserves only at the very beginning ("frontloading") or at the end of the month ("backloading"). The maintenance period for EMU banks begins on Wednesday after the first Governing Council meeting and ends the same day of the following month. In the dataset used in this chapter, the maintenance period ranges from 19 to 42 days and usually begins between the 10th and 15th day of the respective month. The main function of the minimum reserve requirement is to stabilize money market rates. The average reserve requirement is likely to have some indirect impact on banks' demand for government bonds. As long as a bank does not fulfil its reserve requirement, it has an incentive to obtain more cash. Presumably this will lower an institution's demand for debt securities, including government bonds. Once an institution fulfils its reserve requirement, it is likely to substitute cash for other, more profitable investment opportunities, such as government bonds or other types of bonds. Anecdotal evidence suggests that most banks "frontload" their reserve requirement and then gradually substitute cash with debt securities until the end of the remittance period.

[11] The ECB reserve ratio was reduced from previously 2% to 1% on January 18th 2012.

5.2. Data description

5.2.1. Data sources

In order to analyze the impact of regulatory treatment on banks' demand for government bonds, this chapter brings together data on 1) bilateral transactions of Dutch securities between Dutch banks; 2) banks' regulatory liquidity and capital position; 3) banks' fulfillment of the minimum central bank reserve requirement; 4) risk indicators and other measures calculated from the balance sheet, as well as 5) macroeconomic factors.

The data on bilateral transactions of securities stems from the MiFID database. The dataset covers June 2009 to December 2012. Each recorded transaction includes the identification number (ISIN) of the traded security, the two trading counterparts, volume, time to maturity, time as well as whether the reporting institution acted as a buyer or a seller. The MiFID regulation requires institutions to report transactions per entity as opposed to the full consolidation of the balance sheet information. To match the two data sources, banks' demand for government bonds and other bonds (financial bonds, covered bonds and ABS) are calculated per consolidated entity. As control variables, the analysis includes the yield of the respective bond type. To ensure as clear identification as possible, only transactions in which both counterparts can be identified as banks and at least one of the two counterparts is a Dutch bank are included. This approach ensures that all considered transactions are executed by a bank subject to prudential regulation of DNB, which causes 18 banks to remain in the dataset. The MiFID transaction reports also indicate whether a bank acted as "Principal" or "Agent". Acting as Agent implies that the bank acts on behalf of clients and therefore never takes ownership of the instrument while a principal transaction refers to a bank acting on its own behalf. Since they are not relevant for the fulfilment of regulatory requirements, all agent transactions are dropped. Finally, the data is cleaned following the same procedure as Dick-Nielsen et al. (2012). Specifically, the analysis corrects for double reporting which occurs when both institutions are EU financial institutions, erroneous reporting of counterpart codes and banks' reporting of (reverse) repos which should not be reported in MiFID.

The regulatory liquidity data stems from banks' reporting of the DLCR. The DLCR is very similar to the Basel III LCR and was introduced in July 2003. It applies to all banks, clearing as well as settlements institutions and grants only a few waivers for foreign branches.[12] The capital ratio is taken from banks' reporting in the context of Basel 2.5 while the data on the reserve requirement is obtained from DNB's payment systems data. All other bank-specific and demand-related variables stem from DNB's prudential reporting.

[12] Note that the analysis excludes all foreign branches and subsidiaries to avoid any issues regarding consolidation and subsequent identification.

As macroeconomic variables, the analysis includes the EONIA interest rate, the GDP growth rate of the European Union, total government debt over GDP of the Netherlands as well as the relative rating of the Netherlands compared to its peers (Germany, Finland, France, Austria and Belgium). With the exception of the relative rating, which comes directly from the S&P database, all macroeconomic variables are retrieved from the ECB's statistical data warehouse.

5.2.2. Bond holdings and gross demand and supply

Although this chapter focuses on banks' daily net demand for government bonds, it is worth to first have a look at banks' holdings as well as gross demand and supply of government bonds. The data includes all government bonds with a 0% RW under the Basel 2 Standardized Approach. On average, Dutch government bonds comprise around 40% of total government bond holdings.

Figure 5.1: Banks' holdings of government bonds

a: Holdings per bank in total assets

b: Holdings per bank in liquid assets

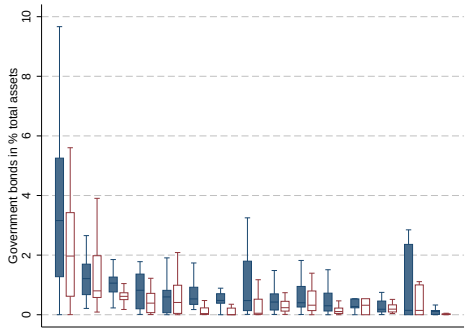
c: Holdings in total assets over time

d: Holdings in liquid assets over time

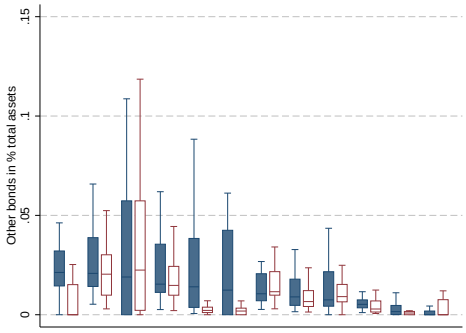
Note: The figure shows banks' holdings of government bonds. Figure 5.1a presents the distribution of individual banks' government bond holdings as percentage of total assets. Figure 5.1b illustrates banks' holdings of government bonds as percentage of available liquidity as defined by the DLCR. Figures 5.1c and 5.1d show average and median bond holdings of the entire sample over time.

Figure 5.1a shows that banks' holdings of government bonds differ substantially both between banks but also over time. For two banks, government bonds amount to about 25% of total assets. Other banks hold between 3% and 10% of government bonds in total assets.
Figure 5.1b, which illustrates banks' holdings of government bonds in liquid assets (as defined by the DLCR), does not show particular outliers. The distribution of banks is smooth with the highest bank holding on average about 40% of government bonds in liquid assets while the lowest holdings amount to 5% of liquid assets. Again, however, banks show large variations over time.
Figures 5.1c and 5.1d show aggregate bond holdings over time. Aggregate bond holdings vary between almost 10% at the beginning of 2010 to just below 6% in 2012. Although bond holdings are relatively stable, there appears to be a downward tendency in both mean and median bond holdings. Government bond holdings in liquid assets, on the other hand, do not show such a pattern. After a low of 14% at the end of 2010, average government bond holdings increase to almost 25% by mid-2011.

Figure 5.2: Banks' supply and demand of Dutch government and other bonds



a: Buying (left) and selling (right)



b: Buying (left) and selling (right)

c: Government bonds in total assets

d: Other bonds in total assets

Note: The figure shows banks' supply and demand of Dutch government bonds and all other bonds issued by Dutch institutions. Figure 5.2a presents the distribution of individual banks' demand and supply of Dutch government bonds while Figure 5.2b shows the same information for other types of bonds. Figures 5.2c and 5.2d show aggregate demand and supply over time.

Turning to banks' gross supply and demand of government bonds and other bonds (Figure 5.2), it is important to note that different from the data on holdings, the data on supply and demand only includes Dutch government bonds.

Looking at banks' demand and supply of government bonds, Figure 5.2a shows large differences among banks but also over time. One bank buys government bonds amounting on average to 3% of total assets while most other banks buy on average 1% of total assets in government bonds. Most banks show larger demand than supply. While one bank's supply amounts on average to 2% of total assets, most banks sell about 0.5%. The fact that banks' supply appears smaller than demand is confirmed by Figure 5.2c, which shows that except for two months, aggregate demand is larger than supply. Comparing this to Figure 5.1 where decreasing holdings can be observed, the data suggests that Dutch banks seem to have decreased their government bond holdings in general while at the same time buying more Dutch government bonds. A likely reason for this is that the rating of the Netherlands remained stable at AAA while several European countries suffered (significant) downgrades during the sample period. This pattern can either be interpreted as a flight-to-quality or a potential home bias.

Banks' demand and supply of other bonds follows a similar pattern (Figure 5.2b). However, volumes are considerably smaller (roughly by a factor of 10) and show higher volatilities across banks and over time.

Finally, it is important to understand whether there is a structural correlation between banks' capital and liquidity position and their gross demand and supply of government bonds. It could, for instance, be that banks that trade large volumes rationally decide to hold lower liquidity buffers. The reason for this could be that liquidity buffers are an insurance against liquidity shocks. Banks with large trading volumes tend to have better market access and therefore less need to insure themselves against large shocks.[13]

The data shows no evidence of banks' regulatory capital and liquidity position playing a significant role in determining their gross demand and supply of government bonds or other bonds.[14] Rather, current prices and the relative rating of the Netherlands compared to its peers seems to determine banks' behavior in this regard.

