The Role of Liquidity in Financial Intermediation

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Thesis submitted in fulfilment of the requirement for the Degree of Doctor of Philosophy in Finance

Finance Discipline, UTS Business School

University of Technology Sydney

Date: 3 January 2018

Certificate of Original Authorship

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This research is supported by an Australian Government Research Training Program Scholarship.

Acknowledgements

I am indebted to A/Prof. Harald Scheule and A/Prof. Eliza Wu for their supervision, guidance, helpful comments and financial assistance in the writing of this thesis. The skills and knowledge that I have developed under their supervision will be of great value to my academic career. I would also like to thank Professor Iftekhar Hasan, Professor Tony Hall and Dr Gerhard Hambusch for providing helpful comments and mentorship. I thank the Australian Government Research Training Program Scholarship for financing my PhD study. I thank the University of Technology Sydney Business School for providing additional financial assistance. Thanks to John Revington for editing a draft of my thesis.

Lastly, I would like to sincerely thank my father (Muhammad Badruddin Khan), mother (Suraiyea Khanam), wife (Farhana Islam) and daughter (Sanjana Khan). None of my successes and achievements would have been possible without your endless love and continuous support.

Abstract

Bank liquidity has become an important focus of financial regulatory reforms since the dangers of liquidity crunches became all too apparent in the recent global financial crisis. The Basel Committee on Banking Supervision initiated two new liquidity standards in global banking regulation – the liquidity coverage ratio (LCR) and the net stable funding ratio (NSFR) which are designed to increase banks' liquidity buffers and funding stability respectively. This dissertation contributes to the literature on financial intermediaries by investigating the role of liquidity on banks' risk taking, financial performance, funding costs, probability of failure and credit risk, and by investigating stock market investors' perceptions on bank liquidity.

The first essay examines the relationship between funding liquidity and bank risk taking. Using quarterly data for US bank holding companies (BHC) from 1986 to 2014, we find evidence that banks with lower funding liquidity risk, as proxied by higher deposit ratios, take more risk. A reduction in banks' funding liquidity risk increases bank risk, as evidenced by higher risk-weighted assets, greater liquidity creation and lower z-scores. However, our results show that bank size and capital buffers usually limit banks from taking more risk when they have lower funding liquidity risk. Moreover, during the global financial crisis banks with lower funding liquidity risk took less risk. The findings of this study have implications for bank regulators advocating greater liquidity and capital requirements for banks under Basel III.

The second essay investigates the effects of liquidity creation on funding costs, profitability and market value in US bank holding companies. We find empirical evidence to suggest that bank liquidity creation lowers funding costs and improves BHC profitability and market value. However, our findings indicate that larger banks face higher costs of debt funding in response to higher liquidity creation due to their need for more expensive wholesale debt funding resulting in lower profitability and market values compared to smaller banks that remain reliant on deposit taking.

The third essay investigates the links between asset liquidity, funding stability and the adjusted market-to-book value of the equity of US bank holding companies. We find that a reduction in banks' liquidity risk destroys bank market value. However, a reduction in liquidity risk enhanced bank market value during the global financial crisis and the post-Basel III announcement period. Moreover, liquidity risk is inversely related to bank market value for large banks, for banks with higher capital buffers and for banks that are more profitable and

liquid. Our results indicate that there are direct regulatory costs arising from Basel III liquidity standards during normal times but the costs are lower during a financial crisis.

The fourth essay investigates the links between liquidity risk and credit risk in US commercial banks. High funding stability and low liquidity creation indicate low liquidity risk. We consider the probability of failure and credit default swaps (CDS) spreads as proxies of banks' credit risks. Using logit regressions, we find that a reduction in liquidity risk proxied by high funding stability and low liquidity creation reduces the probability of the failure of US commercial banks for the period from 2001–2014. We also find that increases in NSFR and decreases in the liquidity creation of banks that have low funding stability and high liquidity creation have a lower probability of failure. Using three-stage least squares (3SLS) simultaneous regressions, we find evidence that reductions in liquidity risk reduce banks' credit risk proxied by CDS spreads.

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1 Introduction

1.1 Background to the thesis

The global financial crisis that took place between 2007 and 2009 had a significant impact on the financial markets and highlighted the importance of liquidity in banking. Three hundred and eighteen US commercial banks failed between 2007 and 2010, and liquidity constraints were found to be a major contributor. The banking system came under pressure which led to a response from the central bank to support the functioning of markets and also to assist some individual institutions. Thus, on February 2008, the Basel committee publicised challenges arising from a lack of liquidity risk management and challenges in supervision. They highlighted that most banks had failed to manage the liquidity constraints associated with businesses and individual products.

Liquidity risk management is paramount because a single liquidity shortfall can have adverse consequences on a single institution. Recently, liquidity risk management in financial markets has increased in complexity. Banks like the JP Morgan succumbed to pressure after the consumer protection act was introduced in July 2010 and the Dodd-Frank Wall Street reforms were implemented. They have increased their liquid securities and cash holdings, mainly to address concerns regarding liquidity issues. Nonetheless, no one is sure whether the reforms suggested in the global Basel III rules, and the Dodd-Frank Acts, will stabilise the financial system. Thus, it is essential to understand fully the importance of the relationship between a bank's funding liquidity, bank risks and bank returns. Current global banking regulatory reforms are mainly focusing on making banks more liquid.

1.2 Definition of liquidity risk

Banks need to be able to finance assets and meet their obligations without experiencing losses. This is known as liquidity. Thus, banks are susceptible to liquidity risk since they play a critical role in transforming short-term deposits into long-term loans, which affects the institution. Virtually every transaction made in a bank has an effect on the bank's liquidity. Hence, a bank's ability to effectively manage liquidity risk and meet cash flow obligations depends on the

efficient management of liquidity. Liquidity risk has long been recognised as a significant threat to financial institutions management and financial system stability. Banks are generally advised to maintain a liquidity buffer for managing liquidity risk and to insure against small liquidity shocks. Drehmann and Nikolaou (2013) define funding liquidity risk as the failure of a bank to take care of urgent obligations. Banks are considering the option of having higher deposits to lower funding liquidity risk since this will mean they will have enough money to take care of their responsibilities and also that they will run less risk because of deposit insurance. Hong, Huang and Wu (2014) showed that systematic liquidity risk was an important contributor to bank failures in the 2009–2010 period in the aftermath of the 2007–2008 global financial crisis (GFC). They revealed that liquidity risk could lead to bank failures through systematic and idiosyncratic channels. Asset liquidity means banks maintain enough high-quality liquid assets to meet their obligations. Funding stability means banks reduce the mismatch of maturities between assets and liabilities. That is, long-term assets are financed by long-term sources of funds. This thesis will focus on bank funding stability.

1.2.1 Liquidity risk measures developed in the academic literature

Studies conducted to define the role of banks in the creation of liquidity, which leads to economic development, have a long history. This history goes back to the work of Adam Smith in 1776. Recently statistics showing the prominent role that banks play in liquidity creation have appeared in formal analysis done by Bryant (1980). The concepts used by Bryant (1980) propose that liquidity is created by banks through the funding of assets that cannot be cashed, with relatively liquid liabilities. Bryant (1980) also suggests that loan commitments can be used to create liquidity and liquid funds. The banks' roles in liquidity creation are well documented. A vast amount of literature is available showing the risks banks take, the supervision involved, and discipline in the market and regulations, all of which are meant to control risk-taking behaviour. Berger and Bouwman (2009) state that the way banks transform risk is by securing deposits which involve no risk in order to fund loans that do involve risk. The transformation of risk can go hand in hand with the creation of liquidity. For example, a bank may decide to acquire riskless deposits to fund illiquid, risky loans. Nonetheless, transformation and creation of liquidity are different, since the amount made after the creation of liquidity may differ considerably for every transformed risk. Liquidity creation can be part of consumer needs

(deposits and loans) and also consumer protection standards in an economy (i.e. consumers may not ask for this specifically but banks may have to meet regulator expectations).

1.2.2 Liquidity risk measures developed in the Basel III

After the brief crisis in 2008, the Basel III Committee established several standards meant to ensure the stable management of liquidity risk and its supervision. The first objective of the regulations introduced by the Committee was to make sure that banks could handle high liquidity risks by having enough high-quality liquid assets. Controlling the liquidity coverage ratio (LCR) can accomplish this. The LCR ensures that banks maintain a high liquidity in assets to meet their obligations. The second objective was to create additional incentives to enable banks to finance their operations with a stable cash source in a continuing process. The net stable funding ratio (NSFR) achieves the second objective; it executes a matching role to the liquidity coverage ratio by supporting a more stable funding of business activities and assets.

The Basel III LCR model's objectives are dependent on a bank holding enough high-quality and unencumbered liquid assets that are able to be easily converted into cash, thereby enabling it to meet its obligations under severe conditions. The LCR is the ratio of high-quality liquid assets to the total net cash outflows over a period of 30 days:

LCR= *Stock of high-quality liquid assets/ The total net cash outflows over the next 30 days* (1)

The standard requirement for banks is an LCR of at least 100%. An LCR value is dependent on assumptions used in calculating the high-quality liquid assets stock and the amounts of cash inflow and outflow. High quality liquid assets are divided into Level 1 and 2 assets. While making LCR calculations, it is mandatory to assume classifications on assets into Levels 1 and 2, their group weights and the rates of cash inflows and outflows for several liabilities and assets categories.

The liquidity coverage ratio is applicable to all banks that have $10 million or more in their balance sheets and assets. In addition, the ratio applies to every financial institution with US$250 billion or more in consolidated assets. Every bank must hold high-quality liquid assets such as cash, that are equal to or greater than their net cash outflows less the projected cash

inflows in a period of thirty days. This liquidity coverage regulation began in 2010. However, the full act was partially enforced in 2015. Thus, banks were from then on required to hold a particular amount in liquid assets. Consequently, banks are now unable to lend short-term loans

Under the Basel III regulations, Level 1 assets are those from the Federal Reserve Bank securities delivered by specific independent bodies and multilateral banks. Level 2A assets include securities insured by sovereign entities and securities issued by the United States government. Level 2B assets are the commonly traded policy stock and asset-grade corporate credit securities offered by non-financial institutions.

The NSFR's objective is to maintain stability in funding in the medium and long term. NSFR is defined as the ratio of the available stable funding (ASF) to the required stable funding (RSF). Under the Basel III liquidity rules, the NSFR should be at least equal to 100%. When making calculations, we need to make assumptions about the categories of unlike assets and liabilities and the weights assigned to different classifications. LCR and NSFR were introduced in 2010. We computed the relative measures of LCR and NSFR according to revised versions of the LCR and NSFR provided in January 2013 and 2014 respectively, by the Basel committee.

The NSFR contains internationally agreed definitions. However, some elements remain subject to national discretion meant to follow jurisdiction-specific regulations. Hence, there should be explicit national discretion and defined in every country's laws and regulations. One important supervisory approach is that the NSFR must follow supervisory assessment work. The people involved may require banks to adopt more rigorous rules that reflect their ability to meet set principles in compliance with their funding risk profiles.

The NSFR requires banks to maintain stability in the funding of their off balance sheet operations and assets. The regulations are also meant to reduce the over-reliance placed on the short-term financing and influences engagement in better risk assessment of financing and also promotes stability in the financing. During the global financial crisis, many banks experienced setbacks despite having met their capital requirements because they failed to manage their liquidity prudently. The global financial crisis led to a reduction in the importance of liquidity in banks and financial markets. Out of 475 failed banks 65 banks had minimum required capital during the period 2001-2014 in the quarter before failure. Therefore, banks failed for liquidity

shortfall as well. Prior to the crisis, financial markets were resilient, and funding was readily available. The rapid changes that took place in financial markets demonstrated how fast liquidity changes and how much time banks took to recover. Central banks were forced to intervene by providing financial support to some individual institutions since the banking system faced many challenges.

The problems that many banks were experiencing arose from a failure to follow basic rules in the management of liquidity. Thus, the Basel III Commission published the *Principles for sound liquidity risk management and supervision* in 2008. This is meant to help banks by promoting better risk management and oversight in funding liquidity risk. The Committee is actively involved in monitoring the implementation of these regulations by banks to make sure that they adhere to the set principles. The committee further introduced two minimum standards meant to help funding liquidity. These standards are designed to help banks achieve short-term resilience in their liquidity risk by making sure that they have enough high-quality liquid assets (HQLA) to help overcome a potential scenario of stress lasting about 30 days. Also, the Committee introduced the LCR (liquidity coverage ratio). This is meant to reduce funding risk for a long period by ensuring that all banks are able to fund their activities from stationary sources to overcome the risk due to stress in funding in the future. For this objective to be met, the net stable funding ratio was introduced in 2010, in which it was taken under review. The review was for addressing any unanticipated results from financial markets and the economy. Additionally, it was intended to improve the design of NSFR from many important issues.

Banks that are at high liquidity risk are the ones creating more liquidity. Whereas the NSFR reduces mismatch of maturity between assets and liabilities, liquidity creation increases the maturity mismatch. Thus, the creation of liquidity is opposite to the NSFR and LCR. According to Distinguin et al. (2013), requirements in deposit insurance and minimum liquidity protect banks from constraints brought about by liquidity. Regarding minimum liquidity prerequisites, the Basel Committee on Banking Supervision (BCBS) suggests two requirements of 100% for coverage on LCR and NSFR. This is meant to increase banks' asset liquidity and the stability of their financing.

Banerjee and Mio (2017) examine the effect of tighter liquidity regulation in the United Kingdom. They reveal that while banks have increased their high-quality liquid assets and non-financial deposits, they have also reduced short-term wholesale funding and intra-financial

loans. Due to tighter liquidity controls, banks no longer shrink their balance sheets and reduce non-financial loans. For the LCR to cover short-term cash overflows, it is mandatory for banks to maintain enough high-quality liquid assets. The NSFR also requires banks to make use of more stable funding sources and more high-quality assets (King (2013)). 60% of LCR was implemented on 1 January 2015 after which it increased by 10% annually. The NSFR will be carried out on 1 January 2018.

1.3 Liquidity risk literature

The risks associated with liquidity has been recognised for a long time as a great threat to institutions involved in managing finances and finance stability structures. Typically, most banks and financial institutions are advised to make use of liquidity buffers to manage risks in liquidity and provide insurance against small liquidity stocks. According to Hong, Huang and Wu (2014), systematic liquidity was a significant contributor to the bank failures that were experienced between 2009 and 2010, as a result of the 2007–2008 financial crisis. Moreover, they suggest that banks will fail if they face liquidity risks brought about by idiosyncratic and systematic channels. Agreeing to this, Acharya and Naqvi (2012), and Wagner (2007), make correct theoretical predictions on the impacts of short-term liquidity for banks taking risks and stability. Increases in bank risk will result from high levels of asset liquidity, and also high costs may be incurred by risky banks as seen in the recent banking crisis. Banks with lower funding liquidity risks are those with higher deposits, and deposits shield banks from risks. This, in turn, leads to a reduction in market discipline and to banks taking greater risks. In addition, Keeley (1990), states that deposit insurance leads to a lack of incentive meant to guard against risk after taking an excessive risk by banks responding to increases in deposits at the deposit insurer's cost. Deposit insurance acts like a contract giving the owner the right to sell the banks' assets.