5.2.3. Daily net demand

Since the purpose of this chapter is to distinguish *regulatory* from *internal* effects, it is important to understand banks' trading patterns throughout a month. Figure 5.3 shows banks' average net demand for government bonds (Figure 5.3a) and other bonds (Figure 5.3b) over buckets consisting

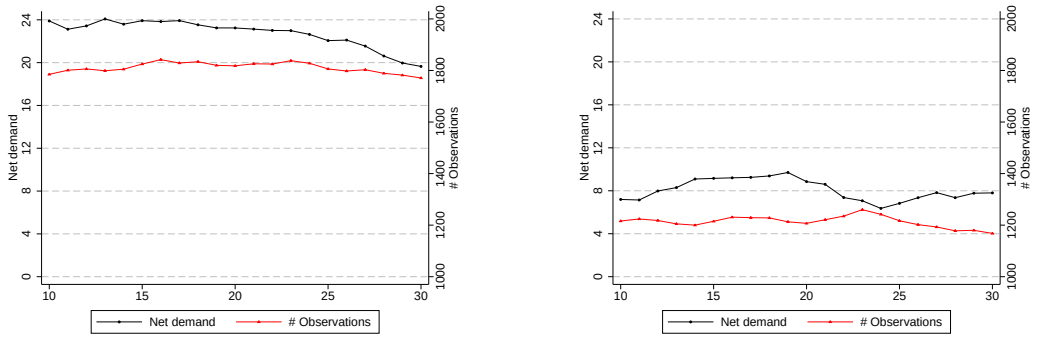
[13] For more information on the incentives of banks to hold liquidity buffers, see Chapter 3.

[14] See Tables A5.3 and A5.4 in the Appendix.

of 10 days as well as the corresponding number of observations.[15] Day 12, for instance, refers to banks' average net demand between day 3 and day 12.

Figure 5.3a shows that banks' net demand for government bonds is fairly stable throughout a month and only shows a slight downward slope towards the end of the month. The average over the entire month is 22.74% with 19.65% and 24.08% being the minimum and maximum, respectively. A similar pattern can be observed for the number of observations. An important takeaway from Figure 5.3a is that on aggregate banks do not seem to increase but rather decrease their demand for government bonds towards the reporting date.

Figure 5.3: Banks' net demand for Dutch government bonds and other bonds



a: Government bonds b: Other bonds

Note: Figure 5.3 shows banks' average net demand for government bonds (Figure 5.3a) and other bonds (Figure 5.3b) over buckets consisting of 10 days as well as the corresponding number of observations. Banks' net demand is calculated as the average of the difference between institution i's gross demand and gross supply of bond b (government bond or other bonds) in percentage of its average daily gross demand during the year. The number of observations corresponds with the total number of trades executed by banks that are at least once every day active as buyer and seller. Day 12, for instance, refers to banks' average net demand between day 3 and day 12.

Figure 5.3b shows that, similar to government bonds, banks' demand for other bonds is stable during the course of the month. However, net demand of other bonds is significantly smaller than net demand for government bonds. The average over the entire sample is 8.08% with the maximum and minimum being 6.36% and 9.70%, respectively. In contrast to government bonds, banks' demand for other bonds somewhat increases towards the end of the month. The data does not suggest the presence of a general *regulatory effect* with all banks buying more government bonds while selling more other bonds right before reporting.

[15] Banks' net demand is calculated as the difference between institution i's gross demand and gross supply of bond b (government bond or other bonds) in percentage of its average daily gross demand during the year. The number of observations corresponds with the total number of trades executed by banks that are at least once every day active as buyer and seller.

5.3. Methodology

5.3.1. General approach and endogeneity

The graphical analysis suggests that on aggregate banks do not increase their government bond holdings towards the end of the month. However, since the purpose of this paper is to understand the impact of financial regulation, it is important to distinguish banks according to their regulatory position. To understand the impact of regulation, this chapter assesses on which days of the month a bank's regulatory capital and liquidity position has a significant impact on its net demand for government bonds and other bonds.

The hypothesis is that if a low regulatory liquidity or capital position in month m-1 affects banks' demand over the entire month m, it cannot be established whether this is caused by a *regulatory effect* or an *internal effect*. If, however, a bank's demand is only affected during the last few days before reporting, there is a strong indication for the presence of a *regulatory effect*. To conduct this analysis, the regression function is looped over 10 day buckets.

Since this chapter analyzes banks' demand for government bonds compared to other bonds, the application of Seemingly Unrelated Regressions (SUR) seems the appropriate approach.[16] SUR is a system of linear equations with only exogenous regressors. The key difference to OLS is that it assumes that the errors are correlated across equations but not individuals. It is very likely that banks' demand for government bonds is partially driven by some unobserved factors which are highly correlated to the unobserved factors driving the same banks' demand for other bonds. SUR allows nonzero covariance between the error terms of the equations with government bonds and other bonds as dependent variables.

While SUR seems a suitable approach for the purpose of this analysis, there are shortcomings which need to be addressed. Firstly and similar to pooled OLS, SUR requires all explanatory variables to be exogenous. While the assumption of exogeneity is likely to hold for the macroeconomic controls, the bank-specific factors might be subject to endogeneity. To address this issue, all bank-specific variables are instrumented with their lags. Since it is implausible that an institution's demand for government bonds in period t affects its profitability and return on equity in t-1, the issue of endogeneity seems sufficiently addressed.

A bank's capital and liquidity positions are also instrumented by their lags, since the purpose of this chapter is to analyze whether a bank's capital and liquidity ratios in month m-1 affect its demand for government bonds in period m.

Another potential problem is that SUR assumes that there is no correlation of the error term across individuals. However, in case of an unobserved macroeconomic shock there would be correlation

[16] See the seminal contribution of Zellner (1962) and a literature overview by Fiebig (2001).

of the error terms. Although this does not make SUR a biased estimator, this issue is addressed by including time-dummies which correct for these potential correlations.
In addition, the conducted Hausman tests indicate that fixed effects would be preferred over random effects as the independent variables and bank-specific effects are correlated. These results motivate the inclusion of bank dummies in the SUR regressions.

5.3.2. The model

The baseline regression takes the following form:

$$\begin{aligned} \textit{Net Demand}_{i,b,d} = \beta_0 + \beta_1 (\textit{Liquidity ratio} - 100\%)_{i,m-1} + \beta_2 (\textit{Capital ratio} - 8\%)_{i,m-1} \\ + \beta_3 \textit{Reserves}_{i,d} + \beta_4 \textit{Controls}_{(i,b),m(-1)} + \varepsilon_{i,m} \end{aligned} \tag{5.2}$$

where $\textit{Net Demand}_{i,b,d}$ refers to the difference between institution i's gross demand and gross supply of bond b (government bond or other bonds) on day d in percentage of its average daily gross demand during the year.
$(\textit{Liquidity ratio} - 100\%)_{i,m-1}$ describes the distance of an institution's actual liquidity position in month m-1 from its regulatory threshold of 100%. Similarly, $(\textit{Capital ratio} - 8\%)_{i,m-1}$ refers to the difference between an institution's capital ratio in month m-1 and the regulatory threshold of 8%. Defining the ratios that way ensures that the intercept reflects the value of the regressions function at the regulatory threshold.[17] $\textit{Reserves}_{i,d}$ refers to an institution's daily fulfilment of its minimum central bank reserve requirement.
$\textit{Controls}_{(i,b),m(-1)}$ includes a combination of macroeconomic, bond-specific (b) and other bank-specific (i) variables in month m (for the macroeconomic and bond-specific variables) or m-1 (for the other bank-specific variables). The additional bank-specific control variables include an institution's profitability (net income as percentage of total assets) and return on equity (income as percentage of total equity). As argued by Delechat et al. (2012), it is easier for more profitable banks to fund themselves. Those banks are therefore more likely to look for alternative, more profitable funding sources to correct a regulatory capital or liquidity deficiency.[18] On top of that, more profitable banks might show different characteristics regarding their risk management frameworks, which additionally motivate its inclusion. The macroeconomic control variables include the EONIA interest rate, the GDP growth rate of the European Union, the government debt of the Netherlands as percentage of GDP, as well as the relative rating of the Netherlands compared to its peers

[17] See, for instance, Lee and Lemieux (2010).
[18] Also see, for instance, Gennaioli et al. (2014) or Acharya and Steffen (2013).

(Germany, Finland, France, Austria and Belgium).[19] The EONIA interest rate proxies the costs of banks' alternative funding sources. If other interest rates in the economy are high, banks are more likely to demand more government bonds and vice versa.[20] Since the analysis only includes Dutch government bonds, the relative rating of the Netherlands compared to its peers is likely to affect banks' demand. Depending on the motivation for banks to buy a specific bond, a relatively better rating might have a positive (i.e. if the banks is very risk averse) or a negative impact on demand (i.e. if the bank chases high returns). The GDP growth rate is likely to capture demand effects of bank lending, which in turn, might be funded with bond issuances or motivates banks to hold less government bonds to avoid excessive balance sheet expansion. Finally, the average price of an institution's monthly trades represents a bank's funding costs. All regressions are performed with and without bank-specific dummies. The error term $\varepsilon_{i,m}$ is standard for SUR and hence institution- and period-specific but the same across different types of bonds.