Nonetheless, the effect of the new Basel III liquidity standards on market valuations of banks' equity is not clear. On the other hand, more liquid banks earn lower returns as a result of maintaining more high-quality liquid assets and incurring the higher costs of stable funding. Thus, markets may consider high NSFR and LCR banks to be less valuable due to their low returns. The much-anticipated tighter Basel III liquidity reforms may lead to large negative cumulative abnormal returns (Bruno, Onali and Schaeck (2016)). High stability in funding

reduces financial performance, increases interest expenses and reduces interest income (Dietrich, Hess and Wanzenried (2014)).

Until now, there has been little information on the effects of constraints on the creation of liquidity on bank funding costs, market value and profitability. In contrast, liquidity premium theory suggests that liquidity-creating banks earn higher returns on long-term assets and pay lower premiums for short-term funds. Nevertheless, suppliers of funds may consider that the creation of liquidity increases the credit risks of banks and so they may charge a higher premium for credit risk.

The LCR and NSFR will enhance the stability of the overall financial system. A factor that contributes significantly to bank failures is systematic liquidity risk, but the LCR and the NSFR had minor impacts on failures by banks during the 2007 and 2008 global financial crisis (Hong, Huang and Wu (2014)). Credit default swaps represent default-based information more efficiently than bond and stock markets, and the agencies responsible for ratings (Blanco, Brennan and Marsh (2005)). Leverage, some CAMELS indicators, risk-free rates, deposit insurance and stock market volatility determine global banks' credit default service spreads (Hasan, Liu and Zhang (2016)).

1.4 Objectives of this thesis

The objective of this thesis is to examine the effects of different liquidity risk levels on bank risk taking. We use quarterly data from United States bank holding companies between 1986 and 2014 to empirically test the effects of banks' funding liquidity risk on different proxies for bank risk taking. Following the findings of Acharya and Naqvi (2012), we use deposits relative to total assets as a proxy for funding liquidity risk, since deposits protect banks from run risk. Banks with more deposits are less likely to experience challenges in funding in the near future. Banks with higher deposits have lower funding liquidity risk. We will also examine the influence of banks' capital buffers and bank size on the relationship between funding liquidity risk and bank risk taking.

To answer some questions based on the impact of future regulation changes, we calculate the quarterly liquidity creation of United States bank holding companies between 1995 and 2014 using call report data. Thus, we investigate the effect of liquidity creation on banks' costs of funds, market values and profitability. The cost of banks' debt funding is represented by ratios of total interest expense to total liabilities and interest expenses on deposits to total deposits whereas profitability is represented by banks' net interest margin and return on equity, and value is represented by the adjusted market-to-book value of equity.

This study also uses historical data to calculate the LCR and NSFR for United States bank holding companies between 2001 and 2014, to examine the association between liquidity risk measures and banks' adjusted market-to-book values of equity. The Basel liquidity ratio metrics are applied in the study by looking at the past and examining how these representations of liquidity have been historically related to the market's evaluation of equity for banks.

This thesis also investigates the association between banks' liquidity risk and credit risk. We examined the weights used to calculate NSFR and whether they are correct. Using logit regressions, we discover that reductions in liquidity risk represented by high funding stability and low creations in liquidity reduced the probability of failure of Unites States commercial banks between 2001 and 2014. Using three-stage least-square simultaneous regressions, we discovered evidence that reductions in liquidity risk reduce banks' credit risks as represented by credit default service spreads. Our results are in agreement with the objectives of the Basel III liquidity measures that aim to improve funding stability by requiring high NSFR, and we found that low liquidity creation reduces banks' credit risks as represented by the probability of failure and credit default swap spreads.

Table 1.1 shows the research design of this thesis. In Chapter Two deposits are considered as the proxies of funding liquidity risk. Chapter Two provides empirical evidence that banks with lower funding liquidity risk, as proxied by higher deposits, take more risk. This is motivated by the theory developed by Acharya and Naqvi (2012) that banks with excessive deposits take more risk. The third chapter considers liquidity creation as a measure of bank liquidity risk and investigates the impact of liquidity creation on banks' costs of funds, profitability and market value. The fourth chapter investigates the impact of Basel III liquidity measures on banks' market values. The fifth chapter investigates the link between liquidity risk and credit risk.

Table 1.1: Research design of the thesis

Chapter	Liquidity measure	Objects	Dependent variable	Methodology	Data
2	Deposits	BHC	Bank risk	OLS, 2SLS	Federal reserve bank
3	Liquidity creation	BHC	Cost of funds, profitability, market value	3SLS	Federal reserve bank
4	LCR and NSFR	BHC	Market value	3SLS	Federal reserve bank
5	NSFR and Liquidity creation	Commercial banks	Probability of default, CDS spreads	3SLS, logit	Federal reserve bank, FDIC, Markit

1.5 Contribution to the literature

In the literature, bank risk has been measured in various ways. The primary focus is on the overall riskiness of banks and their asset risk. We consider alternative representations for every risk category. We examine z-scores and liquidity creation (financial intermediation risk) in addition to the standard deviation of bank stock returns for banks' overall risk levels. To measure the asset risks of banks, we consider the relative amounts of risk-weighted assets and loan loss provisions as they capture the quality of banks' assets. We make use of quarterly data from United States bank holding companies for the period between 1986 and 2014. To our knowledge, no prior study has empirically investigated the association between banks' funding liquidity risk and bank risk-taking while controlling for bank characteristics and macroeconomic changes over time.

Related to the free cash flow hypothesis developed by Jensen (1986) for companies, managers with free cash flows will make poor investments. We conduct a comprehensive examination of whether lower funding liquidity risk resulting from deposit taking may cause bank managers

to lend more aggressively, thereby increasing in the riskiness of banks. Because of the close attention paid to this issue in the banking literature, it requires a comprehensive investigation in light of the implications that regulatory liquidity requirements may present for financial system stability. There is some evidence in the literature to support a potentially adverse relationship between lower funding liquidity risk and bank risk. For instance, the technical evidence presented by Acharya and Naqvi (2012) shows that lower funding liquidity risk measured by deposits may lead to managers engaging in more aggressive lending practices. Similarly, Ivashina and Scharfstein (2010) reveal that banks with greater access to deposit funding during the 2007–2008 global financial crisis were willing to lend more than those that relied on short-term debt financing.

Also, Wagner (2007) developed a model that shows higher liquidity leads to increased banking system instability and increases in externalities related to bank failure. Furthermore, Altunbas, Gambacorta and Marques-Ibanez (2014) show that extended periods of relatively low interest rates encourage banks to take more risk. New empirical evidence is presented in this study to firmly indicate the substantial inverse relationship between banks' funding liquidity risk and bank risk-taking. Notably, we find evidence that supports Achrya and Naqvi's (2012) theoretical prediction that decreases in banks' funding liquidity risk, as represented by deposits, leads to increases in bank risk-taking.

Theoretically, an increase in deposit funding will lead to more aggressive lending (because high deposit levels allow banks to make more loans at lower interest rates). To support this statement, we see that increases in deposit funding are followed by increases in banks' risk-weighted assets and liquidity creation. Furthermore, an increase in deposit funding increases overall bank risk, as supported by lower z-scores of banks. Nonetheless, we find that to some extent, the size of banks and of capital buffers prevent banks from taking risks when they face lower liquidity risk funding. Related to our expectations, we also discover that banks that are subjected to greater monitoring have less scope to take more significant risks in response to lower liquidity risk funding as represented by deposits in the course of a crisis.

Policy makers have a clear implication of the findings, similar to market participants. A clearer understanding of the ramifications of banks' funding liquidity risk, bank size and capital levels on banks' risk-taking behaviours can help watchdogs to improve the banking regulatory agenda to better discipline and govern the behaviour of bank directors and enhance financial resilience.

Our findings support the new regulations under the Basel III for banks to use long-term funding sources to match their use of funds and hold more capital. We provide evidence that these measures will effectively help prevent bank risk taking.

The Bank of International Settlements (2010), acknowledges that the new standards might affect banks' performance by squeezing lending margins and reducing profitability. Banks may pass on the higher regulatory costs to borrowers by charging higher loan rates (Yan, Hall and Turner (2012)). Furthermore, Binsbergen et al. (2010) and Pasiouras and Kosmidou (2007) reveal that a bank's level of liquidity, banks' size and financial conditions may also affect the relationship between financial performance, market value, the cost of funds and liquidity creation. The empirical literature has focused on banks' roles as transformers of risk and liquidity creators. Consequently, although creating liquidity is important to banks, large empirical measures of bank liquidity creation are conspicuously absent.

In the extant literature, it is shown that many different variables can affect the market value of banks' equity (Calomiris and Nissim (2014); Caprio, Laeven and Levine (2007)), but no existing research investigates the relationship between liquidity risk and banks' market values of equity. To our knowledge, this is the first empirical study that studies the perception of stock market investors on banks' liquidity risk.

The risk involved is that it generates a failure to meet current financial obligations by banks because of a lack of funds or cash-equivalent assets. When more liquidity is created, more risk is involved and the greater the possibility and severity of losses due to being forced to cash illiquid assets in order to meet liquidity demands from depositors. Additionally, banks are also exposed to the risk of unexpected liquidity demands from their debtors.

Wagner (2007) reveals that people value money as a means of storing wealth and also use it for current investments. Thus, they tend to sacrifice the ability to earn interest and prefer having it on hand. In contrast, when interest rates increase, people are also willing to hold less money in order to secure profits. Acharya and Navqi (2012), show that when they are in need of money to spend or are anticipating future interest rates path, or people just hold money as a precaution for unseen future needs. These motives are known as precautionary and speculative motives for money demand. Banks' approaches to liquidity preferences are to pursue current balance sheet policies instead of the passive accommodation of the demand for credit.

1.6 Structure of the thesis

This thesis includes four essays. The first essay investigates the link between funding liquidity and the risk-taking behaviour of US bank holding companies. The second essay investigates the impact of liquidity creation on the cost of funds, and the profitability and the market values of US bank holding companies. The third essay investigates the impact of the Basel III liquidity measures, LCR and NSFR, on the market-to-book values of equity of US bank holding companies. The fourth essay investigates the association between banks' liquidity risk and credit risk. Liquidity risk is proxied by NSFR and liquidity creation whereas credit risk is proxied by probability of failure and CDS spreads.

The first essay examines the relationship between funidng liquidity risk and bank risk-taking. We use quarterly data from United States bank holding companies between 1986 and 2014 to reveal that banks having lower funding liquidity risk, as represented by higher deposit ratios, take more risk. A decrease in banks' funding liquidity risk increases bank risk-taking, as evidenced by higher risk-weighted assets, lower z-scores and greater liquidity creation.

The results support a partial appreciation of increased bank liquidity by investors and may smooth out bank valuations over the course of the business cycle. Moreover, financial system resilience may be improved as systemic risk is likely to be reduced by encouraging greater liquidity for larger banks and prudent banking may be encouraged by improving market valuations for banks with higher capital buffers, profitability and liquidity.

In the literature, the main focus is on the overall riskiness of banks and their asset risk. We take into consideration alternative proxies for each risk category. For banks' overall risk, we examine their distance to default, financial intermediation and the standard deviations of bank stock returns. We use relative amounts of risk-weighted assets and loan loss provisions to measure banks' assets. Using quarterly data from United States bank holding companies between December 1986 and December 2014, we study the relationship between banks' funding liquidity risk and bank risk-taking while controlling for bank characteristics and macroeconomic changes over time.

We conduct comprehensive research on whether lower funding liquidity risk resulting from deposit taking will cause bank managers to lend more aggressively and thus increase the

riskiness in banks. As there is a dearth of attention on this issue in the banking literature, it warrants a thorough investigation in light of the implications that regulatory liquidity requirements may have for financial system stability. The model of Wagner (2007) shows that high liquidity increases banking system instability and the externalities related to bank failure. Furthermore, extended periods of relatively low interest rates have been shown by Altunbas, Gambacorta and Marques-Ibanze (2014) to encourage banks to take more risk. The new empirical evidence we present in this study strongly indicates a substantial inverse association between banks' funding liquidity risk and bank risk-taking.

In the second essay, we calculate the quarterly liquidity creation of US bank holding companies for the period 1995–2014 using call report data. We investigate the effect of liquidity creation on banks' costs of funds, profitability and market values. Banks' cost of debt funding is proxied by the ratios of total interest expense to total liabilities and interest expenses on deposits to total deposits, whereas profitability is proxied by banks' net interest margin and return on equity, and value is proxied by the adjusted market-to-book value of equity. We find evidence that banks experience lower funding costs but higher profitability and market values in response to liquidity creation. Moreover, larger banks face higher funding costs, profitability and market values in response to increases in liquidity creation. Banks with excessive liquidity creation face lower costs of debt funding, profitability and value, as do all banks during financial crises.

The third essay uses historical data to calculate the Basel III liquidity measures (LCR and NSFR) for US bank holding companies from 2001 to 2014 in order to examine the relationship between these liquidity risk measures and banks' market-to-book values of equity. We apply the Basel III liquidity measures metric by looking back in time and examining how these proxies for liquidity risk have been historically related to banks' market valuation of equity. Using 3SLS simultaneous equations to capture reverse causality, we present empirical evidence in this study that reductions in liquidity risk destroy the banks' adjusted market-to-book values of equity. A decrease in a bank's liquidity risk harms its financial performance, which reduces its market value. However, larger banks and banks having higher capital buffers, profitability and liquidity derive benefits from their higher market-to-book values of equity while they reduce liquidity risk. Our results are consistent with the existing literature in that the market value of equity is positively related to size, capital, profitability and the level of liquidity risk

(Bertay, Demirgüç-Kunt and Huizinga (2013); Calomiris and Nissim (2014); Cornett, McNutt, Strahan and Tehranian (2011); Cummins, Lewis and Wei (2006); Lindquist (2004)). We also find that during the global financial crisis and in the post-Basel III announcement period, the market-to-book value of equity increased in response to higher Basel III liquidity measures which is consistent with the existing literature (Bai, Krishnamurthy and Weymuller (2016); Parwada, Lau and Ruenzi (2015); Roggi and Giannozzi (2015)). These results indicate that the liquidity shortfalls of banks during the global financial crisis caused investors to pay more attention to liquidity risk, such that investors considered banks with low liquidity risk to be more valuable. Our findings are consistent with the prediction that tighter liquidity standards impair banks' financial performance (Basel Committee on Banking Supervision (2016)).

The fourth essay investigates the link between banks' liquidity risk and credit risk. We also investigate whether the weights used to calculate NSFR are appropriate. Using logit regressions, we find that reductions in liquidity risk proxied by high funding stability and low liquidity creation, reduced the probability of the failure of US commercial banks for the period from 2001 to 2014. We also find that increases in NSFR and decreases in the liquidity creation of banks with low funding stability and high liquidity creation have a lower probability of failure. Using 3SLS simultaneous regressions, we find evidence that reductions in liquidity risk reduce banks' credit risk proxied by CDS spreads. Our findings are consistent with the objective of the Basel III liquidity measures that improved funding stability by high NSFR, and low liquidity creation reduces banks' credit risk proxied by the probability of failure and CDS spreads.

2 Funding liquidity and bank risk taking[1]

2.1 Introduction

Bank liquidity has become an important focus of financial regulatory reforms since the dangers of liquidity crunches became all too apparent in the recent Global Financial Crisis (GFC). In response to ongoing regulatory pressure and the introduction of the Dodd-Frank Wall Street Reform and Consumer Protection Act in July 2010, large US banks like JP Morgan Chase increased the amount of liquid securities and cash they held in an effort to allay concerns about liquidity risks. However, it is uncertain whether the new emphasis on funding liquidity requirements suggested in the new Basel III guidelines globally and in the Dodd-Frank Act within the US will make banks less risky and the whole financial system more stable going forward. Therefore, better understanding the potential relation between banks' funding liquidity risk and their risk-taking behaviour is of paramount importance when current regulatory reforms in global banking regulation have focused on getting banks to become more liquid than they have been in the past.

Liquidity risk has long been recognized as a significant threat to financial institutions management and financial system stability. Banks are generally advised to maintain a liquidity buffer for managing liquidity risk and to insure against small liquidity shocks. Recently, Hong, Huang and Wu (2014) showed that systematic liquidity risk was an important contributor to bank failures occurring over 2009–2010 in the aftermath of the 2007–2008 GFC. They revealed that liquidity risk could lead to bank failures through systematic and idiosyncratic channels. Corroborating with this, the theoretical predictions of Acharya and Naqvi (2012) and Wagner (2007) on the implications of short-term liquidity for bank risk taking and bank stability suggest that high levels of asset liquidity can potentially increase bank risk and warrants further attention given the significant welfare costs that risky banks may pose as witnessed in recent banking crises. Deposits shield banks from "run" risk and banks with higher deposits have less funding liquidity risk, which in turn reduces market discipline and leads to greater risk taking

[1] This chapter has been published in the *Journal of Banking and Finance*. We thank our anonymous referee, Viral Acharya, Kose John, Iftekhar Hasan, Gerhard Hambusch, Tony He, Ralf Meisenzahl, Qing He, Xin Liu, Phong Ngo and seminar participants at the University of Technology Sydney and University of Sydney for useful comments on earlier drafts. We also wish to thank conference participants at the 27th Australasian Finance and Banking Conference, the Third Fordham-JBF Banking Conference and 2015 FIRN/ANU Banking and Financial Stability Meeting for their useful suggestions that have helped to improve the paper. All errors remain our own.

by banks.[2] Moreover, deposit insurance creates a moral hazard for excessive risk taking by banks in response to increases in deposits at the cost of the deposit insurer (Keeley (1990)). Deposit insurance acts like a put option on the banks' assets. Drehmann and Nikolaou (2013) define funding liquidity risk as the banks' failure to settle obligations immediately and measure funding liquidity risk based on banks' aggressive bidding at central bank auctions to secure liquidity. We are considering banks having higher deposits to have lower funding liquidity risk because these banks will have enough funds to settle their obligations and there is less "run" risk in the presence of deposit insurance.

The objective of this study is to examine the impact of varying funding liquidity risk on bank risk taking. Using quarterly data for US bank holding companies from 1986 to 2014, we empirically test the impact of banks' funding liquidity risk on various proxies for bank risk taking. Following Acharya and Naqvi (2012) we consider the amount of deposits relative to total assets as our proxy for banks' funding liquidity risk because deposits shield banks from "run" risk. Banks having excessive deposits are less likely to have funding shortfalls in the near future, and bank managers will take more risk. We consider banks having higher deposits have lower funding liquidity risk. We also examine the influence of banks' capital buffers and bank size on the funding liquidity risk and bank risk relation.

Bank risk has been measured in the literature in many different ways. We focus specifically on the overall riskiness of banks and their asset risk. We consider alternative proxies for each risk category. For banks' overall risk, we examine the Z-scores (a measure of their distance to default), liquidity creation (financial intermediation risk) as well as the standard deviation of bank stock returns. To measure banks' asset risks, we consider the relative amounts of risk-weighted assets as well as loan loss provisions as they capture banks' asset quality. We use quarterly data for US bank holding companies for the time period from December 1986 to December 2014. To the best of our knowledge, no prior study has empirically investigated the relationship between banks' funding liquidity risk and bank risk taking while controlling for bank characteristics and macroeconomic changes over time.

[2] We are grateful to Viral Acharya for pointing this out.

Akin to the free cash flow hypothesis developed by Jensen (1986) for corporations, managers having free cash flows will make poor investments. We examine comprehensively whether lower funding liquidity risk resulting from deposit taking will cause bank managers to lend more aggressively and ultimately increase the riskiness of banks. As there is a dearth of attention on this issue in the banking literature, it warrants a thorough investigation in light of the implications that regulatory liquidity requirements may present for financial system stability. There is some evidence in the extant literature to support a potential adverse relationship between lower funding liquidity risk and bank risk. For example, Acharya and Naqvi (2012) present theoretical evidence to show that lower funding liquidity risk measured by deposits can induce bank managers to engage in more aggressive lending practices. In line with this view, Ivashina and Scharfstein (2010) revealed that banks with greater access to deposit funding during the 2007–2008 international financial crisis were willing to lend more than those that relied more on short-term debt financing. Similarly, Wagner (2007) developed a model showing that higher liquidity can increase banking system instability and the externalities related to bank failure. Moreover, extended periods of relatively low-interest rates have been shown by Altunbas, Gambacorta and Marques-Ibanez (2014) to influence banks to take more risk.

We present new empirical evidence in this study that strongly indicates a significant inverse relationship between banks' funding liquidity risk and bank risk-taking. In particular, we find evidence to support Acharya and Naqvi's (2012) theoretical prediction that decreases in banks' funding liquidity risk as proxied by deposits leads to an increase in bank risk. In theory, an abundance of deposit funding spurs more aggressive lending (that is, allows banks to make more loans at lower interest rates). In support of this, we find that an increase in deposit funding is consistently followed by an increase in banks' risk-weighted assets and liquidity creation. Moreover, an increase in deposit funding increases overall bank risk as evidenced by lower Z-scores. However, we find that bank size and capital buffers impede banks to some extent from taking more risk when they face lower funding liquidity risk. Consistent with expectations, we also find that in times of financial crises, banks when they are subjected to greater monitoring have less scope to take greater risks in response to lower funding liquidity risk as proxied by deposits.

There are clear implications of our findings for policymakers and market participants alike. A clearer understanding of the ramifications of banks' funding liquidity risk, bank size and capital levels on banks' risk-taking behaviour can help regulators to improve the banking regulatory framework to better discipline and control the behaviour of bank managers and to enhance financial resilience going forward. Our findings are supportive of the new requirements under Basel 3 for banks to use longer term funding sources to match their use of funds and to hold more capital going forwards as these measures will effectively help to curb bank risk taking.

The remainder of this paper is organised as follows. Section 2 summarises the theoretical motivations for examining funding liquidity and bank risk taking. Section 3 explains our key hypotheses. Section 4 describes the data used. Section 5 presents our empirical models before results are discussed in Section 6. Finally, conclusions are provided in Section 7.

2.2 Theoretical motivation

Our empirical analyses are well supported by existing theoretical frameworks in the literature. First, Acharya and Naqvi (2012) theoretically show that when banks have lower funding liquidity risk as a result of large amounts of deposit inflows, bank managers have the incentive to take more risk by aggressively lowering the lending rate to increase loan volumes in order to enhance their own compensation. Banks with more deposits may lower lending standards because bank managers' compensation could be partially based on the amount of loans that is used as a benchmark for managerial performance or alternatively long-term risks created may not be considered for managers' compensation. Banks only perform the costly audit to investigate managers' decisions regarding the lending standard if the funding liquidity deficit experienced by the bank is sufficiently large. Hence, excess deposits make bank managers overconfident that banks will not face a funding liquidity crisis shortly and their lending practices will not be questioned. Banks may face a capital shortfall from losses in relation to aggressive lending which may in turn trigger bank failure.

In a related vein, Cheng, Hong, and Scheinkman (2015) show that based on classical principal-agent theory, risk-averse managers require higher compensation levels to work in riskier financial firms as they face greater uncertainty in their wealth. Hence, in order to achieve the higher compensation levels required by managers to work in riskier banks, they may also be

given more leeway to pursue aggressive lending strategies when liquidity is in abundance. We develop our core hypotheses in the subsequent section.

2.3 Hypothesis development

Liquidity risk and bank risk

It has been recognised that liquidity risk and credit risk of banks do not have contemporaneous or causal relations, but both of the risks individually and jointly contribute to banks' probability of default (Imbierowicz and Rauch (2014)). Consistent with this view, Hong, Huang and Wu (2014) find that systemic liquidity risk is an important contributor to bank failures. Vazquez and Federico (2015) find that higher funding stability as measured by the net stable funding ratio featured in the new Basel III guidelines, reduces the probability of bank failures. King (2013) recognises that to maintain a higher net stable funding ratio, banks will have to pay higher interest expenses for borrowing more long-term funds. In this way, liquidity regulation can adversely affect bank profitability and increase bank risk despite the associated public sector gains from the reduction in disruptive bank failures across the society.

Deposit insurance is considered as a put option on the value of banks' assets at a strike price of the face value of its liabilities (Merton (1977)). Banks can obtain funds at or below the risk-free rate by issuing insured deposits and investing the proceeds in risky assets. We have shown in figure 1 that during the recent financial crisis flight to safety took place and deposits increased as investors preferred bank deposits instead of risky direct investments. Deposit insurance creates a moral hazard for excessive risk-taking by banks (Keeley (1990)). Hence, banks having excessive deposits can take more risk at the cost of the deposit insurer. Diamond and Dybvig (1983) show that deposit-taking exposes banks to funding liquidity risk which may cause bank runs. Depositors make withdrawals at random, and central banks act as lenders of last resort if the deposit withdrawal is larger than banks' liquidity buffers. Banks having excessive deposits are less likely to have a "run" because these banks face lower funding liquidity risk in the presence of deposit insurance. Repullo (2005) develops a model showing that the risk taking of banks increases if the lender of last resort charges higher penalty rates for borrowing from the central bank.

Funding liquidity risk is negatively related to market liquidity (Drehmann and Nikolaou (2013)). Banks need to hold a certain portion of deposits as their liquidity reserve with the central bank in the form of high-quality liquid assets. Funding liquidity levels fluctuate for banks over time, and there are concerns that high liquidity levels can lead to financial crises. In analysing aggregate financial sector liquidity, Adrian and Shin (2010) note that in order to utilise the excess capacity that comes about from balance sheet growth, financial intermediaries will search for potential borrowers even when borrowers do not have the resources to repay the loan and thus higher levels of aggregate liquidity can cause financial crises. Wagner (2007) theoretically models the relationship between the liquidity of bank assets and banking stability and finds that an increased liquidity of bank assets reduces banking stability during financial crises but not during normal times.

Increases in liquidity within the banking sector can arise from increases in interest rates via changes in monetary policy. Lucchetta (2007) shows that banks take more risk when risk-free interest rates increase as there is greater investment in risk-free bonds, which increases liquidity supply in the interbank market and encourages more interbank lending. The increased liquidity supply also boosts other banks' investment in risky assets. Hence, both the theoretical and empirical literature suggests that banks' funding liquidity risk is closely related to bank risk-taking and our first hypothesis is consistent with Acharya and Naqvi's (2012) prediction:

Hypothesis 1: Banks facing lower funding liquidity risk will have incentives to take more risk

Bank capital

Capital buffers reduce the banks' probability of default. Hence banks holding more risky asset portfolios maintain higher capital buffers to face lower default risk (Shim (2013)). Therefore, maintaining higher capital buffers is an indication of holding risky asset portfolios and these banks may not invest aggressively. Bank's risk and capital relation can be negative or positive depending on the relative forces of the deposit insurer, the shareholder and the manager (Jeitschko and Jeung (2005)). Shareholders of well-capitalized banks may prefer less risky asset portfolios because they will lose more in the case of default (Jeitschko and Jeung (2005)). A manager concerned about his/her loss of the private benefits of control in the case of default will prefer to take less risk with higher capitalization (Jeitschko and Jeung (2005)). Risk-based capital requirements induce banks to reduce bank lending which is one of the risky activities

of banks (Thakor (1996)). Inefficient European banks that held more capital were revealed to have taken less risk prior to recent banking crises (Altunbas, Carbo, Gardener and Molyneux (2007)). Shareholders of banks holding higher capital will face losses in the case of default, which in turn induces well-capitalized banks to take less risk (Repullo (2004)). Distinguin et al. (2013) examined the relation between bank regulatory capital and bank liquidity. They argue that banks reduce their regulatory capital when they have a greater involvement in liquidity creation and are faced with a lower net stable funding ratio. Moreover, illiquidity causes smaller US banks to strengthen their solvency standard which is expected given that illiquid banks and illiquid customers can create sufficiently large withdrawals that result in bank runs and bank failure (Carmona (2007)). Nonetheless, if banks reduce their capital holdings in times of higher liquidity creation and lower their net stable funding, bank riskiness should be dependent on both capital and funding liquidity.

Konishi and Yasuda (2004) find that the implementation of capital adequacy requirements has reduced risk taking by commercial banks. Similarly, Repullo (2005) finds that bank risk taking is negatively related to capital requirements. Calem and Rob (1999) in fact find the relation between capital and bank risk-taking is U-shaped as severely under-capitalized banks do experience a risk reduction when bank capital increases but in well-capitalized banks, bank risk actually increases in the long run in response to more bank capital. However, other studies have argued that as capital regulation induces banks to increase capital to avoid incurring penalties for violating minimum capital requirements, increasing bank capital actually has the desired effect in reducing bank risk (Furlong and Keeley (1989); Lee and Hsieh (2013); Zhang, Wu and Liu (2008)). In support of the risk reduction view, Hyun and Rhee (2011) provide evidence to show that banks typically reduce high-risk assets instead of issuing new equity to meet higher capital ratios.

Yet, it has also been documented that the size of capital buffers is not significantly related to the riskiness of Canadian banks (Guidara, Lai, Soumaré and Tchana (2013)). Moreover, Jokipii and Milne (2011) provide evidence to show that banks with smaller capital buffers reduces their riskiness by topping up their capital buffers. However, banks usually hold a capital buffer to avoid the penalties associated with a regulatory capital shortfall, and Lindquist (2004) find that a bank's capital buffer is negatively related to the risk of savings banks. US bank holding companies set target capital ratios significantly higher than the minimum regulatory capital requirements but reduced their target ratios during the period from 1992 to 2006 and became

less capitalised prior to the onset of the 2007–2008 financial crisis (Berger, DeYoung, Flannery, Lee and Öztekin (2008)). Overall, the literature indicates that banks with larger capital buffers are less willing to take risks compared to those that are not well capitalised.

Hypothesis 2: Banks with higher capital buffers take less risk in response to lower funding liquidity risks

Bank size

We expect that bank size should have an impact on -banks' risk-taking behaviour. It has been established in the banking literature that large banks are not necessarily riskier as Bertay et al. (2013) revealed, bank size is not related to bank risk as measured by the Z-scores. Big banks have a greater ability to generate funds in the form of non-deposit or wholesale funding (Bertay, Demirgüç-Kunt and Huizinga (2013)). Earlier on, Demsetz and Strahan (1997) also showed that increases in banks' total assets reduce firm-specific risk and is positively related to diversification. Similarly, larger banks take less risk as bank size increases banking stability as evidenced by higher Z-scores (Mercieca, Schaeck and Wolfe (2007); Stiroh (2004)). The implementation of Basel II pushed the smaller banks to take more risk compared to larger banks because larger banks have the option to choose between the Standardized and Internal Ratings Based Approach (Hakenes and Schnabel (2011)). Moreover, Boyd and Runkle (1993) found bank size is negatively related to the volatility of asset returns. Thus, larger banks with a lower volatility of asset returns should convey lower risk profiles. More recently, bank size has also been shown to be negatively related to earnings volatility, and this relation was stronger during the international financial crisis (De Haan and Poghosyan (2012)). Hence, the existing literature suggests that larger banks are less prone to taking on more risk in response to lower funding liquidity risk.