5.4. Results

5.4.1. Reading the figures

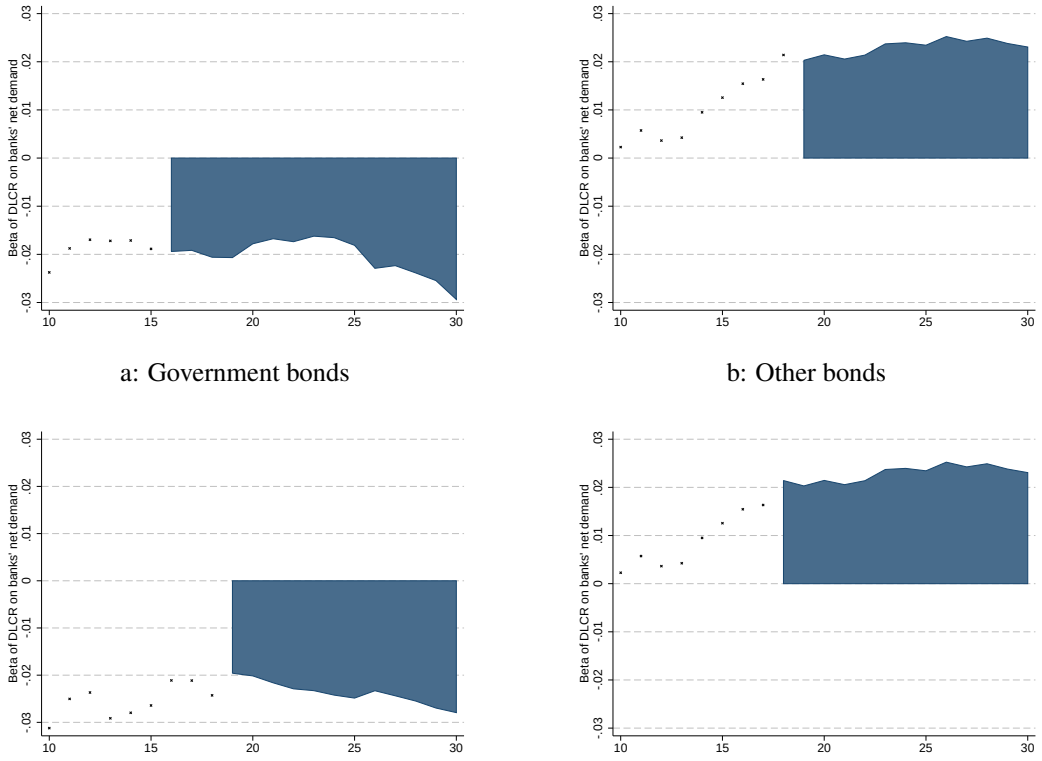
Figures 5.4, 5.5 and 5.6 present the results obtained using SUR with and without including bank-specific dummies. The analysis aims at explaining the impact of banks' regulatory capital and liquidity position on their demand for government bonds.
The dependent variable reflects the difference between institution i's gross demand and gross supply of bond b (government bond or other bonds) on day d in percentage of its average daily gross demand for bond b during the year.
Apart from the presented coefficients for the *DLCR* (distance of an institution's DLCR to the 100% regulatory threshold), *Capital* (distance of an institution's regulatory capital holdings to the 8% threshold) and *Reserves* (fulfilment of the average reserve requirement in percentage of total requirement) all regressions include a large number of additional control variables.
The regressions are looped over blocks consisting of 10 days over the course of the month, plotted on the x-axis in the figures below. For instance, on day 13 in Figure 5.4 one can see the coefficient of regressing the DLCR in month m-1 on banks' daily net demand during day 4 to 13 of month m. Day 28 reflects banks' daily net demand from day 19 to 28. Areas represent statistically significant values while "x" points to insignificance.[21]

[19] To calculate the relative rating, all country-specific ratings are converted to numeric values (AAA=1). The Netherlands' rating is then divided by the average rating of its peers. In case a country is put on "negative watch", the rating is reduced by 0.5.
[20] Also see Acharya and Steffen (2013) or Aspachs et al. (2005).
[21] Note that the figures exclude insignificant outliers.

5.4.2. Liquidity

Figure 5.4 shows that banks' regulatory liquidity position significantly affects their demand for government bonds. The liquidity requirement seems to cause a substitution effect with banks close to their regulatory threshold buying more government bonds while selling other bonds. Figure 5.4 also suggests that banks' increased demand leads to a persistent rather than a short-term change, indicating increased long-term holdings of government bonds due to a liquidity requirement.

Figure 5.4: Impact of regulatory liquidity on banks' daily demand



a: Government bonds

b: Other bonds

c: Government bonds (bank dummies)

d: Other bonds (bank dummies)

Note: The figure presents results obtained using SUR, with and without including bank-specific dummies. The analysis aims at explaining the impact of banks' regulatory liquidity position on their demand for government bonds and other bonds. The dependent variable reflects the difference between institution i's gross demand and gross supply of bond b (government bond or other bonds) on day d in percentage of its average daily gross demand for bond b during the year. Apart from the presented coefficients for the *DLCR* (distance of an institution's DLCR to the 100% regulatory threshold), all regressions include *Capital* and *Reserves* as well as a large number of additional control variables. The regressions are looped over blocks consisting of 10 days over the course of the month, plotted on the x-axis in the figure. For instance, on day 13 one can see the coefficient of regressing the *DLCR* in month m-1 on banks' daily net demand during day 4 to 13 of month m. Areas represent statistically significant values while "x" points to insignificance. The figures exclude insignificant outliers.

Figure 5.4 shows that banks' liquidity position determines their demand for government bonds as well as other bonds. More specifically, it can be seen that a higher DLCR in the previous period causes banks to reduce their demand for government bonds while it increases their supply of other types of bonds. This effect is in line with the previously described theory regarding the functioning of a liquidity ratio. Government bonds can be counted fully towards the liquidity requirement while other bonds can only be included up to a certain extent. As such, when running the risk of becoming non-compliant with the requirement, banks are incentivized to substitute other bonds with government bonds.

Figure 5.4a presents the regression coefficients of the DLCR on banks' demand for government bonds when bank dummies are not included. It can be seen that banks' regulatory liquidity position does not seem to affect banks' demand for government bonds in the first half of the following month. However, from the 16th day until the end of the month, a 1% higher DLCR reduces banks' net demand for government bonds between 0.016% and 0.029% of average demand. Alternatively, an increase of the DLCR from the 25th percentile to the 75th percentile, reduces banks' demand for government bonds between 1.49% and 2.08%. On top of that, a downward slope towards the end of the month can be observed.

Figure 5.4b shows that a bank's regulatory liquidity position in period m-1 does not affect its demand for other bonds during the first half of month m. However, from day 19 banks with lower liquidity holdings seem to increase their supply of other bonds, substituting them with government bonds. Specifically, a 1% lower DLCR increases banks net supply of other bonds between 0.020% and 0.025% and is therefore in terms of economic significance very similar to Figure 5.4a. Similarly, an increase from the 25th percentile to the 75th percentile causes supply to increase between 1.49% and 1.86%.

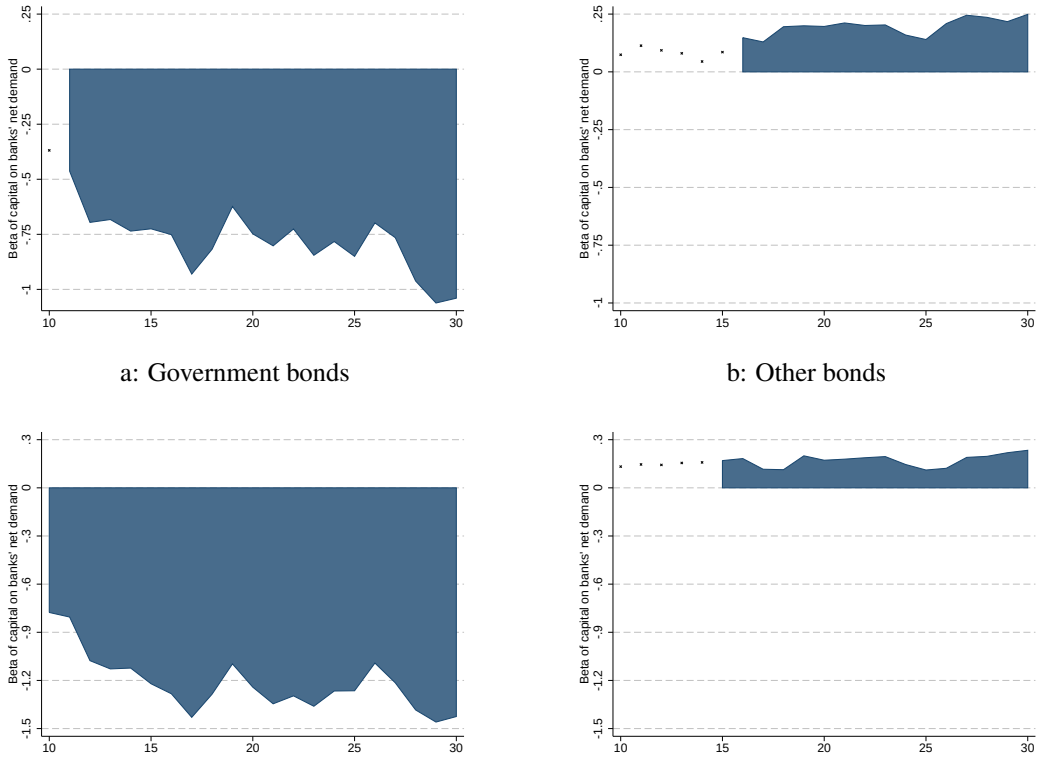
Including bank-specific dummies (Figures 5.4c and 5.4d) does not change the overall pattern of the results. Starting from day 19, a 1% higher DLCR reduces banks' demand for government bonds between 0.020% and 0.028% of average demand while it increases their net demand for other bonds.

If a bank's regulatory liquidity position affects its demand for government bonds for the entire month, it cannot be established whether this effect comes from regulation or from banks' internal risk management targets. With the DLCR affecting banks' demand earliest from day 16, it can be concluded that there is limited evidence of an *internal effect* incentivizing banks with lower liquidity holdings to attract more government bonds or sell more other bonds. The combined evidence of the DLCR affecting banks' demand only towards the end of the month and the slopes presented in Figure 5.4 shows clear signs of a *regulatory effect*, suggesting that the DLCR incentivizes banks to substitute government bonds for other bonds. On top of that, banks do not seem to sell their government bonds right after reporting, pointing towards a longer-term increase of government bonds.