Hypothesis 3: Larger banks take less risk in response to lower funding liquidity risk

Global Financial Crisis

Delis, Hasan and Tsionas (2014) recently documented that the riskiness of US banks was reasonably steady up to 2001 then increased sharply prior to the onset of the international financial crisis of 2007–2008. Cornett et al. (2011) uncovered that during the financial crisis of 2007–2009 banks with more illiquid asset portfolios cut back on lending and that banks

increased the holding of liquid assets in response to the liquidity injections made by the Federal Reserve Bank. Given the financial turmoil during this period, US banks lifted deposit rates (Acharya and Mora (2015)) to substitute wholesale funding constraints, and they experienced rising deposit ratios as investors became reluctant to make risky investments and instead preferred to hold liquid assets like bank deposits. Banks reduced their new loans to large customers significantly during the peak of the recent financial crisis (fourth quarter of 2008) (Ivashina and Scharfstein (2010)). Hence, we expect that banks took less risk in response to lower funding liquidity risk during the recent financial crisis even when bank deposits increased due to a flight to safety response as bank managers were subjected to greater monitoring and market discipline.

Hypothesis 4: Bank risk decreased in response to reductions in funding liquidity risk during the Global Financial Crisis

2.4 Data

We use US Bank Holding Company (BHC) data from Y-9C forms provided by the Federal Reserve Bank of Chicago since 1986. All BHCs have to file Y-9C forms on a quarterly basis. BHCs with total consolidated assets of $500 million or more and meeting certain criteria have to file a Y-9C form. The Y-9C reports collect basic financial data from banks on a consolidated basis in the form of a balance sheet, an income statement, and detailed supporting schedules. We exclude bank-quarters with missing information on total assets and total deposits of the banks. Quarterly data for the sample period from 1986:Q4 to 2014:Q4 is used in this study. The final data set contains 166,567 bank-quarters for 4,749 unique BHCs. Stock prices of BHCs have been obtained from the Center for Research in Security Prices (CRSP). To address the outlier problems, all variables except the macroeconomic factors have been winsorized at the 5th and 95th percentile which is widely adopted in the literature (Acharya and Mora (2015); Beltratti and Stulz (2012); Berger and Bouwman (2009)).[3] Outlier values may be incorrect and may distort the relation if they are not removed from our analyses.

[3] We found qualitatively similar results if the variables have been winsorized at the 1st and 99th percentile.

The data sources for all variables used in this study are shown in Appendix 2.A. Descriptive statistics for our winsorized sample of BHCs used in the regressions are reported in Table 2.1. The average natural logarithm of the Z-scores for the sample of BHCs is 5.1789. On average, the deposits, risk-weighted assets, and liquidity creation for our sample of BHCs constitute 82.15%, 69.89% and 14.47% of total assets respectively. For the average BHC in the sample, the loan loss provisions represent 0.08% of total assets. The standard deviation of stock returns for the sample of BHCs is 2.45%.

<Insert Table 2.1>

Table 2.2 reports the pair-wise correlation coefficients of the variables used in this study. We do not find the bank variables employed as explanatory variables to be highly correlated indicating that multicollinearity is not a major issue in our empirical analyses. The correlation coefficients of the bank risk proxies, ratios of risk-weighted assets to total assets, loan loss provisions to total assets and liquidity creation to total assets, with the proportion of total deposits to total assets are -0.01, -0.04 and 0.33, respectively. The correlation coefficient of the natural logarithm of the Z-score and stock return volatility with the ratio of total deposits to total assets are -0.03 and 0.04, respectively.

<Insert Table 2.2>

Figure 2.1 shows that US bank deposits increased during the GFC, in part due to the effect that increases in macroeconomic risk induce investors to make more bank deposits rather than to invest directly in riskier securities. This is consistent with a flight to safety by US investors. Figure 2.1 shows that the full sample period for which we have data on BHCs can be divided into three sub-periods with distinct trends in the deposit to asset ratio that define three separate liquidity regimes in the US banking sector. The aggregate deposit-to-asset ratio for all US BHCs remained stable from 1986:Q4 to 1992:Q4, decreased from 1993:Q1 to 2008:Q2 and increased from 2008:Q3 to 2014:Q4. We term the latter period of deposit growth from 2008:Q3 to 2014:Q4 as the post-GFC high liquidity regime. Figure 2.1 is consistent with the existing literature that during the global financial crisis a ‘flight to safety’ took place and investors preferred to deposit funds in banks instead of investing in risky securities (Acharya and Mora (2015)).

<Insert Figure 2.1>

2.5 Model

In order to test the impact of banks' funding liquidity risk on the risk-taking behaviour of banks, we use a panel regression with heteroskedasticity robust standard errors. The empirical model includes a number of control variables for bank characteristics and activities, which may influence the risk-taking behaviour of banks. Bank and time specific effects are captured by introducing bank and quarter dummies, respectively. Time dummies capture macroeconomic effects over time.

The baseline model developed to test the impact of funding liquidity risk on bank risk taking is:

$$Risk_{i,t} = \alpha\ Liquidity_{i,t-1} + \beta\ Controls_{i,t-1} + \gamma_i + \delta_t + \varepsilon_{i,t} \quad (1)$$

where α , β , γ , and δ reflect the extent to which the relative factor contributes to the change in the dependent variable, and $\varepsilon_{i,t}$ represents the error term for bank *i* in quarter *t*.

The dependent variable, Risk is the vector of alternative bank risk variables for bank *i* in quarter *t*. Bank risk has been measured by the ratios of risk-weighted assets to total assets, loan loss provisions to total assets, liquidity creation to total assets, the natural logarithm of the Z-score, and the standard deviation of banks' stock returns. Our choice of bank risk proxies is guided by Cebenoyan and Strahan (2004). More recently, the Z-score has been used by Houston et al. (2010) to measure bank risk taking in a cross-country study to show that creditor rights and information sharing are related to risk-taking and have real implications for spurring economic growth.

The independent test variable*, Liquidity* is the funding liquidity risk measure for bank *i* in quarter *t-1*. We are assuming a lagged relation between funding liquidity risk and bank risk, i.e., a decrease in the funding liquidity risk increases the risk-taking of banks in the next period. We use the ratio of total deposits to total assets as our proxy for banks' funding liquidity risk following Acharya and Naqvi (2012) who argue that excessive deposits will induce bank managers to take more risk. Banks having more deposits have lower "run" risk, and managers will take more risk because these banks are less likely to face a funding crisis in the near term.

The *control variables* are bank characteristics for bank *i* in quarter *t-1*. The list of control variables for bank characteristics and activities used in this study are commonly adopted in the literature. Consistent with Casu et al. (2011), Distinguin et al. (2013), Gonzalez (2005), Laeven and Levine (2009), Lee and Hsieh (2013), Ramayandi et al. (2014), Rime (2001) and Shrieves and Dahl (1992) we consider the natural logarithm of total assets (Asset), as well as the ratios of total loans to total assets (Loan), total equity to total assets (Equity) and return on assets (ROA) as potential determinants of bank risk.

It should be stressed that in the model specifications using Z-scores, total equity to total assets and return on assets are not considered as control variables because the Z-scores are a function of these two variables and would lead to spurious results. We also included some macroeconomic factors in our panel regression namely the interbank deposit rate spreads (IBSpread), the growth rate of the real gross domestic product (GDP), unemployment rate (Unemploy) and changes in the house price index (House) to investigate the relation between banks' funding liquidity risk and risk taking.

We extend the baseline model to test the relationship between funding liquidity risk and bank risk for banks with high capital buffers, large banks, banks with high levels of deposits and during the GFC sub-period:

$$Risk_{i,t} = \alpha_1 Testdummy_{i,t-1} \times Liquidity_{i,t-1} + \alpha_2\ Testdummy_{i,t-1} + \alpha_3\ Liquidity_{i,t-1} + \beta Controls_{i,t-1} + \gamma_i + \delta_t + \varepsilon_{i,t} \quad (2)$$

We use *testdummy* to capture the effects of both bank types and sub-periods. Firstly, *HCB* is an indicator variable taking on a value of 1 for the top quartile banks in terms of the size of their capital buffers in each quarter and zero otherwise whilst *Big* is an indicator variable taking on a value of 1 for the banks in the top quartile by total asset value in each quarter and zero otherwise. All banks report their risk-based capital from 1996:Q1. The size of capital buffers is measured as banks' regulatory capital in excess of the minimum required regulatory capital. Secondly, *GFC* is an indicator variable taking a value of 1 for the sub-period from 2007:Q1 to 2010:Q1 when liquidity was injected by the Federal Reserve through the Term Auction Facility program, and zero for other times. Thirdly, *HL* is an indicator variable taking on values of 1 for banks in the top quartile by the ratio of total deposits to total assets and zero otherwise.

Ratios of balance sheet and income statement items relative to total assets are used in order to account for bank heterogeneity. Because of the high skewness of the Z-scores, we follow the literature and employ the natural logarithm of the Z-scores to measure overall bank riskiness (Laeven and Levine (2009)). The regression model also includes γ_i and δ_t to account for omitted bank-specific and time fixed effects, respectively. The robust error term ε is clustered at the bank-level and allowed to be heteroskedastic and autocorrelated.

2.5.1 Proxies for banks' funding liquidity risk

Acharya and Naqvi (2012) predict that banks having lower funding liquidity risk as measured by higher deposits will take more risk. They consider deposits as a measure of banks' funding liquidity risk because deposits shield banks from "run" risk. Banks need to maintain a certain fraction of deposits as liquidity reserves. We use deposits to measure banks' low funding liquidity risk as a greater reliance on deposits to fund long-term assets makes banks less vulnerable to deposit runs in the near term. Deposits are insured, and deposit insurance acts as a put option on the assets of banks. Hence, banks take more risk in response to increases in deposits due to the deposit insurance in place.

2.5.2 Proxies for bank risk

Bank asset risk

Risk-weighted assets are widely used in the literature as a proxy for bank risk (Delis, Hasan and Tsionas (2014); Jokipii and Milne (2011); Rime (2001); Stolz and Wedow (2011); Zhang, Wu and Liu (2008)). We consider the ratio of risk-weighted assets to total assets as a proxy for bank risk as this is a key credit risk measure under the Basel accords. Risk-weighted assets have been calculated according to Basel rules for capital regulation as regulatory capital charges are based on banks' risk-weighted assets. Hence, banks' risk-weighted assets is a relevant measure of their asset quality and in turn riskiness. All banks report their risk-weighted assets from 1996:Q1.

Loan loss provisions capture the asset quality of banks (Delis, Hasan and Tsionas (2014); Lee and Hsieh (2013)). Banks have to maintain loan loss provisions if there is a possibility of loan impairments. Hence, higher loan loss provisioning indicates that banks are taking on more risky assets. Cebenoyan and Strahan (2004) use the standard deviation of the ratio of loan loss provisions to total loans to measure bank risk. Shrieves and Dahl (1992) emphasise that loan loss provisions in a given year reflect investment decisions made in preceding years. Hence, loan loss provisions can also reflect the aggressiveness of banks' lending decisions.

Overall bank risk

We use the Z-score to measure the overall risk of banks. A higher Z-score value indicates greater bank stability. Z-scores are equal the return on assets plus the capital-to-asset ratio divided by the standard deviation of asset returns. It represents the number of standard deviations below the mean by which profits would have to fall so as to deplete the bank's equity capital (Houston, Lin, Lin and Ma (2010)). In this way, the Z-score measures the distance from insolvency (Laeven and Levine (2009)). The Z-score has been widely used in the recent literature for measuring bank risk (Delis, Hasan and Tsionas (2014); Houston, Lin, Lin and Ma (2010); Laeven and Levine (2009); Ramayandi, Rawat and Tang (2014)) and is computed as follows:

$$Z - scores = \frac{Return\ on\ Asset + (Equity/Asset)}{Standard\ Deviation\ of\ Return\ on\ Asset} \quad (3)$$

We calculated the standard deviation of asset returns using 1-year rolling windows[4].

Berger and Bouwman (2009) introduce a measure for banks' liquidity creation, which effectively measures the extent to which banks finance relatively illiquid assets with relatively liquid liabilities. Banks are exposed to financial intermediation risk because of their unique role in financial intermediation, which creates an inherent mismatch in the maturities of banks' assets and liabilities. Hence, banks creating more liquidity are taking more financial intermediation risk. Liquidity creation has been widely used in the literature as a measure of banks' liquidity risk (Berger and Bouwman (2009); Berger, Bouwman, Kick and Schaeck (2016); Distinguin, Roulet and Tarazi (2013); Horváth, Seidler and Weill (2014)). Liquidity creation considers a large number of banks' balance sheet items which are shown in Appendix

[4] We also used 2-year, 3-year and 5-year rolling windows for calculating the standard deviation of asset returns for the Z-score but the results are qualitatively similar.

2.B. Specifically, we follow Berger and Bouwman (2009) to compute liquidity creation as follows:

Liquidity Creation=0.5 × Illiquid Assets+0.5 × Liquid Liabilities-0.5 × Liquid Assets-0.5×Illiquid Liabilities-0.5×Equity (4)

We also consider a market-based assessment of overall bank risk as measured by the standard deviation of bank stock returns. Quarterly stock return volatility for each bank is calculated from the bank's daily stock returns for each quarter. Konishi and Yasuda (2004) have similarly used the standard deviation of stock returns to proxy bank risk.

For brevity, we use deposits, risk-weighted assets, loan loss provisions, liquidity creation, and the Z-scores in referring to the ratios of total deposits to total assets, risk-weighted assets to total assets, loan loss provisions to total assets, liquidity creation to total assets, and the natural logarithm of the Z-scores, respectively, in the remainder of the paper. Moreover, as reductions in the Z-scores imply higher bank risk whereas increases in other risk proxies converts to higher bank risk, we multiply the values for banks' Z-scores by -1 to facilitate a more consistent interpretation amongst risk proxies (such that a higher value indicates greater risk in all instances).

2.5.3 Two stage least squares instrumental variable (IV) method

We address the possibility that banks' deposits may be endogenous and may be affected by macroeconomic risk. In times of macroeconomic uncertainty, commercial paper spreads will be high and investors will avoid direct investments and choose to make more bank deposits. We have shown in figure 1 that during the recent financial crisis deposits increased in the US banking industry when macroeconomic risk was high. We are guided by Acharya and Naqvi (2012) to consider commercial paper spreads for non-financial firms as an instrument for bank liquidity.[5] Commercial Paper Spread (Non-Finance) is calculated by deducting the yield on US 3-Month Treasury Bills from the yield on US 3-Month Non-finance Commercial Papers. The

[5] As an alternative instrument, we also used commercial paper (CP) spreads for financial firms and the 2SLS results are qualitatively similar but we report only those for the non-finance CP spreads for brevity.

yield spreads represent the cost of short-term borrowing by other non-financial firms in the economy and whilst it gauges aggregate funding conditions it should not be closely related to bank-specific risk. The control variables selected for the 2SLS approach are the natural log of total assets, as well as the ratios of total equity to total assets, total loans to total assets and return on assets.

2.6 Discussion of findings

2.6.1 All banks

Overall risk of banks

We first examine the effect of banks' funding liquidity risk on asset risk and the overall risk of banks using our full sample. The OLS panel regression results are reported in Table 2.3.