5.4.3. Capital

Similar to liquidity, Figure 5.5 shows that the regulatory capital position is an important determinant of banks' demand for government bonds. One can see that a lower regulatory capital ratio in the previous month causes banks to buy considerably more government bonds and sell moderately more other bonds. The analysis does not show evidence of banks increasing their supply after reporting, suggesting that capital regulation has a longer-term impact on banks' government holdings.

Figure 5.5: Impact of regulatory capital on banks' daily demand



a: Government bonds

b: Other bonds

c: Government bonds (bank dummies)

d: Other bonds (bank dummies)

Note: The figure presents results obtained using SUR with and without including bank-specific dummies. The analysis aims at explaining the impact of banks' regulatory capital position on their demand for government bonds and other bonds. The dependent variable reflects the difference between institution i's gross demand and gross supply of bond b (government bond or other bonds) on day d in percentage of its average daily gross demand for bond b during the year. Apart from the presented coefficients for *Capital* (distance of an institution's regulatory capital holdings to the 8% threshold), all regressions include *DLCR* and *Reserves* as well as a large number of additional control variables. The regressions are looped over blocks consisting of 10 days over the course of the month, plotted on the x-axis. For instance, on day 13 one can see the coefficient of regressing *Capital* in month m-1 on banks' daily net demand during day 4 to 13 of month m. Areas represent statistically significant values while "x" points to insignificance. The figures exclude insignificant outliers.

Figure 5.5a shows that a 1% higher capital ratio reduces banks' demand for government bonds between 0.46% and 1.06%. The effect is already significant from the beginning of the month or day 11 when bank dummies are not included. On top of that, a downward trend towards the end of the month can be observed. To put these results in perspective to liquidity, an increase of the capital ratio from the 25th to the 75th percentile reduces banks' demand between 2.60% and 5.96%. As such, the economic significance of capital regulation is significantly larger compared to liquidity regulation.

Capital regulation seems to cause a similar substitution effect as liquidity regulation. As can be seen in Figure 5.5b, a 1% higher regulatory capital ratio increases banks' demand for other bonds between 0.11% (0.13%) and 0.23% (0.25%) when bank dummies are (not) included. Again, the coefficient is highest right before reporting and significant results appear from day 15 but not prior to that.

The results point to capital regulation causing a substitution effect with banks buying more government bonds while selling more other bonds. There are no signs of banks increasing their supply of government bonds right after reporting, indicating that capital regulation leads to a longer-term increase in banks' government bond holdings.

5.4.4. Average reserve requirement and other variables

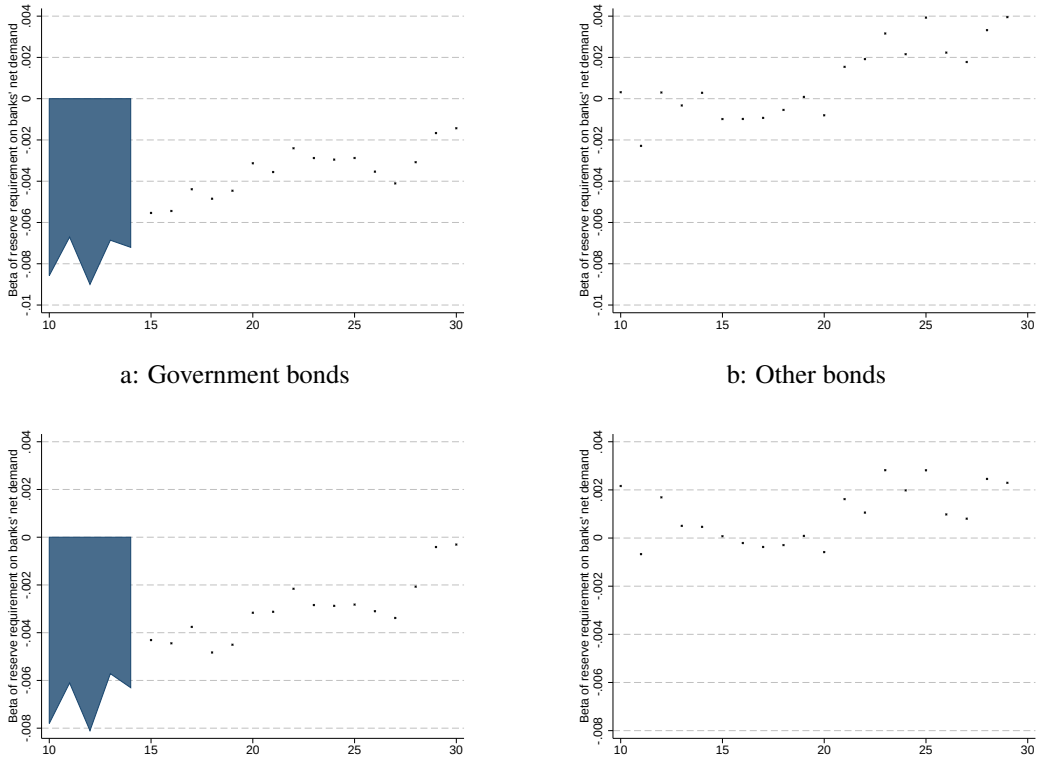
Banks' daily fulfillment of the average reserve requirement significantly affects their demand for government bonds in the first half of the month. Specifically, one can see that the closer a bank is to fulfil its reserve requirement, the lower its demand for government bonds. The closer a bank is to the end of the remittance period of the reserve requirement, the larger is its demand for government bonds. The combination of these results suggests that banks "frontload" their fulfilment of the average reserve requirement (higher demand for government bonds closer to the remittance date) and that central bank reserves are a substitute for government bonds (the higher a banks' reserves before reporting, the lower its demand for government bonds).

The results suggest that being 1% closer to fulfilling the reserve requirement causes banks to reduce their demand for government bonds between 0.005% and 0.010%. An increase from the 25th to the 75th percentile reduces the demand between 0.18% and 0.35%. In contrast to the regulatory liquidity and capital position, however, the effect is only significant during the first half of the month.

It is likely that this effect stems from the end of the remittance period of the reserve requirement. Since those banks need more cash and less government bonds, the fact that demand for government bonds is higher for banks with lower reserves around the end of the remittance period is counterintuitive at first. However, this effect is likely to be caused by cash being a substitute for government bonds in the liquidity and capital requirement. With the exception of a very small number of outliers, all banks in the sample are very close to fulfilling the average reserve requirement already

one week before the end of the remittance period. As such, banks with higher reserves demand less government bonds because they are holding a perfect substitute.[22] The average reserve requirement does not seem to affect banks' demand for other bonds.

Figure 5.6: Impact of reserve requirements on banks' daily demand



a: Government bonds

b: Other bonds

c: Government bonds (bank dummies)

d: Other bonds (bank dummies)

Note: The figure presents results obtained using SUR with and without including bank-specific dummies. The analysis aims at explaining the impact of banks' fulfilment of the average reserve requirement on their demand for government bonds and other bonds. The dependent variable reflects the difference between institution i's gross demand and gross supply of bond b (government bond or other bonds) on day d in percentage of its average daily gross demand for bond b during the year. Apart from the presented coefficients for *Reserves* (daily fulfilment of the average central bank reserve requirement), all regressions include *DLCR* and *Capital* as well as a large number of additional control variables. The regressions are looped over blocks consisting of 10 days over the course of the month, plotted on the x-axis. For instance, on day 13 one can see the coefficient of regressing *Reserves* in month m-1 on banks' daily net demand during day 4 to 13 of month m. Areas represent statistically significant values while "x" points to insignificance. The figures exclude insignificant outliers.

[22] Note that the difference between the interest rates on the ECB deposit facility and the yield on Dutch government bonds was negligibly small during the period June 2009 to December 2012.

Looking at the role of the other control variables during the course of the month, it appears that most of them only play a role at the beginning of the month but not afterwards. Until day 18, the EONIA interest rate has a significant positive impact on banks' demand for government bonds while it turns insignificant afterwards. Similarly, the GDP growth rate of the EU as well as the relative rating of the Netherlands play an important role until the 16th and 18th day of the month but not afterwards. The yield on government bonds, on the other hand, reduces banks' demand thereof over the entire month while banks' profitability shows a positive interaction with demand for government bonds from day 9 until the end.

Although the evidence is less clear in this regard, these results can be interpreted that at the beginning of the month, the demand for government bonds is driven by several bank-specific and macroeconomic variables. Closer to reporting, however, most of these determinants are substituted by regulatory effects.[23]

5.5. Government bond holdings and bank behavior

The previous section suggests that regulation increases banks' demand and holdings of government bonds while it decreases the stock of other bonds. While this is an important insight, it is important to understand the potential impact of banks substituting other types of bonds with government bonds.[24]

The existing literature points to two variables of interest: 1) banks' profitability, and 2) banks' lending to the private sector. Additionally, one would like to specifically understand the interaction of government bond holdings with these two variables during normal times and during stress.

Analyzing the European sovereign debt crisis, Acharya and Steffen (2013) find that high government bond holdings of peripheral European countries (e.g. Greece or Portugal) increase banks' returns while high holdings of bonds issued by core European countries (especially Germany) have a negative impact on banks' returns. Since Dutch government bonds are usually traded in a peer group with German bonds, a negative impact on banks' returns can be expected.[25]

Regarding lending, one can distinguish two ways through which government bond holdings affect credit supply.[26] The first one is direct and also explained in Gennaioli et al. (2014). A sovereign crisis has a relatively larger negative impact on the asset value of institutions with high government

[23] These results are in line with the results obtained in Chapter 3.