<Insert Table 2.3>

Table 2.3 shows that lower funding liquidity risk increases overall bank risk as indicated by the significant relationship between deposits, Z-scores and liquidity creation at the 1% level of significance which is supportive of our first hypothesis and is also consistent with Acharya and Naqvi's (2012) theoretical prediction.[6] The impact of banks' funding liquidity risk on bank risk is economically significant as a one standard deviation increase in a bank's deposit-to-total asset ratio increases liquidity creation by 0.0147 and reduces the natural logarithm of the Z-scores by 0.0660.

Asset risk of banks

We examine the specific effects of bank funding liquidity risk on the asset quality of banks. The panel regression results are reported in Table 2.3. Deposits are positively related to risk-

[6] In the unreported regressions we considered the spread between the ratio of total interest income to total loans and the treasury bill rate and we found that increases in deposits reduces loan rates. This result lends further support for the theoretical prediction of Acharya and Naqvi (2012) in that increases in deposits induces bank managers to take more risk by lending aggressively at a loan rate lower than the optimal rate.

weighted assets at the 5% level of significance. This risk-taking behaviour increases the riskiness of banks' assets as evidenced by rising risk-weighted assets. The impact of banks' funding liquidity risk on bank riskiness is economically significant as a one standard deviation increase in the deposits ratio increases its risk-weighted assets ratio by 0.0022.

In all panel regressions, we include bank characteristics, as well as bank and time fixed effects to control for other unobservable factors that may affect bank risk. The control variables are mostly significant in the expected direction. Table 2.3 reports that the natural logarithm of total assets are positively related to risk-weighted assets and loan loss provisions but negatively related to liquidity creation and stock return volatility indicating that bank size increases banks' asset risk but reduces the overall riskiness of banks. The ratio of total loans to total assets is positively related to risk-weighted assets, loan loss provisions, liquidity creation and stock return volatility which suggests that banks lending more are typically riskier. The ratio of total equity to total assets is negatively related to liquidity creation and stock return volatility which suggests that banks having more capital are less risky. Return on assets is negatively related to loan loss provisions and stock return volatility suggesting that banks with a higher return on assets are riskier.

2.6.2 Banks with high capital buffers

The effect of the size of bank capital buffers on the relation between banks' funding liquidity risk and bank risk taking is reported in Table 2.4.

<Insert Table 2.4>

In Table 2.4, HCB is a test dummy which is used to indicate the banks with higher capital buffers. The interaction term between the deposit ratio and the high capital buffer (HCB) dummy is negatively related to risk-weighted assets, loan loss provisions and liquidity creation at the 5%, 5% and 1% level of significance, respectively. The interaction term is also significantly related to Z-scores at the 1% level of significance. Banks with higher capital buffers carry lower asset risk and overall risk compared to smaller capital buffer banks when they have lower funding liquidity risk as evidenced by lower risk-weighted assets and loan loss provisions. Therefore, the results lend support to our second hypothesis that banks with higher

capital buffers tend to take less risk overall relative to banks with lower capital buffers when faced with lower funding liquidity risk as evidenced by lower risk-weighted assets, loan loss provisions, liquidity creation, and higher Z-scores. In Table 2.4, the intercept dummy HCB shows that banks with high capital buffers are riskier based on loan loss provisions, Z-scores, and liquidity creation which is consistent with the existing literature that banks holding higher capital buffers are risky and these banks maintain higher capital buffers to face lower default risk because capital acts as a protective cushion in the case of default (Shim (2013)). Our finding with regards to high capital buffers are consistent with the previous findings of Furlong and Keeley (1989), Lee and Hsieh (2013), Lindquist (2004) and Repullo (2004) in that well-capitalized banks tend to take less risk. However, we also extend their results by showing that these banks are less inclined to take risks relative to banks with lower capital buffers when they have less funding liquidity risk. Our results for banks having high capital buffers are consistent with the existing literature that banks having high capital buffers take less risk in response to having more deposits because shareholders will lose out in the case of default (Repullo (2004)). Table 2.4 shows that the positive relationship between deposit funding and bank risk taking holds after controlling for the size of capital buffers as evidenced by the significant relation between deposits and risk-weighted assets, Z-scores, liquidity creation and stock return volatility. These results are economically significant as a one standard deviation increase in the deposits of high capital buffer banks reduces the bank's risk-weighted assets, loan loss provisions and liquidity creation by 0.0028, 0.00003 and 0.0041 respectively but increases Z-scores by 0.0443.

2.6.3 Big banks

The effect of bank size on the relation between funding liquidity risk and bank risk taking is reported in Table 2.5.

<Insert Table 2.5>

Table 2.5 shows that the interactive term for bank size and deposits is significantly and negatively related to risk-weighted assets, liquidity creation, and stock return volatility at the 10%, 1% and 1% level of significance, respectively. These results suggest that the banks' asset risk and overall risk of larger banks generally reduces compared to smaller banks in response

to lower funding liquidity risk. Also, larger banks become relatively safer when deposits increase as evidenced by higher Z-scores at the 1% level of significance. Our general finding with regards to big banks is not only consistent with the previous findings of Boyd and Runkle (1993), De Haan and Poghosyan (2012), and Demsetz and Starahan (1997) in that bank size is negatively related to risk but we also extend their results by showing that larger banks are less inclined to take risks when they have lower funding liquidity risk. Big banks take less risk in response to lower funding liquidity risk because they have in relative terms less scope due to their more complicated business models that are less focused on traditional bank lending and they also face tighter prudential supervision and regulatory constraints given their systemic importance within banking sectors. The intercept dummy, Big, shows that larger banks are riskier based on risk-weighted assets, Z-scores, liquidity creation and stock return volatility which is consistent with the existing literature documenting that large banks prefer to hold less economic capital (Demsetz and Strahan (1997)). Table 2.5 shows that the positive relationship between deposit funding and bank risk taking holds even after controlling for bank size as evidenced by the significant relation between deposits and risk-weighted assets, Z-scores, liquidity creation and stock return volatility. The results for large banks are economically significant as a one standard deviation increase in the amount of deposits taken by big banks reduces their risk-weighted assets, liquidity creation and stock return volatility by 0.0027, 0.0133 and 0.0018 respectively and increases their Z-scores by 0.0923.

2.6.4 Global financial crisis

To provide a better identification of the effects of higher funding liquidity risk on bank risk, we specifically examine the sub-period of the Global Crisis when the Federal Reserve Bank injected liquidity through the Term Auction Facility program into the banking system to ease the full effects of the crisis. Additionally, this period was also marked by a 'flight to safety' as investors became highly risk averse and had a strong preference to deposit their funds in banks instead of investing in risky securities (Acharya and Mora (2015)). The results on the impact of funding liquidity risk on bank risk during the period of global financial are shown in Table 2.6.

We find that increases in deposits have reduced bank risk in the period of the Global Financial Crisis sub-period compared to the other non-crisis periods based on the loan loss provisions, Z-scores, liquidity creation and stock return volatility at the 1%, 1%, 1% and 10% level of significance, respectively. Our results confirm that banks took less risk in response to decreases in funding liquidity risk during the GFC. These results are consistent with our fourth hypothesis that banks took less risk during the GFC in response to lower funding liquidity risk as proxied by higher deposits. However, the intercept dummy, GFC, shows that banks were riskier during the GFC based on their risk-weighted assets, Z-scores, and stock return volatility. Table 2.6 shows that the positive relationship between deposit funding and bank risk taking holds even after controlling for the GFC as evidenced by the significant relation between deposits with risk-weighted assets, Z-scores and liquidity creation. These results are economically significant as a one standard deviation increase in the deposits taken in the GFC liquidity injection regime reduces a bank's loan loss provisions, liquidity creation and stock return volatility by 0.0001 and 0.0061, and 0.0006 respectively and increases Z-scores by 0.0663.

<Insert Table 2.6>

Our findings for the GFC liquidity injection regime are consistent with the prior findings of Cornett et al. (2011) and Ivashina and Scharfstein (2010) in that during the global crisis banks' riskiness was reduced as a result of decreased funding liquidity risk through greater deposit taking by banks.

2.6.5 Two stage least squares instrumental variable (IV) method

To address the potential endogeneity concerns we use commercial paper spreads (Non-Finance) as an instrument for deposits. The commercial paper spreads are known to affect banks' funding liquidity risk and is a proxy for macroeconomic risk. If the macroeconomic risk is high, banks will have more deposit inflow because investors will avoid risky investments.

We find that in the first stage of our 2SLS estimations the coefficients for Commercial Paper Spreads (Non-Finance) are significantly related to deposits at the 1% level of significance.[7]

[7] We omit reporting the first stage results from our 2SLS to save on space but these are available upon request.

These results affirm that the selected instrument is closely related to the endogenous variable, deposits, and they are valid instruments for our purpose.

The results for the 2SLS estimations for deposits are reported in Table 2.7. Table 2.7 affirms that a reduction in funding liquidity risk encourages bank risk taking as evidenced by the significant relation for all of our risk proxies at the 1% level of significance. In fact, our 2SLS regression results are even stronger than the OLS results when we control for the potential endogeneity of deposits. Table 2.7 shows that increases in deposits results in higher bank asset risk and overall risk as proxied by risk-weighted assets, loan loss provisions, Z-scores, liquidity creation and stock return volatility at the 1% level of significance. Taken together, our core finding is that banks' lower funding liquidity risk significantly increases bank risk, and this result remains robust to alternative empirical methods. 2SLS results are economically significant as a one standard increase in banks' deposit-to-total assets ratio increases their risk-weighted assets, loan loss provisions, liquidity creation and stock return volatility by 0.0854, 0.0016, 0.2999, and 0.0856 respectively but reduces Z-scores by 0.9537.

<Insert Table 2.7>

2.6.6 Macroeconomic factors

As a robustness check, we include some macroeconomic factors to test the relation between banks' funding liquidity risk and risk taking. We consider the interbank deposit rate spreads (IBSpread), the growth rate of real gross domestic product (GDP), the unemployment rate (Unemploy) and changes in the house price index (House) as macroeconomic factors that may affect the risk-taking behaviour of banks. These macroeconomic factors are widely used in the literature. For instance, Buch et al. (2014) use the log differences of real GDP, the GDP deflator, real house prices and the level of effective federal funds rate to investigate the risk taking behaviour of banks. Similarly, Berger and Udell (1994) use the real growth rate of the gross national product, national and state unemployment rate and real state income growth rate, bond yield spreads and the treasury bill rate as macroeconomic factors to investigate the link between risk-based capital and lending behaviour of US banks. The OLS regression results of all banks including macroeconomic factors as control variables are reported in Table 2.8. These results are similar to the results without macroeconomic factors because the time dummies

previously captured the macroeconomic effects over time (see Table 2.3). Results in Table 2.8 indicate that deposits increase bank risks based on the significant relations of deposits with risk-weighted assets, Z-scores, and liquidity creation. Table 2.8 shows that interbank deposit rate spreads, GDP growth rate and house prices reduce bank risk taking whereas unemployment increases bank risk taking. A higher interbank deposit rate spread indicates a higher cost of funds which in turn reduces the risk-taking behaviour of banks.

<Insert Table 2.8>

2.6.7 Banks with high deposits

To check the robustness of the relation between banks' funding liquidity risk and banks' risk-taking we further examine the relationship for high levels of deposits. In Table 2.9, HL is a test dummy for banks with high levels of deposits. Results in Table 2.9 show that the interactive term between deposits and the high deposit dummy is positively related to loan loss provisions, liquidity creation and stock return volatility at the 1%, 5% and 1% level of significance, respectively. Banks with higher levels of deposits also take more risk in response to decreases in funding liquidity risk as evidenced by higher Z-scores at the 1% level of significance. These results suggest that lower funding liquidity risk increases bank risk more in the banks having higher levels of deposits. This result lends further support to Acharya and Naqvi's (2012) theoretical prediction that excess liquidity encourages greater risk taking by banks in the lead up to financial crises.

<Insert Table 2.9>

2.7 Conclusions

This study investigates the impact of banks' funding liquidity risk on their risk-taking behaviour. We find empirical evidence that banks facing lower funding liquidity risk take more risk. We consider banks with higher deposits to have lower funding liquidity risk because deposits shield banks from run risk in the presence of deposit insurance. Banks having higher deposits are less likely to face a funding shortfall immediately and bank managers' aggressive risk-taking behaviour is less likely to be audited. Our results show that increases in bank

deposits increase risk-weighted assets and liquidity creation, consistent with the findings of Acharya and Naqvi (2012) that banks lend aggressively at lower loan rates in response to higher deposits. Our results are also consistent with the findings of Keely (1990) that deposit insurance creates a moral hazard problem for excessive risk taking by banks in response to increases in deposits. We affirm that deposit ratios are positively related to bank risks as captured by Z-scores.

We also find that the interactive variable between deposits and the high capital buffer dummy is significantly and negatively related to banks' risk-weighted assets, loan loss provisions and liquidity creation which confirm that banks with higher capital buffers take less risk compared to lower capital buffer banks in response to decreased funding liquidity risk. Similarly, the significant relation between Z-scores with the interactive term between deposits and capital buffers indicates that banks with high capital buffers take less risk. Our finding with regards to high capital buffers substantiates that well-capitalized banks tend to take less risk. Our results show that the interactive variable between deposits and the big bank dummy is negatively related to risk-weighted assets, liquidity creation, and bank stock return volatility. Therefore, larger banks take less risk compared to smaller banks when they have more deposits which is also evidenced by higher Z-scores. Therefore, larger banks take less risk in response to decreases in banks' funding liquidity risk as proxied by higher deposits. During the global financial crisis, banks took less risk when their funding liquidity risk decreased. We also show empirically that banks having higher levels of deposits take more risk compared to the banks with lower levels of deposits in response to increases in deposits.

In sum, our results strongly support the view that banks should steer away from short-term funding to improve the quality of their assets and to reduce their riskiness. The findings of this study show that capital buffers and size generally help to curb banks' risk-taking behaviour in response to decreased funding liquidity risk. Banks are also less aggressive during financial crises when they are more actively monitored and disciplined for risk taking. Our study provides a clear understanding of the link between funding liquidity risk as captured by deposit ratios and bank risk-taking behaviour which may help regulators to redesign the banking regulatory framework to better discipline and control the perverse incentives of bank managers to take too much risk in the future when bank deposits change. Specifically examining the effect of funding liquidity risk on bank managers' compensation packages would be a worthwhile direction for future research on this topic.

Figure 2.1: Average total deposit-to-total asset ratio of the US banking industry

The entire sample period for which we have data on BHCs can be divided into three sub-periods with distinct trends in the deposit to asset ratio marking three separate liquidity regimes, namely Stable, Decreasing and Increasing in the US banking sector. The aggregate deposit-to-asset ratio for all US BHCs remained stable from 1986:Q4 to 1992:Q4, decreased from 1993:Q1 to 2008:Q2 and increased from 2008:Q3 to 2014:Q4. We define the latter as the post-GFC high liquidity sub-period.