[24] See Gorton and Huang (2004) for a paper discussing the role of governments in liquidity provision.

[25] Please note that the dataset does not include structural, detailed information on the distribution of banks' government bond holdings. The available information, however, suggests that the banks in the sample mainly hold German and Dutch government bonds.

[26] Also see Popov and Van Horen (2013).

bond holdings.[27] Losses on sovereign debt can reduce the profitability of the bank and also raise concerns about counterparty risk, which in turn will have an adverse impact on the availability and cost of funding. Second, Holmstroem and Tirole (1993) as well as Popov and Van Horen (2013) argue that sovereign debt is usually a reliable source of liquidity and collateral. Increased sovereign risk would therefore reduce the value of an important funding source.

Most analyses studying the link from increased government bond holdings and credit issuances argue that regulation is a key driver of banks' government bond holdings. For their analysis, Gennaioli et al. (2014) as well as Popov and Van Horen (2013), use an absolute measure of government bond holdings (e.g. government bond holdings in percentage of total assets). When analyzing the impact of government bond holdings on banks' profitability and lending to the real economy, there is an important difference between banks' absolute government bond holdings and their holdings relative to other bonds. Since they are all part of banks' assets and banks usually try to avoid excessive balance sheet expansions, there is a direct link between banks' bond holdings and their loan issuances. The result that high government bond holdings reduce banks' loan issuances might not be specific to government bonds. It might be the case that banks, when obtaining more bonds, generally try to reduce lending. Similarly, since Popov and Van Horen (2013) and Gennaioli et al. (2014) specifically focus on sovereign debt crises, the negative impact of government bond holdings on lending seems a logical consequence. Again, however, one might observe similar effects when analyzing other types of bonds during other types of crises. Since financial regulation seems to increase banks' relative holdings of government bonds, it is useful to understand whether relatively higher government bond holdings cause banks to act differently during different types of stress. Depending on the type of stress, one can expect positive or negative effects of relatively high government bond holdings on bank lending and profitability.

Since this final step does not include the MiFID data, it is possible to obtain data for the period from July 2003 to December 2012. The main advantage of using such a long time series is that it allows the identification of both pure sovereign and banking stress as well as a period of combined sovereign and banking stress.

Although setting the start and end date of a crisis is always connected to some subjective judgment, October 2009 is expected to be an appropriate start date of the sovereign debt crisis. In October 2009, Greece revealed that it significantly underreported its budget deficit. Latest by December 2009, fears of European sovereign defaults have developed among investors. The end date is set at December 2012, which coincides with the latest observation in the dataset.

[27] This reduction in the value of banks' assets is likely to occur during crisis and since it is equivalent to a large counterparty default, straightforward in case of a government default.

Regarding banking stress, a recent study by the European Systemic Risk Board (ESRB) points to two recent periods: 1) October 6th 2008 to February 2nd 2009, and 2) September 26th 2011 to February 8th 2012.[28] As such, the first period is defined as banking crisis while the second period reflects a combination of banking and sovereign stress. The estimation model is defined as follows:

$$\begin{aligned} Impact_{i,m} = \beta_0 + \beta_1 Bondratio_{i,m-1} + \beta_2 Crisis\ dummy_m + \beta_3 Bondratio * crisis_{i,m-1} \\ + \beta_4 Bond\ holdings_{i,m-1} + \beta_5 Demand_{i,m} + \beta_6 Controls_{i,m(-1)} + \varepsilon_{i,m} \end{aligned} \tag{5.3}$$

where $Impact_{i,m}$ refers to either institution i's lending to the private sector or its net income in month m. Both dependent variables are expressed as percentage of total assets. The key explanatory variable $Bondratio_{i,m-1}$ describes the share of government bonds in other bonds of institution i in month m-1. $Crisis\ dummy_m$ is a dummy describing banking, sovereign or combined crises while $Bondratio * crisis_{i,m-1}$ is an interaction term. $Bond\ holdings_{i,m-1}$ is defined as institutions' total bond holdings (sum of government bonds and other bonds) in percentage of total assets.
As common in the literature, the model also includes $Demand_{i,m}$ to capture the demand side of bank lending.[29] $Demand_{i,m}$ is calculated as the exposure weighted average growth rate of the economic sectors, institution i is lending to in month m.
Finally, $Controls_{i,m(-1)}$ include institutions' lagged net income in percentage of total assets, the GDP growth rate of the Netherlands as well as the EONIA interest rate.[30] Motivated by Hausman tests, all regressions are performed with fixed effect panel estimations.[31]
The variable *Bondratio* has a mean of 11.73 and a median of 1.74. The 25th percentile is 0.63 while the 75th percentile amounts to 6.02. These figures imply that the median institution's government bond holdings are about twice its holdings of other bonds. The mean of almost 12, however, implies that there are institutions with substantially larger government bond holdings compared to other bonds. This is confirmed by the 99th percentile amounting to 181.
Table 5.1 shows that higher relative government bond holdings have a positive impact on lending during normal times but reduce banks' lending during sovereign and banking crises. Profitability is negatively affected by relatively higher government bond holdings during normal times but not during stress.

[28] See ESRB (2014). It can also be argued that the liquidity crisis ended after ECB president Mario Draghi's speech on July 26th in London. Defining the crisis period that way that does not lead to significantly different results.
[29] See for instance Popov and Van Horen (2013) as well as Brown et al. (2010), Fabbro and Hack (2011) or Deans and Stewart (2012).
[30] The extended version of Table 5.1 can be found in the Appendix (Table A5.5).
[31] Results of pooled OLS are presented in Table A5.6 in the Appendix.

Table 5.1: Bond holdings, lending and profitability - shortened -

	Lending				Profitability			
	1	2	3	4	5	6	7	8
Bondratio (gov. bonds over other bonds, lagged)	0.102***	0.108***	0.116***	0.103***	-0.003***	-0.003***	-0.002***	-0.002***
	(0.021)	(0.018)	(0.020)	(0.021)	(0.000)	(0.000)	(0.001)	(0.000)
Bondratio * sov.crisis		-3.785***				0.000		
		(1.355)				(0.001)		
Sovereign crisis		-12.908***				0.122*		
		(1.580)				(0.063)		
Bondratio * bank. crisis			-2.458***				-0.001	
			(0.651)				(0.001)	
Banking crisis			-4.460*				-0.053	
			(2.437)				(0.087)	
Bondratio * combined				2.285				-0.001
				(3.314)				(0.001)
Combined crisis				-7.958				-0.065
				(5.518)				(0.119)
Total bonds in % total assets (lagged)	-0.320**	-0.053	-0.094	-0.307**	0.007***	0.007***	0.007***	0.007***
	(0.139)	(0.136)	(0.151)	(0.140)	(0.002)	(0.002)	(0.002)	(0.002)
Observations	224	224	224	224	3020	3020	3020	3020
R^2	0.745	0.808	0.761	0.749	0.437	0.437	0.437	0.437

Note: The table presents results of regressions estimated with fixed effect panel estimations including lagged variables, bank dummies and clustered standard errors. The dependent variable is either banks' lending to the private sector or their net income over total equity. Apart from the presented variables, the regressions includes a number of bank-specific and macroeconomic variables. An extended version of this table can be found in the Appendix. Statistical significance is indicated by *** p<0.01, ** p<0.05, * p<0.1 while standard errors are in parentheses.

A relative increase of government bond holdings by 1 unit (1 standard deviation) increases banks' lending to the private sector by 0.10pp (5.5pp).[32] During sovereign and liquidity stress, however, a 1 unit relative increase in government bond holdings reduces lending by 3.8pp and 2.5pp respectively. The analysis further shows that 1 unit higher government bond holdings reduce banks' profitability by 0.003pp. However, during the three different crises this negative impact diminishes, making government bond holdings an insignificant factor.[33]

Summarizing, Table 5.1 shows that during normal times high government holdings seem to increase banks' lending to the private sector and reduce profitability. During banking and sovereign crises, however, government bond holdings reduce banks' lending but do no longer have a negative impact on banks' profitability.

The negative effect of higher government bond holdings, especially when rated AAA, on banks' profits is straightforward and also found in Acharya and Steffen (2013). However, during the most severe crises this negative impact on banks' profitability diminishes, suggesting that at least high quality government bonds are a relatively stable source of liquidity and collateral, giving banks access to funding. As such, the relatively higher opportunity costs of holding government bonds are offset during stress, when government bonds continue to be a stable source of funding.

This chapter's results regarding lending are related to Gennaioli et al. (2014) and Popov and

[32] To recall, unit in this regard refers to a bank's holdings of other bonds.

[33] The OLS estimations show even a positive impact of government bond holdings on banks' returns during stress (Table A5.6).

Van Horen (2013). However, while these two studies focus on failed or nearly failed governments, the banks in this analysis hold mainly Dutch and German government bonds.[34] The results therefore suggest that even high quality government bonds have a negative impact on banks' lending during stress. A likely reason for this effect is that, although they maintained their high ratings, also European core government bonds were subject to high price volatility and uncertainty.