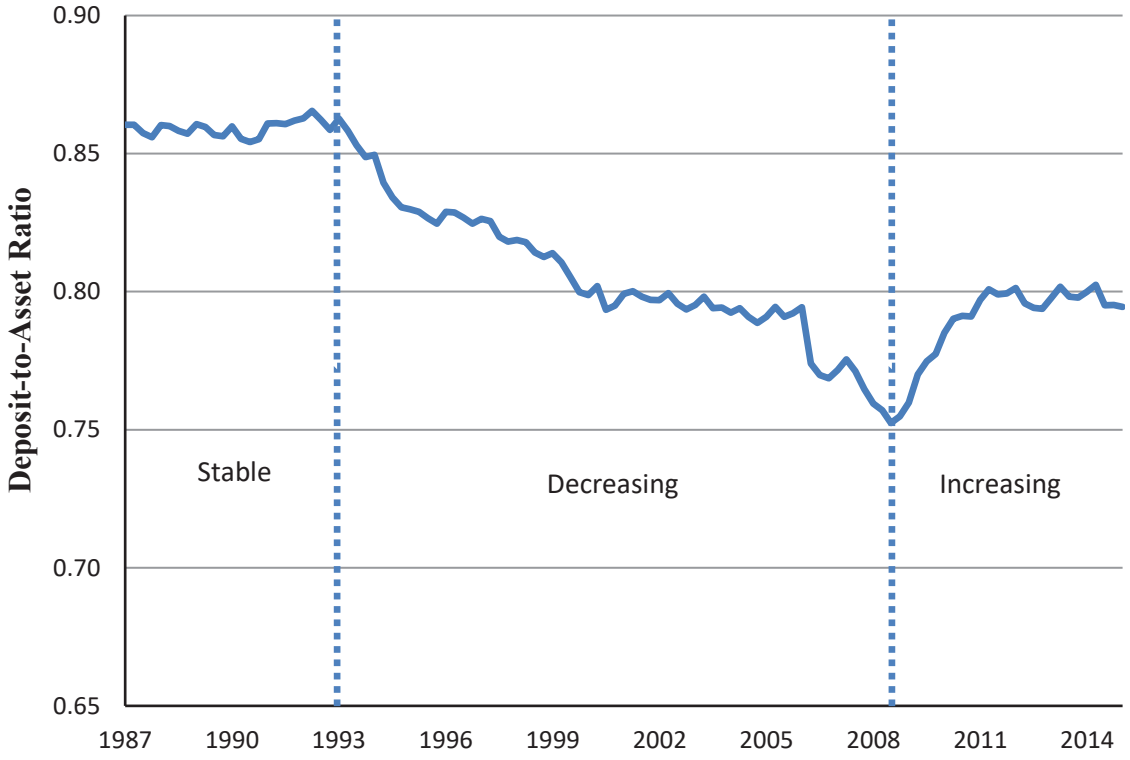

Table 2.1: Summary statistics

This table reports the summary statistics of the quarterly data for 4,749 BHCs from 1986:Q4 to 2014:Q4. The top and bottom 5% of all observations for all variables except the macroeconomic factors have been winsorized to limit the extreme values.

Variable	Mean	Std. Dev.	Min	Max	Observations
		Dependent variables			
RWA	0.6989	0.1073	0.4874	0.8822	107,873
LLP	0.0008	0.0009	0.0000	0.0037	162,989
Z-scores	5.1789	1.0603	2.9104	6.8717	150,624
LC	0.1447	0.1158	-2.5304	0.6154	166,567
SRV	0.0245	0.0141	0.0096	0.0636	37,653
		Independent variable			
Deposit	0.8215	0.0744	0.6426	0.9114	166,567
		Control variables			
Asset	13.2486	1.2508	11.5495	16.2706	166,567
Loan	0.6281	0.1212	0.3768	0.8239	166,567
Equity	0.0861	0.0246	0.0454	0.1394	166,567
ROA	0.0023	0.0015	-0.0015	0.0049	162,989
CPSpread	0.4146	0.3195	0.0200	1.4300	166,567
IBSpread	0.1473	0.9285	-7.9700	2.7100	166,567
GDP	2.7381	2.3451	-8.1900	7.7700	166,567
Unemploy	5.9234	1.3722	3.9000	9.9000	166,567
House	1.3216	2.1564	-5.9400	5.9600	166,567

Table 2.2: Pairwise Pearson correlation coefficients

This table reports the correlation coefficients of all variables used for 4,749 BHCs over the period from 1986:Q4 to 2014:Q4. The top and bottom 5% of all observations for all variables except the macroeconomic factors have been winsorized to limit the extreme values.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1 RWA	1.00														
2 LLP	0.24	1.00													
3 Z-scores	-0.10	-0.38	1.00												
4 LC	0.51	0.08	-0.09	1.00											
5 SRV	0.08	0.41	-0.36	0.04	1.00										
6 Deposit	-0.01	-0.04	-0.03	0.33	0.04	1.00									
7 Asset	0.14	0.16	0.02	-0.08	-0.09	-0.43	1.00								
8 Loan	0.76	0.22	-0.07	0.53	0.09	0.07	-0.01	1.00							
9 Equity	-0.14	-0.10	0.27	-0.26	-0.12	-0.12	0.00	-0.18	1.00						
10 ROA	-0.05	-0.45	0.36	-0.01	-0.38	0.04	-0.09	-0.06	0.27	1.00					
11 CPSpread	-0.03	0.00	0.04	-0.07	0.23	-0.01	-0.06	0.01	-0.04	0.04	1.00				
12 IBSpread	0.12	0.10	-0.10	0.05	0.25	-0.07	0.10	0.08	-0.03	-0.13	0.12	1.00			
13 GDP	-0.14	-0.18	0.14	-0.03	-0.33	0.09	-0.15	-0.10	0.01	0.20	-0.09	-0.20	1.00		
14 Unemploy	0.05	0.36	-0.24	0.08	0.27	-0.02	0.26	0.01	0.05	-0.32	-0.49	0.13	-0.24	1.00	
15 House	-0.07	-0.30	0.17	0.01	-0.46	0.07	-0.23	-0.06	0.01	0.24	-0.38	-0.18	0.37	-0.30	1.00

Table 2.3: Liquidity and bank risk for all banks

This table reports the panel regression results where the dependent variables are the measures of banks' asset risk as proxied by the ratios of risk-weighted assets to total assets (RWA) and loan loss provisions to total loans (LLP) and banks' overall risk as proxied by the natural logarithm of the Z-scores (Z-scores), liquidity creation and the standard deviation of bank stock returns (SRV). The independent variable of interest is banks' funding liquidity risk as proxied by the ratio of total deposits to total assets (Deposit) in the past quarter. Control variables used are natural logarithm of total assets (Asset), return on assets (ROA) and the ratios of total loans to total assets (Loan) and total equity to total assets (Equity). The sample is based on the quarterly data of US bank holding companies over the period from 1986:Q4 to 2014:Q4. Time fixed effects and bank fixed effects are included in the regressions. P-values are computed using heteroskedasticity-robust standard errors clustered for banks and are presented in parentheses. *, **, and *** represent statistical significance at the 10%, 5%, and 1% level, respectively.

	Asset risk		Overall risk		
	1	2	3	4	5
	RWA_t	LLP_t	$-Z\text{-scores}_t$	LC_t	SRV_t
Deposit $_{t-1}$	0.0297**	0.00002	0.8860***	0.1976***	0.0029
	(0.0380)	(0.8358)	(0.0000)	(0.0000)	(0.3063)
Asset $_{t-1}$	0.0043*	0.0002***	0.0413	-0.0222***	-0.0027***
	(0.0931)	(0.0000)	(0.1650)	(0.0000)	(0.0000)
Loan $_{t-1}$	0.5875***	0.0020***	-0.0357	0.3060***	0.0051**
	(0.0000)	(0.0000)	(0.7326)	(0.0000)	(0.0353)
Equity $_{t-1}$	0.0485	-0.0004		-0.5798***	-0.0863***
	(0.2341)	(0.3457)		(0.0000)	(0.0000)
ROA $_{t-1}$	0.5169	-0.1492***		1.9188***	-1.7655***
	(0.1105)	(0.0000)		(0.0000)	(0.0000)
Constant	0.2481***	-0.0022***	-5.5943***	0.2290***	0.0670***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Time fixed effect	Yes	Yes	Yes	Yes	Yes
Firm fixed effect	Yes	Yes	Yes	Yes	Yes
Observations	104,210	157,711	150,599	157,711	35,607
Adjusted R-sq	0.5315	0.2835	0.1058	0.5492	0.4341

Table 2.4: Liquidity and bank risk in banks with high capital buffers

This table reports panel regression results on the impact of banks' funding liquidity risk as proxied by the ratio of total deposits to total assets (Deposit) on the asset risk and overall risk of banks with a high capital buffer. HCB is an indicator variable taking on values of 1 for banks in the top quartile in terms of the size of their capital buffer and zero otherwise. Banks' asset risk is measured by the ratios of risk-weighted assets to total assets (RWA) and loan loss provisions to total loans (LLP). Banks' overall riskiness is measured by the natural logarithm of their Z-scores (Z-scores), liquidity creation and the standard deviation of bank stock returns (SRV). Control variables used are the banks' natural logarithm of total assets, the ratios of total loans to total assets, total equity to total assets and return on assets. The sample is based on the quarterly data of US bank holding companies over the period from 1986:Q4 to 2014:Q4. Time fixed effects and bank fixed effects are included in the regressions. P-values are computed using heteroskedasticity-robust standard errors clustered for banks and are presented in parentheses. *, **, and *** represent statistical significance at the 10%, 5%, and 1% level, respectively.

	Asset risk		Overall risk		
	1	2	3	4	5
	RWA_t	LLP_t	$-Z\text{-scores}_t$	LC_t	SRV_t
$Deposit_{t-1}*HCB_{t-1}$	-0.0373**	-0.0004**	-0.5954**	-0.0550***	0.0042
	(0.0245)	(0.0108)	(0.0148)	(0.0039)	(0.2529)
HCB_{t-1}	0.0052	0.0004**	0.3369*	0.0349**	-0.0026
	(0.6905)	(0.0121)	(0.0910)	(0.0232)	(0.3467)
$Deposit_{t-1}$	0.0310**	0.0001	1.2909***	0.1886***	0.0069**
	(0.0313)	(0.3148)	(0.0000)	(0.0000)	(0.0200)
$Controls_{t-1}$	Yes	Yes	Yes	Yes	Yes
Time fixed effect	Yes	Yes	Yes	Yes	Yes
Firm fixed effect	Yes	Yes	Yes	Yes	Yes
Observations	102,515	102,612	99,330	102,612	26,274
Adjusted R-sq	0.5516	0.3340	0.1331	0.3161	0.5045

Table 2.5: Liquidity and bank risk in big banks

This table reports panel regression results on the impact of banks' funding liquidity risk as proxied by the ratio of total deposits to total assets (Deposit) on the asset risk and overall risk of big banks. *Big* is an indicator variable taking on values of 1 for banks in the top quartile by total asset value and zero otherwise. Banks' asset risk is measured by the ratios of risk-weighted assets to total assets (RWA) and loan loss provisions to total loans (LLP). Banks' overall riskiness is measured by the natural logarithm of their Z-scores (Z-scores), liquidity creation and the standard deviation of bank stock returns (SRV). Control variables used are the natural logarithm of total assets, the ratios of total loans to total assets, total equity to total assets, total deposits to total loans and return on assets. The sample is based on the quarterly data of US bank holding companies over the period from 1986:Q4 to 2014:Q4. Time fixed effects and bank fixed effects are included in the regressions. P-values are computed using heteroskedasticity-robust standard errors clustered for banks and are presented in parentheses. *, **, and *** represent statistical significance at the 10%, 5%, and 1% level, respectively.

	Asset risk		Overall risk		
	1	2	3	4	5
	RWA_t	LLP_t	$-Z\text{-scores}_t$	LC_t	SRV_t
$Deposit_{t-1}*Big_{t-1}$	-0.0358*	-0.0001	-1.2396***	-0.1788***	-0.0239***
	(0.0795)	(0.7125)	(0.0000)	(0.0000)	(0.0000)
Big_{t-1}	0.0301*	0.0000	1.0434***	0.1472***	0.0214***
	(0.0696)	(0.7867)	(0.0000)	(0.0000)	(0.0000)
$Deposit_{t-1}$	0.0405***	0.0001	1.3674***	0.2668***	0.0098***
	(0.0093)	(0.7024)	(0.0000)	(0.0000)	(0.0022)
$Controls_{t-1}$	Yes	Yes	Yes	Yes	Yes
Time fixed effect	Yes	Yes	Yes	Yes	Yes
Firm fixed effect	Yes	Yes	Yes	Yes	Yes
Observations	104,210	157,711	150,599	157,711	35,607
Adjusted R-sq	0.5317	0.2835	0.1069	0.5526	0.4376

Table 2.6: Liquidity and bank risk during GFC

This table reports panel regression results on the impact of banks' funding liquidity risk as proxied by the ratio of total deposits to total assets (Deposit) on asset risk and overall risk of banks in the sub-period of the global financial crisis. *GFC* is an indicator variable that takes a value of 1 for the period from 2007:Q4 to 2010:Q1 and 0 otherwise. Proxies used for bank asset risk are the ratios of risk-weighted assets to total assets (RWA) and loan loss provisions to total loans (LLP). Overall bank risk is captured by the natural logarithm of the Z-scores (Z-scores), liquidity creation and the standard deviation of bank stock returns (SRV). Control variables used are the natural logarithm of total assets, the ratios of total loans to total assets, total equity to total assets and the return on assets. The sample is based on the quarterly data of US bank holding companies over the period from 1986:Q4 to 2014:Q4. Time fixed effects and bank fixed effects are included in the regressions. P-values are computed using heteroskedasticity-robust standard errors clustered for banks and are presented in parentheses. *, **, and *** represent statistical significance at the 10%, 5%, and 1% level, respectively.

	Asset risk		Overall risk		
	1	2	3	4	5
	RWA_t	LLP_t	$-Z\text{-scores}_t$	LC_t	SRV_t
$Deposit_{t-1}$*GFC	-0.0041	-0.0015***	-0.8909***	-0.0815***	-0.0085*
	(0.7912)	(0.0000)	(0.0077)	(0.0000)	(0.0867)
GFC	0.0260**	0.0003	0.1366***	-0.0582***	0.0131***
	(0.0360)	(0.1817)	(0.0000)	(0.0001)	(0.0011)
$Deposit_{t-1}$	0.0302**	0.0001	0.9594***	0.2044***	0.0037
	(0.0399)	(0.2052)	(0.0000)	(0.0000)	(0.2026)
$Controls_{t-1}$	Yes	Yes	Yes	Yes	Yes
Time fixed effect	Yes	Yes	Yes	Yes	Yes
Firm fixed effect	Yes	Yes	Yes	Yes	Yes
Observations	104,210	157,711	150,599	157,711	35,607
Adjusted R-sq	0.5315	0.2844	0.1061	0.5496	0.4342

Table 2.7: 2SLS regression for liquidity and bank risk for all banks

This table reports the 2SLS regression results to test the impact of the banks' funding liquidity risk as proxied by the ratio of total deposits to total assets (Deposit) in the past quarter on the asset risk of banks as proxied by the ratios of risk-weighted assets to total assets (RWA) and loan loss provisions to total loans (LLP) and the overall risk of banks as proxied by the natural logarithm of the Z-scores (Z-scores), liquidity creation and the standard deviation of bank stock returns (SRV). Commercial paper spread (Non-Finance) is used as an instrument. Control variables used are banks' natural logarithm of total assets (Asset), return on assets (ROA) and the ratios of total loans to total assets (Loan) and total equity to total assets (Equity). The sample is based on the quarterly data of US bank holding companies over the period from 1986:Q4 to 2014:Q4. Time fixed effects and bank fixed effects are included in the regressions. P-values are computed using heteroskedasticity-robust standard errors clustered for banks and are presented in parentheses. *, **, and *** represent statistical significance at the 10%, 5%, and 1% level, respectively.