5.6. Shortcomings

Although this is one of the first studies, attempting to directly estimate the impact of capital and liquidity regulation on banks' demand for government bonds, a few caveats are in order.
As the MiFID data only includes Dutch government bonds, the time series does not include a rating downgrade. However, the Netherlands has been put on "negative watch" a few times during this chapter's sample period, allowing to at least partially control for the impact of downgrades. Additionally, all regressions include the relative rating of the Netherlands compared to its peers (Germany, France, Belgium, Finland and Austria), which can be expected to additionally account for these dynamics.
As the analysis combines two datasets with different means of consolidation, there is a risk of a measurement bias. To address this bias and although it implies dropping parts of the dataset, the analysis excludes all entities which do not belong to a Dutch group. Since there is more detailed information on the Dutch entities, it is possible to match the different datasets minimizing a measurement bias.
The analysis in this chapter aims at capturing the impact of preferential treatment on banks' demand for government bonds and, in a second step, the impact of high government bond holdings on bank lending and profitability. Although the chapter includes a clear link to the real economy, it remains a partial analysis. To draw firm policy conclusions from this analysis one would need to more broadly account for the impact of increased government spending on the economy as a whole.

5.7. Conclusion

Government bonds receive preferential treatment in financial regulation. The purpose of this chapter is to analyze whether this preferential treatment increases banks' demand for government bonds beyond their own risk appetite. The final step of the analysis aims at capturing the impact of high government bond holdings on banks' profitability and lending to the real economy.

[34] Note that this is additionally confirmed by the negative impact of government bond holdings on profitability. In case of peripheral countries, one would expect positive returns as found by Acharya and Steffen (2013).

The results of this chapter suggest that preferential treatment in both capital and liquidity regulation increases banks' demand for government bonds. On top of that, it seems to cause a substitution effect with banks buying more government bonds while selling more other bonds. The analysis also points to both types of regulation leading to a somewhat longer-term increase of banks' government bond holdings.

Further, high government bond holdings were associated with higher lending and lower profits during normal times. During liquidity or sovereign crises, however, high government bond holdings are associated with less lending to the real economy but not with lower profits.

Financial regulation changes banks' behavior and is therefore an important determinant of banks' government bond holdings. The rationale behind favorable treatment in financial regulation is the view that government bonds are risk-free assets making them a reliable source of liquidity and collateral. While there seems to be a positive impact during normal times, the results of this chapter suggest that government bond holdings have a negative impact on lending during stress. At the same time, the opportunity costs of holding government bonds and the implied negative impact on profits seem to be compensated by government bonds being a reliable source of funding, even during stress. This combination of positive and negative effects during stress suggests that there is scope to consider a more risk-sensitive approach regarding the regulatory treatment of government bonds. The fact that the sample mainly includes highly rated government bonds, further suggests that there are additional factors, such as price volatility, which should be taken into consideration when estimating the risk of government exposure.

Appendix

Table A5.1: Summary statistics

Variable	**Mean**	**Std.Dev.**	**Min**	**Max**
Net demand government bonds	22	25	-61	123
Net demand other bonds	8	42	-98	152
Liquidity ratio - 100%	151	155	-47	809
Capital ratio - 8%	10	5	-0.09	32
Net income in % total assets	0.23	0.74	-1	5
Net income in % total capital	0.82	4	-18	17
EONIA	0.49	0.28	0.07	1
GDP growth rate EU	0.19	0.37	-0.48	0.90
Government debt in % GDP	55	2	49	57
Rating NL over average peers' rating	0.77	0.06	0.68	0.83
Government bonds as share of other bonds	14	53	0.03	235
Private sector lending in % total assets	39	13	12	62

Note: The above table shows summary statistics for all relevant variables.

Table A5.2: Results of Figures 5.4 and 5.5 - Examples of day 5 and 22

	Government Bonds				Other bonds			
METHOD	Day 12	Day 22	Day 12	Day 22	Day 12	Day 22	Day 12	Day 22
DLCR (lagged)	-0.017	-0.017***	-0.024	0.023***	0.004	0.021***	0.004	0.021***
	(0.014)	(0.005)	(0.016)	(0.007)	(0.016)	(0.007)	(0.018)	(0.005)
Capital (lagged)	-0.696**	-0.726***	-1.077***	-1.296***	0.093	0.200***	0.142	0.187***
	(0.280)	(0.270)	(0.293)	(0.281)	(0.142)	(0.074)	(0.128)	(0.078)
Reserve	-0.009**	-0.002	-0.008**	-0.002	0.000	0.002	0.000	0.001
	(0.004)	(0.003)	(0.004)	(0.003)	(0.004)	(0.004)	(0.004)	(0.004)
Days to remittance	-0.042	-0.267**	-0.047	-0.275**	0.128	-0.120	0.126	-0.103
	(0.115)	(0.119)	(0.125)	(0.129)	(0.131)	(0.132)	(0.130)	(0.151)
Net income (lagged)	25.855*	20.046	20.009	9.904	4.822	25.946	13.121	23.828
	(14.836)	(16.758)	(14.714)	(16.552)	(19.252)	(17.926)	(18.728)	(17.719)
RoE (lagged)	-0.911	-0.600	-0.678	-0.197	-0.536	-1.736**	-1.030	-1.726**
	(0.688)	(0.749)	(0.681)	(0.739)	(0.894)	(0.816)	(0.866)	(0.798)
EONIA	-5.504	10.483*	-2.865	12.791**	18.660***	12.780**	17.446***	12.086*
	(5.524)	(5.445)	(5.992)	(5.812)	(6.964)	(6.195)	(6.589)	(6.953)
GDP EU	-0.209	4.817	0.807	5.680	8.926	3.354	9.965*	3.120
	(5.204)	(5.026)	(5.644)	(5.384)	(6.344)	(5.543)	(6.028)	(6.282)
Spread	-41.442***	-24.745	-39.116***	-17.225	-35.166	-87.100***	-39.430	-86.195***
	(15.242)	(20.407)	(15.136)	(20.198)	(29.140)	(23.925)	(26.838)	(23.759)
Government debt	1.010	-0.291	0.939	-0.248	-1.876*	-0.873	-1.988*	-0.869
	(0.964)	(0.902)	(1.040)	(0.966)	(1.135)	(0.977)	(1.075)	(1.111)
Peers rating	6.122	-63.237	-4.175	-73.847	-100.115*	-31.349	-103.516*	-37.343
	(46.812)	(43.810)	(50.790)	(47.125)	(55.935)	(48.527)	(53.598)	(55.122)
Bank dummies	NO	NO	YES	YES	NO	NO	YES	YES
Observations	1769	1794	1769	1794	1068	1205	1185	1205
R^2	0.233	0.213	0.349	0.272	0.249	0.220	0.394	0.240

Note:The table is an example of the results presented in Figures 5.4 and 5.5.

Table A5.3: Total demand entire month

	OLS		IV FE		SUR	
Dependent	Government bonds	Other bonds	Government bonds	Other bonds	Government bonds	Other bonds
DLCR (lagged)	0.00	-0.00	0.00	-0.00	0.00	-0.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Capital (lagged)	0.07***	0.00	0.02	-0.00	0.03	-0.00
	(0.02)	(0.00)	(0.03)	(0.00)	(0.03)	(0.00)
Net income (lagged)	-0.16	-0.00	-0.24**	0.00	-0.25**	0.00
	(0.10)	(0.01)	(0.10)	(0.01)	(0.10)	(0.01)
RoE (lagged)	0.01	-0.00	0.05	-0.00	0.05	-0.00
	(0.04)	(0.00)	(0.04)	(0.00)	(0.04)	(0.00)
EONIA	-0.02	-0.11**	-0.39	-0.12**	-0.37	-0.12**
	(0.67)	(0.06)	(0.63)	(0.06)	(0.73)	(0.05)
GDP EU	-0.43	0.03	-0.73	0.04	-0.70	0.04
	(0.60)	(0.05)	(0.54)	(0.05)	(0.62)	(0.05)
Price	0.03	-0.01**	-0.00	-0.01**	0.00	-0.01**
	(0.04)	(0.00)	(0.04)	(0.00)	(0.04)	(0.00)
Government debt	-0.09	-0.01	-0.04	-0.01	-0.07	-0.01
	(0.12)	(0.01)	(0.11)	(0.01)	(0.13)	(0.01)
Peers rating	-1.26	-0.41	0.61	-0.43	-0.58	-0.43
	(5.28)	(0.45)	(4.82)	(0.45)	(5.60)	(0.43)
Observations	430	354	430	354	354	354
R^2	0.057	0.044	0.236	0.134	0.236	0.134

Note: The table presents results regarding the impact of banks' capital and liquidity position on their gross demand for government and other bonds.

Table A5.4: Total supply entire month

	OLS		IV FE		SUR	
Dependent	Government bonds	Other bonds	Government bonds	Other bonds	Government bonds	Other bonds
DLCR (lagged)	0.00	-0.00	0.00	-0.00	0.00	-0.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Capital (lagged)	0.07***	0.00	0.02	-0.00	0.03	-0.00
	(0.02)	(0.00)	(0.03)	(0.00)	(0.03)	(0.00)
Net income (lagged)	-0.16	-0.00	-0.24**	0.00	-0.25**	0.00
	(0.10)	(0.01)	(0.10)	(0.01)	(0.10)	(0.01)
RoE (lagged)	0.01	-0.00	0.05	-0.00	0.05	-0.00
	(0.04)	(0.00)	(0.04)	(0.00)	(0.04)	(0.00)
EONIA	-0.02	-0.11**	-0.39	-0.12**	-0.37	-0.12**
	(0.67)	(0.06)	(0.63)	(0.06)	(0.73)	(0.05)
GDP EU	-0.43	0.03	-0.73	0.04	-0.70	0.04
	(0.60)	(0.05)	(0.54)	(0.05)	(0.62)	(0.05)
Price	0.03	-0.01**	-0.00	-0.01**	0.00	-0.01**
	(0.04)	(0.00)	(0.04)	(0.00)	(0.04)	(0.00)
Government debt	-0.09	-0.01	-0.04	-0.01	-0.07	-0.01
	(0.12)	(0.01)	(0.11)	(0.01)	(0.13)	(0.01)
Peers rating	-1.26	-0.41	0.61	-0.43	-0.58	-0.43
	(5.28)	(0.45)	(4.82)	(0.45)	(5.60)	(0.43)
Observations	430	354	430	354	354	354
R^2	0.057	0.044	0.253	0.305	0.236	0.134

Note: The table presents results regarding the impact of banks' capital and liquidity position on their gross supply of government and other bonds.

Table A5.5: Bond holdings, lending and profitability - extended -

	Lending				Profitability			
	1	2	3	4	5	6	7	8
Bondratio (gov. bonds over other bonds, lagged)	0.102***	0.108***	0.116***	0.103***	-0.003***	-0.003***	-0.002***	-0.002***
	(0.021)	(0.018)	(0.020)	(0.021)	(0.000)	(0.000)	(0.001)	(0.000)
Bondratio * sov.crisis		-3.785***				0.000		
		(1.355)				(0.001)		
Sovereign crisis		-12.908***				0.122*		
		(1.580)				(0.063)		
Bondratio * bank. crisis			-2.458***				-0.001	
			(0.651)				(0.001)	
Banking crisis			-4.460*				-0.053	
			(2.437)				(0.087)	
Bondratio * combined				2.285				-0.001
				(3.314)				(0.001)
Combined crisis				-7.958				-0.065
				(5.518)				(0.119)
Total bonds in % total assets (lagged)	-0.320**	-0.053	-0.094	-0.307**	0.007***	0.007***	0.007***	0.007***
	(0.139)	(0.136)	(0.151)	(0.140)	(0.002)	(0.002)	(0.002)	(0.002)
GDP NL	0.877	1.235*	0.094	0.680	0.077***	0.062**	0.062	0.074***
	(0.661)	(0.707)	(0.951)	(0.669)	(0.027)	(0.028)	(0.039)	(0.027)
EONIA	2.951***	0.397	2.235***	2.893***	0.005	0.034	0.004	0.004
	(0.412)	(0.480)	(0.443)	(0.412)	(0.016)	(0.022)	(0.016)	(0.016)
Return on equity (lagged)	0.002	-0.011	0.007	0.001				
	(0.030)	(0.027)	(0.030)	(0.030)				
Demand	6.071	11.044***	8.505**	6.100				
	(4.191)	(3.709)	(4.133)	(4.196)				
Observations	224	224	224	224	3020	3020	3020	3020
R^2	0.745	0.808	0.761	0.749	0.437	0.437	0.437	0.437

Note: The table is the extended version of Table 5.1.

Table A5.6: Bond holdings, lending and profitability without bank dummies

	Lending				Profitability			
	1	2	3	4	5	6	7	8
Bondratio (gov. bonds over other bonds, lagged)	0.100***	0.072***	0.079***	0.097***	0.001	0.000	0.001	0.000
	(0.027)	(0.028)	(0.028)	(0.027)	(0.000)	(0.000)	(0.001)	(0.000)
Bondratio * sov.crisis		-4.672**				0.003**		
		(2.152)				(0.001)		
Sovereign crisis		-10.014***				0.206***		
		(2.556)				(0.077)		
Bondratio * bank. crisis			-2.310***				0.000	
			(0.852)				(0.001)	
Banking crisis			-9.172**				-0.032	
			(3.774)				(0.114)	
Bondratio * combined				-4.488				0.004***
				(5.471)				(0.001)
Combined crisis				-0.357				-0.323**
				(9.412)				(0.155)
Total bonds in % total assets (lagged)	0.290***	0.322***	0.304***	0.287***	0.001	0.001	0.001	0.001
	(0.059)	(0.058)	(0.058)	(0.059)	(0.002)	(0.002)	(0.002)	(0.002)
GDP NL	-0.740	-1.525	-3.414**	-1.093	0.047	0.035	0.036	0.040
	(1.094)	(1.331)	(1.617)	(1.112)	(0.034)	(0.036)	(0.051)	(0.035)
EONIA	1.928***	-0.203	1.157	1.788***	-0.032	0.020	-0.030	-0.035*
	(0.635)	(0.820)	(0.702)	(0.639)	(0.019)	(0.028)	(0.020)	(0.019)
Return on equity (lagged)	-0.093*	-0.094*	-0.085*	-0.094*				
	(0.050)	(0.049)	(0.049)	(0.050)				
Demand	11.269	15.781**	13.740*	10.782				
	(7.148)	(7.060)	(7.148)	(7.147)				
Observations	224	224	224	224	3020	3020	3020	3020
R^2	0.214	0.270	0.251	0.226	0.092	0.096	0.092	0.095

Note: The table presents the same analysis as Table 5.1 estimated with pooled OLS instead of fixed effects panel estimations.

CHAPTER 6

Conclusion

The aim of this thesis is to analyze the impact of financial regulation, and especially liquidity regulation, on bank behavior. The first of four main chapters is intended to provide general background, including a historic overview, as well as stylized facts regarding liquidity and its interaction with capital standards. The purpose of the next chapter is to put liquidity regulation in context to banks' general policy environment and thereby to understand how liquidity standards should be implemented in different countries across the globe. These more conceptual analyses are followed by two chapters focusing on very specific issues around financial regulation. Both of them, however, can be placed into a wider policy and institutional context. Chapter 4 focuses on the interaction of liquidity regulation with monetary policy and central banking while Chapter 5 discusses the impact of liquidity and capital standards on banks' demand for government bonds and therefore somewhat relates to public policy. Below I will discuss the key findings of this thesis, its policy implications and suggest areas for further work.

The analysis in Chapter 2 suggests that regulating capital reduces banks' liquidity buffers. These results suggest that financial supervisors should, when strengthening regulatory requirements, pay particular attention to avoid banks shifting their activities to less regulated parts of their balance sheets or to less regulated sectors. Chapter 2 also shows that the lack of supervisory momentum, the interaction of liquidity regulation and monetary policy as well as the view that regulating capital also addresses liquidity risks were important factors hampering harmonized liquidity regulation. Having said this, however, the interaction of different regulatory requirements and their impact on banks' risk shifting deserves a closer look.

Chapter 3 discusses the impact of liquidity regulation on banks' risk management. The presented General Methods of Moments (GMM) estimations reveal that in the absence of liquidity regulation, the determinants of banks' liquidity buffers are a combination of bank-specific and country-specific factors. While most incentives are substituted by liquidity regulation, a bank's disclosure requirements remain important. These reinforcing effects of disclosure and liquidity requirements provide a strong rationale for considering them jointly in the design of regulation.

Prior to the Basel III proposals there have been discussions whether the LCR should be defined as a strict minimum requirement or whether banks should be allowed to use their liquid assets during stress, therefore temporarily falling below 100%. While BCBS (2013b) clearly specifies the latter, it remains to be seen whether banks will actually be able to use their liquid assets during stress. Especially in the presence of disclosure requirements, banks might actually not be able to fall below a 100% LCR without risking a self-fulfilling prophecy. When showing that banks subject to a liquidity requirement tend to maintain higher liquidity buffers during stress, Chapter 3 touches upon this issue. However, understanding the effectiveness of liquidity regulation in avoiding fire sales is essential for assessing the general effectiveness of liquidity standards and therefore a more thorough analysis of these observed patterns seems desirable.

As explained in Chapter 2, the interaction of liquidity regulation with monetary policy has been a topic of disunion. Motivated by the recent discussions between the first LCR proposal in 2010 and its revision in 2013, Chapter 4 analyzes the impact of the LCR on the unsecured interbank money market and consequently the bank lending channel. The Regressions Discontinuity Design (RDD) suggests that banks subject to a binding liquidity requirement charge and pay higher interest rates and demand more long-term loans in the unsecured interbank money market. The rationale for central banks to target the overnight rate is the view that developments in the interbank money market are transmitted to the real economy. When focusing on this interaction, however, the analysis in this chapter does not find a significant impact of liquidity regulation on banks' corporate lending rates. Rather, a binding liquidity requirement seems to lower banks' interest margins, suggesting that banks cannot pass on their increased funding costs in the interbank market to their private sector clients. A key takeaway from the analysis is that liquidity regulation does not seem to affect monetary policy transmission itself. Rather, it seems to create situations in which the interbank market rate is a less useful tool for reaching the desired interest rate level in the real economy. In presence of liquidity shortages, interbank market rates seem to increase, affecting banks' interest margins but not real economy lending rates. As such, central banks are advised to closely monitor the LCR of the banking system and potentially use a representative real economy interest rate as additional target for monetary policy implementation. A potential option could be to additionally target the price of certain securities, such as for instance corporate bonds or securitizations, when conducting monetary policy operations.

Finally, Chapter 5 is motivated by the European sovereign debt crisis and aims at analyzing the impact of financial regulation on banks' demand for government bonds. The presented results, obtained with Seemingly Unrelated Regression (SUR) models, suggest that liquidity and capital requirements cause banks' demand for government bonds to increase beyond their internal risk management targets. The relative preferential treatment also seems to prompt a substitution effect with banks buying more government bonds while selling more other bonds. The analysis also shows that these dynamics are likely to cause a longer-term increase of government bond holdings. Further,

holdings of high quality government bonds seem to be positively associated with banks' lending to the real economy but have a negative impact on profits. During both sovereign and liquidity stress, however, the negative impact on banks' profitability diminishes while high government bond holdings seem to have a negative impact on private sector lending. Although one should be careful when drawing policy conclusions, the analysis in this chapter can be interpreted as giving reason to at least consider treating exposures to governments in a more risk-sensitive way and therefore similar to other bonds. The fact that even highly rated government bonds had a negative impact on lending suggests that there are additional factors, such as price volatility, which should be taken into consideration when estimating the risk of government exposure.