	Asset risk		Overall risk		
	1	2	3	4	5
	RWA_t	LLP_t	$-Z\text{-scores}_t$	LC_t	SRV_t
Deposit $_{t-1}$	1.1471***	0.0217***	12.8121***	4.0289***	1.1502***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0022)
Asset $_{t-1}$	0.0453***	0.0007***	0.3028***	0.0974***	0.0302***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0050)
Loan $_{t-1}$	0.6525***	0.0017***	0.0876	0.2408***	-0.0528*
	(0.0000)	(0.0000)	(0.5375)	(0.0000)	(0.0783)
Equity $_{t-1}$	0.4089***	0.0134***		1.3276***	0.4535***
	(0.0009)	(0.0000)		(0.0000)	(0.0205)
ROA $_{t-1}$	-0.7705*	-0.2259***		-4.3747***	-3.5819***
	(0.4499)	(0.0000)		(0.0060)	(0.0002)
Constant	-1.2925***	-0.0285***	-19.7647***	-4.7117***	-1.3053***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0037)
Time fixed effect	No	No	No	No	No
Firm fixed effect	No	No	No	No	No
Observations	104,210	157,711	150,599	157,711	35,607

Table 2.8: Liquidity and bank risk for all banks including macroeconomic factors

This table reports the panel regression results where the dependent variables are the measures of banks' asset risk as proxied by the ratios of risk-weighted assets to total assets (RWA) and loan loss provisions to total loans (LLP) and banks' overall risk as proxied by the natural logarithm of the Z-scores (Z-scores), liquidity creation and the standard deviation of bank stock returns (SRV). The independent variable of interest is banks' funding liquidity risk as proxied by the ratio of total deposits to total assets (Deposit) in the past quarter. Control variables used are the natural logarithm of total assets (Asset), return on assets (ROA) and the ratios of total loans to total assets (Loan), total equity to total assets (Equity), interbank spreads (IBSpread), growth rate of real GDP (GDP), unemployment rate (Unemploy) and changes in house price index (House). The sample is based on the quarterly data of US bank holding companies over the period from 1986:Q4 to 2014:Q4. Time fixed effects and bank fixed effects are included in the regressions. P-values are computed using heteroskedasticity-robust standard errors clustered for banks and are presented in parentheses. *, **, and *** represent statistical significance at the 10%, 5%, and 1% level, respectively.

	Asset risk		Overall risk		
	1	2	3	4	5
	RWA_t	LLP_t	$-Z\text{-scores}_t$	LC_t	SRV_t
Deposit $_{t-1}$	0.0297**	0.00002	0.8860***	0.1976***	0.0029
	(0.0380)	(0.8358)	(0.0000)	(0.0000)	(0.3063)
Asset $_{t-1}$	0.0043*	0.0002***	0.0413	-0.0222***	-0.0027***
	(0.0931)	(0.0000)	(0.1650)	(0.0000)	(0.0000)
Loan $_{t-1}$	0.5875***	0.0020***	-0.0357	0.3060***	0.0051**
	(0.0000)	(0.0000)	(0.7326)	(0.0000)	(0.0353)
Equity $_{t-1}$	0.0485	-0.0004		-0.5798***	-0.0863***
	(0.2341)	(0.3457)		(0.0000)	(0.0000)
ROA $_{t-1}$	0.5169	-0.1492***		1.9188***	-1.7655***
	(0.1105)	(0.0000)		(0.0000)	(0.0000)
IBSpread $_{t-1}$	-0.0131***	-0.0001***	0.0225	-0.0142***	0.0025***
	(0.0000)	(0.0000)	(0.1250)	(0.0000)	(0.0000)
GDP $_{t-1}$	-0.0020***	0.0000	-0.0319***	-0.0019***	-0.0011***
	(0.0000)	(0.4864)	(0.0000)	(0.0000)	(0.0000)
Unemploy $_{t-1}$	-0.0032***	0.0001***	0.1862***	0.0007**	0.0012***
	(0.0000)	(0.0000)	(0.0000)	(0.0447)	(0.0000)
House $_{t-1}$	-0.0032***	-0.0001***	-0.0375***	-0.0007***	-0.0017***
	(0.0000)	(0.0000)	(0.0018)	(0.0000)	(0.0000)
Constant	0.2706***	-0.0035***	-7.3150***	0.1175**	0.0652***
	(0.0000)	(0.0000)	(0.0000)	(0.0190)	(0.0000)
Time fixed effect	Yes	Yes	Yes	Yes	Yes
Firm fixed effect	Yes	Yes	Yes	Yes	Yes
Observations	104,210	157,711	150,599	157,711	35,607
Adjusted R-sq	0.5315	0.2835	0.1058	0.5492	0.4341

Table 2.9: Liquidity and bank risk in banks having high deposits

This table reports the panel regression results where the dependent variables are the measures of banks' asset risk as proxied by the ratios of risk-weighted assets to total assets (RWA) and loan loss provisions to total loans (LLP) and banks' overall risk as proxied by the natural logarithm of the Z-scores (Z-scores), liquidity creation and the standard deviation of bank stock returns (SRV). The independent variable of interest is banks' funding liquidity risk as proxied by the ratio of total deposits to total assets (Deposit) in the past quarter. HL is an indicator variable taking on values of 1 for banks in the top quartile by the ratio of total deposits to total assets and zero otherwise. Control variables used are the natural logarithm of total assets, the ratios of total loans to total assets, total equity to total assets, total deposits to total loans and return on assets. The sample is based on the quarterly data of US bank holding companies over the period from 1986:Q4 to 2014:Q4. Time fixed effects and bank fixed effects are included in the regressions. P-values are computed using heteroskedasticity-robust standard errors clustered for banks and are presented in parentheses. *, **, and *** represent statistical significance at the 10%, 5%, and 1% level, respectively.

	Asset risk		Overall risk		
	1	2	3	4	5
	RWA_t	LLP_t	$-Z\text{-scores}_t$	LC_t	SRV_t
$Deposit_{t-1}*HL_{t-1}$	0.0082	0.0020***	5.6040***	0.1158**	0.0302***
	(0.8458)	(0.0000)	(0.0000)	(0.0205)	(0.0034)
HL_{t-1}	-0.0071	-0.0017***	-4.8393***	-0.1035**	-0.0256***
	(0.8456)	(0.0000)	(0.0000)	(0.0184)	(0.0036)
$Deposit_{t-1}$	0.0292*	-0.0001	0.3511*	0.2001***	0.0001
	(0.0698)	(0.4465)	(0.0745)	(0.0000)	(0.9819)
$Controls_{t-1}$	Yes	Yes	Yes	Yes	Yes
Time fixed effect	Yes	Yes	Yes	Yes	Yes
Firm fixed effect	Yes	Yes	Yes	Yes	Yes
Observations	104,210	157,711	150,599	157,711	35,607
Adjusted R-sq	0.5315	0.2839	0.1098	0.5494	0.4347

Appendix-Chapter 2

Appendix 2.A: Variable names and construction of variables

Variable	Construction	Data Source
RWA	Risk-weighted asset/Total assets	Federal Reserve Bank
LLP	Loan loss provision/ Total assets	Federal Reserve Bank
Z-scores	Log [{Return on assets+(Equity/Asset)}/Standard deviation of return on assets]	Federal Reserve Bank
LC	Liquidity creation/Total assets. Liquidty Creation =0.5×illiquid assets+0.5×liquid liabilities-0.5×liquid assets-0.5×llliquid liabilities-0.5×equity	Federal Reserve Bank
SRV	Standard deviation of daily stock returns of bank *i* in quarter *t*	CRSP
Deposit	Total deposits/ Total assets	Federal Reserve Bank
Asset	Natural logarithm of total assets	Federal Reserve Bank
Loan	Total loans/Total assets	Federal Reserve Bank
Equity	Total equity/Total assets	Federal Reserve Bank
ROA	Net income/Total assets	Federal Reserve Bank
CPSpread	Commercial paper spread= Yield on 3-month U.S. non-finance commercial paper - Yield 3-month U.S. treasury bill	Datastream
IBSpread	Interbank spreads =Three month interbank deposit rate - Federal funds rate	Datastream
GDP	Growth rate of U.S. real GDP	Datastream
Unemploy	U.S. unemployment rate	Datastream
House	Changes in house price index=Standard and Poor's Case-Shiller seasonally adjusted national house prices index(t) - Standard and Poor's Case-Shiller seasonally adjusted national house prices index (t-1)	Datastream
HCB	Indicator variable with 1 for the highest quartile capital buffer banks and 0 otherwise. Capital buffer = (Actual regulatory capital – Risk-weighted assets×0.08) / Risk-eeighted assets.	Federal Reserve Bank
Big	Indicator variable with 1 for the biggest quartile BHCs and 0 otherwise	Federal Reserve Bank
HL	Indicator variable taking on values of 1 for banks in the top quartile by the ratio of total deposits to total assets and zero otherwise	Federal Reserve Bank
GFC	Indicator variable for the high liquidity regime with 1 for the period from 2007:Q4 to 2010:Q1 and 0 otherwise	

Appendix 2.B: Summary of liquidity creation calculation of US bank holding companies

Illiquid Assets	
Commercial real estate loans (CRE)	Loans to finance commercial real estate, construction, and land development activities (not secured by real estate)
Loans to finance agricultural production	Loans to finance agricultural production and other loans to farmers
Commercial and industrial loans (C&I)	Commercial and industrial loans
Other loans and lease financing receivables	
	Other Loans for purchasing or carrying securities
	All other loans
	All other leases
Other real estate owned (OREO)	Other real estate owned
Investment in unconsolidated subsidiaries	Investments in unconsolidated subsidiaries and associated companies
Intangible assets	
	Goodwill
	Other intangible assets
Premises	Premises and fixed assets
Other assets	Other assets
Liquid Assets	
Cash and due from other institutions	Cash and due from depository institutions
All securities (regardless of maturity)	
	Held-to-maturity securities
	Available-for-sale securities
Trading assets	Trading assets
Fed funds sold	Federal funds sold and securities purchased under agreements to resell
Liquid Liabilities	
Transactions deposits	
	Noninterest-bearing balances
	Interest-bearing demand deposits, NOW, ATS, and other transaction accounts
Savings deposits	Money market deposit accounts and other savings accounts
Overnight federal funds purchased	Federal funds purchased in domestic offices
Trading liabilities	Trading liabilities
Illiquid liabilities	
Subordinated debt	
	Subordinated notes and debentures
	Subordinated notes payable to unconsolidated trusts issuing trust preferred securities, and trust preferred securities issued by consolidated special purpose entities
Other liabilities	Other liabilities
Equity	
Total Equity	Total Equity

3 The effect of bank liquidity creation on bank performance[8]

3.1 Introduction

Banks create liquidity by making long-term loans to illiquid borrowers, as well as by raising funds through short-term liquid liabilities. Liquidity transformation is a fundamental function of banks. Berger and Bouwman (2009) introduced the concept of liquidity creation to measure the degree of mismatch between the maturity of a bank's assets and liabilities. Their findings indicate that in creating more liquidity, banks are exposed to higher liquidity risk. Deposit insurance (Distinguin, Roulet and Tarazi (2013)) and minimum liquidity requirements are known to safeguard banks from liquidity constraints. With regard to the latter, the Basel Committee on Banking Supervision (BCBS) proposed two new minimum liquidity requirements under Basel III rules. These were 100% for the liquidity coverage ratio (LCR) and 100% for the net stable funding ratio (NSFR), both of which are designed to increase banks' asset liquidity and ensure a higher degree of funding stability. Banerjee and Mio (2017) investigate the impact of tighter liquidity regulation in the UK and find that banks increase high quality liquid assets and non-financial deposits but reduce intra-financial loans and short-term wholesale funding. Banks, however, do not shrink their balance sheets and reduce non-financial loans due to tighter liquidity regulation (Banerjee and Mio (2017)). The LCR requires banks to maintain sufficient high-quality liquid assets to cover short-term cash outflows. The NSFR requires banks to use more stable funding sources and to hold more high-quality liquid assets (King (2013)).[9] These requirements were implemented in 2015 such that since 1 January 2015 60% of LCR requirement has been implemented. Each successive year they are increased by 10%. The 100% of NSFR will be implemented by 1 January 2018.

[8] This chapter has been invited for revision and resubmission by the *Journal of Financial Services Research*. We thank Charles W. Calomiris, Iftekhar Hasan, Bum J. Kim, Michael King, Hsiu-I Ting, Jan Kruger, Lorenzo Casavecchia and other seminar participants at the University of Technology Sydney for useful suggestions and comments. We also thank conference participants at the 10th Annual Conference on Asia-Pacific Financial Markets, the 23rd Conference on the Theories and Practices of Securities and Financial Markets, the 28th Australasian Finance and Banking Conference, the IFABS 2016 Barcelona Conference and the 6th Financial Engineering and Banking Society Malaga Conference for their useful suggestions that have helped to improve the paper. All errors remain our own.

[9] LCR reduces a bank's asset liquidity risk by increasing their high-quality liquid assets, and NSFR reduces the funding and interest rate risks originating from the maturity mismatches between assets and liabilities (King (2013)).

Little is known about how these constraints on liquidity creation will impact bank funding costs, profitability and market value. Liquidity premium theory suggests that liquidity-creating banks earn higher returns on long-term assets and pay lower premiums for short-term funds. Yet, some fund suppliers consider that liquidity creation increases the credit risk of banks, which means that they will charge a higher premium for credit risk. Banks may be able to transfer some premiums to consumers if all banks are exposed to similar constraints.

Unfortunately, the literature is patchy on the aforementioned topics. The Bank for International Settlements (2010) acknowledges that the new liquidity standards may affect the performance of banks by reducing profitability and squeezing lending margins. Banks may pass on higher regulatory costs to borrowers by charging higher loan rates (Yan, Hall and Turner (2012)). Studies (Athanasoglou, Brissimis and Delis (2008); Binsbergen, Jules, Graham and Yang (2010); King (2013); Pasiouras and Kosmidou (2007)) suggest that bank size, the level of liquidity creation and being in a financial crisis may also affect the relationship between liquidity creation, costs of funds, financial performance and market value.

Answers to these questions provide a basis for assessing the impacts of future regulation changes. First, we must calculate the quarterly liquidity creation of US bank holding companies for the period 1995–2014 using call report data. We investigate the effect of liquidity creation on banks' costs of funds, profitability and market values. Banks' cost of debt funding is proxied by the ratios of total interest expense to total liabilities and interest expenses on deposits to total deposits, whereas profitability is proxied by banks' net interest margin and return on equity, and value is proxied by the adjusted market-to-book value of equity. We find evidence that banks experience lower funding costs but higher profitability and market values in response to liquidity creation. Moreover, larger banks face higher funding costs, profitability and market values in response to increases in liquidity creation. Banks with excessive liquidity creation and banks in the midst of financial crises face lower cost of debt funding, profitability and values.

The remainder of this article is organised as follows. Section 2 summarises the related literature. Section 3 describes the data used. Section 4 presents our empirical model. Section 5 discusses the empirical results. Finally, conclusions are provided in Section 6.