The aim of this thesis is to provide empirical evidence regarding the impact of financial regulation, and especially liquidity regulation, on bank behavior. It specifically focuses on factors to take into account when implementing regulatory requirements and developments to monitor once these requirements are implemented. The results obtained in the individual chapters suggest that financial regulation affects bank behavior but also that these effects are either intended or they can be managed.

The literature on the impact of financial regulation, especially regarding liquidity, on bank behavior and more general on financial markets is still fairly new. While this thesis answers a number of conceptual and empirical questions, there is wide scope for further work. The MiFID transaction reports, used in Chapter 5, carry a lot of information that could improve our understanding of financial markets. The reports can be used to analyze how institutions trade securities with each other and whether relationships play a similar role as in interbank money markets. Focusing more on the securities itself, the data would allow an analysis regarding the "path" of a security from issuance to amortization. With a sufficiently long time series, the MiFID reports could even be used to reconstruct the portfolios of the largest institutions. Another area for further work is the impact of Pillar 2 frameworks on bank behavior. If they have not done so already, most supervisory authorities around the globe will implement Pillar 2 frameworks in the coming years. In contrast to Pillar 1, which focuses on "one size fits all" minimum standards, Pillar 2 processes aim at improving banks' own risk management frameworks. Although there has already been a lot of work on issues around governance and compensation, the introduction of Pillar 2 frameworks offers a number of quasi-experiments that could help us understanding the impact of various risk management incentives on banks' risk taking.

Epilogue

The aim of this thesis is to provide background regarding the development of globally harmonized liquidity standards as well as to answer a number of empirical questions regarding the impact of financial regulation on bank behavior. Whether or not the empirical evidence presented in this thesis will be helpful for regulators to ensure efficient implementation of the liquidity standards remains to be seen. In any case, however, two metrics (LCR and NSFR) cannot provide a complete picture of an institution's liquidity risk profile. This is confirmed by the BCBS when clearly referencing the Sound Principles (BCBS (2008)) as important complement to the LCR and NSFR.

Along with an assessment regarding the quality of banks' risk management, advanced stress tests are a useful instrument to analyze and understand institutions' vulnerabilities. However, unlike capital for which harmonized stress tests are widespread, practices regarding liquidity stress testing still differ and often liquidity risk is only a small component of stress tests.[1] For their recent stress test, the European Banking Authority (EBA), for instance, only accounted for liquidity risks as an assumed increase in funding costs as opposed to actually testing the size and quality of institutions' liquidity buffers. Also in the US, liquidity stress tests play only a subordinated role compared to capital stress tests.[2] The arguments in favor of liquidity stress tests are similar to the ones for minimum liquidity standards. Even when considering capital to be more important, liquidity buffers are important to mitigate the risk of system-wide fire sales and their negative consequences for bank capital.[3]

Despite its still subordinated role, important work has been undertaken to support regulators and banks in improving liquidity stress testing. Recently, the Research Taskforce of the BCBS, for instance, published two BIS working papers (BCBS (2013c,d)), which present current practices, identify gaps and suggest areas of further work regarding liquidity stress testing.

[1] While there is a CEBS guideline on liquidity buffers and survival periods (CEBS (2009)), which somewhat touches upon liquidity stress testing, the CEBS Guideline on Stress Testing (CEBS (2010)) discusses liquidity risk only as small component of capital stress tests.

[2] See FRB (2013).

[3] See Cifuentes et al. (2005), Franklin and Gale (2004, 2005), Schnabel and Shin (2004) and Diamond and Rajan (2005).

As laid out in Chapter 2, one of the issues around the design of the LCR was that there was only very limited empirical evidence of the liquidity stress banks were facing. While the BCBS has chosen a more theoretical approach when designing the LCR, the new evidence can help regulators to design stress tests.[4]

Especially the detailed case studies of failed or near-failed institutions in BCBS (2013c,d) seem important input to improve banks' liquidity risk management and specifically stress testing.[5]

As credit markets froze during the 2007-08 financial crisis, several banks faced difficulties to execute planned sales of loans, forcing them to hold assets when they already faced funding pressures and would have liked to deleverage. These issues forced banks to increase their reliance on wholesale funding markets and therefore over-reliance on wholesale funding was often a symptom of lending pipeline issues. Related to this, some banks were not prepared for the difficulties in shutting down their mortgage portfolios and therefore experienced considerably lower inflows than anticipated. A first insight is therefore that banks cannot rely to heavily on inflows. This point is also important for capital stress tests since the capital position of these institutions worsened simultaneously given the unplanned asset on-boarding.

Turning to outflows, the cases of two US commercial banks show that uninsured deposit outflows were one of the drivers of liquidity stress while one large international bank experienced deposit outflows of 11% over one month, with 8.5% within a single week. As such, the case studies clearly show that uninsured deposit outflows are not a negligible liquidity risk.

Another important insight from the case studies is the heterogeneity of lending commitments. While commitments to corporate borrowers, for instance, were one of the smallest sources of liquidity stress during the recent financial crisis, commitments to ABCP conduits and other capital market instruments significantly affected banks' liquidity positions.[6]

The example of a European bank shows that, while margin calls and pre-funding of foreign currency swaps reduced the bank's liquidity position, these factors amounted to only 8% of the firm's liquidity gap and therefore were a contributing as opposed to a major factor. Similarly, data for a US investment bank suggests that collateral movements due to derivative assignments amounted to only 10% of the firm's outflows and therefore liquidity risks stemming from derivative transactions should not be calibrated overly conservative.

[4] The evidence presented in these studies can also be helpful for the implementation of other Sound Principles in BCBS (2008).

[5] The case studies cover Dexia, Fortis, Hypo Real Estate Bank, Kaupthing Sverige AB (the Swedish subsidiary of an Icelandic bank), Icelandic banks' operations in Norway, the German Landesbanken, Lehman Brothers, Morgan Stanley, Northern Rock, RBS, Wachovia, and Washington Mutual and therefore include commercial, investment, specialty as well as universal banks.

[6] Also see the Introduction for more information on the role ABCP played during the recent crisis.

Other major funding issues were caused by run-off in prime brokerage balances, claims from secured lending counterparties as well as liquidity stress related to the use of clearing and settlement services.

Turning to banks' liquidity buffers, BCBS (2013c) shows that one of the European institutions carried a buffer of EUR 2.1 billion while facing ABCP-related outflows of roughly EUR 20 billion. In line with this, three other case studies show that banks' liquidity buffers were simply too small relative to the stress they experienced during the crisis (as opposed to banks experiencing difficulties in liquidating those assets).

Several banks, however, also had difficulties to access their liquidity buffers. Most interesting is the case of one US firm, which developed a number of creative approaches allowing it to include assets provided to clearing and settlement banks in its liquidity buffer even though these funds could not be accessed during regular business hours. As explained earlier, another source of liquidity risk was the so-called "lemons problem": Difficult-to-value, complex products suffered from higher discounts and have therefore proven to be a less reliable source of liquidity, especially when they were not traded in deep and active markets. Clearly, this stresses the importance of well-defined operational requirements when designing liquidity stress tests.

Finally, the case studies suggest that several firms were able to raise funds through repo with central counterparty clearing houses (CCP) but that there are reasons to view firms' continued access to bilateral repo markets with skepticism. For one institution, CCP-intermediated repos served as a material source of funding even during the most significant period of stress. A bank was able to raise USD 24 billion during its peak liquidity stress and similarly, one failed US institution experienced no material change in triparty repo haircuts or financing volumes until one week prior to failure. As such, this may suggest taking into account the repoability of an asset with a CCP as a criterion for favorable treatment in liquidity stress tests.

Apart from these more specific issues, BCBS (2013c) also points to a number of more general observations to bear in mind when developing liquidity stress tests. Ideally, competent authorities apply both bottom-up and top-down approaches to capture second-round and systemic effects. Similarly, it is also recommendable for banks to take into account second-round effects and especially large banks should account for the impact of their actions on the banking system as a whole. Also Goodhart (2011a) emphasizes the importance of system-wide stress tests.

Regarding central bank funding, the paper discusses arguments in favor and against factoring in the lender of last resort function to supervisors' liquidity stress tests. On balance, the paper concludes that liquidity stress testing assumptions should limit the role of central banks to standard and other already existing monetary policy operations while the assumptions of more expansive central bank support would give wrong incentives with regards to banks' risk taking and reliance on central bank liquidity.

BCBS (2013c,d) once again confirm that liquidity risk is a complex and diverse matter. At the same time, however, the case studies clearly point to a number of patterns. Especially the importance of deposit insurance coverage, the difficulties faced by banks to stop leveraged and residential mortgage loan pipelines, the relevance of operational requirements for the effectiveness of liquidity buffers as well as the important distinction between different types of repos, committed facilities as well as derivative transactions should receive increased attention when designing liquidity stress tests.

Liquidity risks can be a primary source of bank failures. As such, there are strong arguments to not rely on a single metric but to conduct serious Pillar 2 liquidity supervision with supervisory and firms' own stand-alone liquidity stress tests as well as stress tests combining liquidity and solvency risks being the quantitative fundament of such a process.

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