3.2 Hypothesis Development

Bank Liquidity and Cost of Debt Funding

The relationship between bank liquidity creation and funding costs and profitability and market value remains an open empirical question, despite a vibrant literature exploring liquidity creation and the processes banks use in financial intermediation. Berger and Bouwman (2009) introduced this concept of liquidity creation to capture the degree of mismatch between the maturity of banks' assets and liabilities. Under liquidity creation, banks hold more short-term liabilities than long-term liabilities and more long-term assets than short-term assets. Banks generate a higher return from these longer-term assets, whereas they pay lower costs for short-term funds. High-yielding long-term assets and shorter-term funds due to liquidity creation may increase financial performance and reduce the funding costs of banks. According to the liquidity preference hypothesis, the term premiums of assets and liabilities increase monotonically over time to maturity; the yield curve is upward sloping (Boudoukh, Richardson, Smith and Whitelaw (1999); Fama (1984)). Figure 3.1 demonstrates that returns on assets and costs of liabilities are positively related to the illiquidity of assets and illiquidity of liabilities respectively. Return on long-term liquid assets is higher, whereas the cost of short-term liabilities is lower as a result of a liquidity premium. Thus, the combined effect of liquidity creation will decrease banks' costs of funds, yet increase net interest income as well as net income.

<Insert Figure 3.1>

Under liquidity creation, banks are required to hold more long-term assets and accumulate funds from short-term sources. When banks create additional liquidity, they accept higher liquidity risk. Funding assets with shorter maturity liabilities may decrease banks' funding costs due to generally upward sloping yield curves, which are implied by the liquidity premium hypothesis on the term structures of interest rates. However, the liquidity risks and credit risks of banks are closely related, and fund suppliers may require costly debt to banks with high liquidity risk. Banks with lower liquidity risk also have a lower probability of default (Hong, Huang and Wu (2014)). Myers and Rajan (1998) show that liquidity may reduce the borrowing capability of a firm's assets because asset liquidity also increases agency problems by giving managers greater discretion to act at the creditor's expense. In fact, fund suppliers are likely to

demand higher credit risk premiums from banks holding more liquidity, thereby pushing up banks' costs of funds. In contrast, asset liquidity increases a firm's borrowing capacity when debt covenants prohibit the sale of assets (Morellec (2001)). Overall, the literature indicates that banks with higher liquidity creation should face a lower cost of debt funding.

Hypothesis 1: Higher liquidity creation decreases a bank's cost of debt funding.

Bank Liquidity, Bank Profitability and Market Value

To create liquidity banks hold more illiquid assets by increasing the mismatch between the maturity of assets and liabilities. Illiquid assets are likely to generate higher returns than liquid assets; holding illiquid assets increases bank revenues. Liquidity creation should therefore be positively related to a bank's financial performance. Liquid assets reduce the return on investments but help firms to avoid external financing (Kim, Mauer and Sherman (1998)). Consistent with this notion Bordeleau and Graham (2010) show that liquid assets initially increase profitability, although beyond a certain level liquid assets reduces bank profitability. Increases in liquid assets reduce the net interest margins of banks as a result of a lower liquidity risk premium (Angbazo (1997)). Tran, Lin and Nguyen (2016) find that banks which create more liquidity face lower profitability because liquidity creation increases default risk. In turn, this reduces bank profitability. To meet the required NSFR banks must hold more highly-rated securities and expand the maturity of wholesale funding which in turn reduces net interest margins by reducing interest revenue while increasing interest expenses (King (2013)). Funding stability reduces the mismatch between the maturity of assets and liabilities. Improved funding stability actually reduces a bank's interest rate risk and improves bank charter values (King (2013)). Similarly, banks reduce loans and increase their holdings of securities to improve asset liquidity which in turn reduces interest income due to investment in less risky assets (Basel Committee on Banking Supervision (2016)). Liquidity requirements may reduce banks' net interest incomes because they will force them to hold more high-quality liquid assets and stable funding (Basel Committee on Banking Supervision (2016)).

Moreover, firms with more illiquid assets are unable to reduce their investments during economic downturns but need to maintain unproductive capital which requires higher returns for the capital suppliers (Ortiz-Molina and Phillips (2014)). It has been shown that during times of financial distress, cash balances allow managers significant operating discretion (DeAngelo, DeAngelo and Wruck (2002)). The increase in capital may imply a lower return on equity.

Conversely, Distinguin, Roulet and Tarazi (2013) find a negative association between banks' liquidity creation and their regulatory capital ratios. Banks with higher liquidity creation maintain lower capital buffers, which is less costly to them. Moreover, regulatory capital requirements work to increase the cost of equity, and the effect is greater for raising new external equity than it is for holding equity on the balance sheet (Kashyap, Stein and Hanson (2010)). Hence, banks with larger capital buffers have lower liquidity creation and face lower costs of funds. Bonner and Eijffinger (2012) find that banks pay higher interest rates to maintain more stable funding.

Profitability and market value are positively related. Berger and Bouwman (2009) find a positive relationship between liquidity creation and bank value. Increasing requirements for more liquid assets and stable funding have adverse effects on bank efficiency as interest expenses will increase with the greater reliance on longer-term stable funding and interest income will reduce on the holdings of short-term liquid assets (King (2013)). These influences on earnings and efficiency have been shown to explain the gap between the book values and market values of banks. For instance, Abuzayed, Molyneux and Al-Fayoumi (2009) show that the cost-efficiency of banks, as well as their earnings values are directly related to the resulting stock market valuations of banks. It is likely that a reduction of profitability will result in a negative spillover on the valuation of the companies' stocks by investors. This effect will be more pronounced for lower levels of earnings.

Therefore, the existing literature indicates that banks with high liquidity creation should have higher profitability and higher market value.

Hypothesis 2: Higher liquidity creation increases a bank's profitability and market value.

Bank Size

The current literature shows that bank profitability is both weakly related to bank size (Goddard, Molyneux and Wilson (2004)) and positively related to bank size (Pasiouras and Kosmidou (2007)). Larger banks enjoy a higher degree of product and loan diversification than smaller banks and derive benefit from economies of scale and scope. Additionally, larger firms face a higher cost of debt and use less debt (Binsbergen, Jules, Graham and Yang (2010); Faulkender and Petersen (2006)). Diversification to non-traditional banking activities reduces banks' costs of funds, although small and large banks face smaller reductions in their costs of funds than medium-sized banks (Deng, Elyasiani and Mao (2007)). Large banks increase the

cost of debt funding when they are forced to raise more long-term funds to improve NSFRs. Therefore, the existing literature suggests that larger banks will have a higher cost of debt funding and worse financial performance in response to increasing their asset liquidity and funding stability.

Hypothesis 3a: Larger banks face a higher cost of debt funding in response to higher liquidity creation.
Hypothesis 3b: Larger banks have high profitability and market value in response to higher liquidity creation.

Banks with High Liquidity Creation

Banks may experience better financial performance and lower costs of funds as a result of creating liquidity. Excessive liquidity creation increases the probability of bank failure (Fungáčová, Turk and Weill (2013)). Excessive liquidity creation is counterproductive since it increases the probability of failure. Moreover, Berger and Bouwman (2017) find that excessive liquidity creation is a predictor of financial crises. Excessive liquidity creation should reduce financial performance in the form of profitability and market value as a result of taking high risk. Nevertheless, excessive liquidity creation means that banks are generating a greater proportion of their funds from short-term sources which reduces the overall cost of their funds. Moreover, banks' short-term sources of funds are deposits, and these are guaranteed by deposit insurance. Hence, depositors do not charge higher costs for their deposits. Banks can meet required NSFRs most cost-effectively by increasing their holdings of higher-rated securities and by increasing the maturity of wholesale funding (King (2013)). Therefore, the existing literature suggests that banks with excessive liquidity have a lower cost of debt funding and worse financial performance due to their higher liquidity creation.

Hypothesis 4a: Banks with excessive liquidity creation face a lower cost of debt funding in response to higher liquidity creation
Hypothesis 4b: Banks with excessive liquidity creation experience lower profitability and market value in response to higher liquidity creation

The Global Financial Crisis (GFC)

Bai et al. (2016) find that high levels of liquidity mismatch negatively influence the stock returns of banks during crises. This relationship is the reverse of times when there is no

economic distress. In times of crisis, investors regard lower liquidity creation as a more desirable trait of a bank. Goh et al. (2015) find that in the global financial crisis investors placed more emphasis on information related to the variables of asset liquidity and spillovers of liquidity. Given that sufficient liquidity was largely lacking in the market during the global financial crisis, investors may have discounted the fair value estimates reported by financial institutions in order to account for the questionable liquidity of assets. Moreover, Roggi and Gianozzi (2015) find that during liquidity crises, investors show strong negative reactions to institutions with higher illiquid assets and liabilities, whereas during liquidity-expanding events investors consider illiquid assets more valuable. During the global financial crisis federal fund rates were low and hence banks' costs of funds were also low. During the GFC, profitability and market value were reduced, as were bank lending (Ivashina and Scharfstein (2010)).

Hypothesis 5a: Liquidity creation reduced banks' costs of debt funding during the global financial crisis.
Hypothesis 5b: Liquidity creation reduced banks' profitability and market values during the global financial crisis.

3.3 Data

We use US bank holding company data from quarterly call reports provided by the Federal Reserve Bank of Chicago. We exclude bank quarters for which total assets are missing. Quarterly data for the sample period from 1995: Q1 to 2014: Q4 is used in this study. We choose 1995 as the start of our sample period as this is the earliest year for which all the necessary data for calculating the liquidity creation measures are available. BHCs started reporting trading assets and liabilities from 1994: Q1 but gross fair values of derivative contracts, which are required to calculate liquidity creation, were not reported until 1995: Q1. The final quarterly data set contains 117,323 bank quarters for 3,770 bank holding companies. We analyse the data on a BHC level rather than an individual bank level due to the cross-guarantee provision of the Financial Institutions Reform, Recovery, and Enforcement Act of 1989. The Act gives the Federal Deposit Insurance Corporation (FDIC) the authority to charge off losses in relation to a failing banking subsidiary from a non-failing banking subsidiary. Ashcraft (2008) shows that this rule increases the probability of future financial distress and capital injections to subsidiaries. These findings support the use of consolidated (i.e., BHC)

information.[10] Moreover, we analysed market value which is available at the BHC level. To address outlier problems, all variables except the macroeconomic factors have been winsorised at the 1st and 99th percentiles, an approach which is widely adopted in the literature (Acharya and Mora (2015); Beltratti and Stulz (2012); Berger and Bouwman (2009)). Quarterly descriptive statistics for the full sample of bank holding companies used in our regressions are reported in Table 3.1. Following Berger and Bouwman (2009) we measure liquidity creation by means of categorisation of assets and liabilities ("CAT"), weighting their directional liquidity creation by +50% and -50% and alternatively including off-balance sheet activities ("FAT") or excluding them ("NOFAT"). The average CATNOFATs and CATFATs for the sample of bank holding companies are 11.87% and 15.60% of total assets respectively. For the average bank holding companies, total interest expenses and interest expenses on deposits are 0.63% and 0.58% of total liabilities and total deposits respectively. For the average bank holding companies, net interest margin and return on equity constitute 0.92% and 2.52% of total assets and total risk-based equity respectively. The average adjusted market-to-book value of equity, the natural logarithm of total assets, the natural logarithm of z-scores, market power and concentration are 162.38%, 13.47, 5.24, 0.01% and 33.91% respectively. On average, total liabilities and loan loss provisions for our sample of bank holding companies constitute 90.63% and 0.13% of total assets respectively. We calculate the return on equity based on risk-based equity, which is available from 1996. Adjusted market-to-book value of equity is calculated for banks that have stock prices. We calculate standard deviation of return on assets using one-year rolling window for z-scores. Therefore, the numbers of observations for return on equity, market-to-book value of equity and z-scores are less than other variables. Note that only 28.62% of banks are publicly listed and have share prices observable.

<Insert Table 3.1>

Table 3.2 reports the pair-wise correlation coefficients of the variables used in this study. We do not find the bank variables employed as explanatory variables to be highly correlated, which

[10] Note that it is also common in commercial bank literature to analyse the financial strength of the parent instead of a borrowing subsidiary. The analysis is also consistent with the current literature on market-implied systemic risk measures, as equity and CDS prices are generally available for the BHC level but not for the individual bank subsidiaries.

indicates that multi-collinearity is not a major problem in our empirical analyses. The correlation coefficient between CATNOFAT and CATFAT is 0.96 which means that the two liquidity creation measures are related. The correlation coefficients of the banks' cost of debt funding proxied by their interest expenses-to-total liabilities and interest expenses-to-total deposits with CATNOFAT are -0.27 and -0.26 respectively, and with CATFAT they are -0.33 and -0.32 respectively. The correlation coefficients of the banks' profitability proxied by their net interest margins and return on equity with CATNOFAT are 0.29 and 0.04 respectively and with CATFAT are 0.24 and 0.01 respectively. The correlation coefficients of the banks' market valuation proxied by adjusted market-to-book value of equity with CATNOFAT and CATFAT are -0.01 and 0.02 respectively.

<Insert Table 3.2>

Figure 3.2 shows that CATNOFAT and CATFAT increase over time. Figure 3.3 shows that banks that create more liquidity in the form of CATNOFAT face low costs of funds proxied by interest expenses to total liabilities. Figures 3.4 and 3.5 show that banks with high CATNOFAT have high net interest margins and adjusted market-to-book values of equity. Therefore, banks creating additional liquidity face lower costs of funds but achieve high profitability and market values.

<Insert Figure 3.2-3.5>

3.4 Model

In order to test the impact of liquidity creation on banks' costs of funds, profitability and market value we use the following model developed to test the impact of bank liquidity creation on banks' costs of funds:

$$\begin{cases} Cost\ of\ Funds_{i,t} = \alpha Liquidity_{i,t} + \beta Controls_{i,t} + \varepsilon_{i,t} \\ Liquidity_{i,t} = \gamma Cost\ of\ Funds_{i,t} + \delta Controls_{i,t} + \xi_{i,t} \end{cases} \quad (1)$$

where α and β (γ and δ) reflect the extent to which the relative factor of the model contributes to the change in the dependent variable in the cost of funds (liquidity creation) equation, and $\varepsilon_{i,t}$ and $\xi_{i,t}$ represent the error term for bank i in quarter t in the cost of funds equation and liquidity creation equation respectively. Banks' costs of funds are measured by the interest expenses-to-total liabilities and interest expenses-to-total deposits.

The independent control variables include an intercept and bank characteristics for bank i in quarter t. In all 3SLS regressions, we include bank characteristics as well as some macroeconomic factors that affect banks' costs of funds, profitability and market value. The list of control variables for bank characteristics, activities and CAMELS indicators used in this study are commonly used in the literature. Consistent with Berger and Bouwman (2009), Binsbergen et al. (2010), Bordeleau and Graham (2010), Calomiris and Nissim (2014), Díaz and Huang (2013), Dietrich et al. (2014), Distinguin et al. (2013), Fungáčová et al. (2010), Hasan et al. (2015), Ortiz-Molina and Phillips (2014) and Pasiouras and Kosmidou (2007) we consider the natural logarithm of total assets (Asset), the ratio of total liabilities divided by total assets (Leverage), the real estate loans divided by total loans (REL), the natural logarithm of z-score (z-score), loan loss provisions divided by total loans (LLP), the total assets of the five largest banks in quarter t divided by the total assets of banking system in quarter t (CONC), the growth rate of real gross domestic product (GDP), and the inflation rate (Inflation) as the potential determinants of banks' costs of funds, profitability and market value. Consistent with Berger and Bouwman (2009), Díaz and Huang (2013), Distinguin et. al. (2013) and Fungáčová et al. (2010) we consider the natural logarithm of total assets (Asset), the ratios of total assets of bank i in quarter t divided by the total assets of the banking system in quarter t (MktPow), and the growth rate of real gross domestic product (GDP) as the potential determinants of banks' liquidity creation in the liquidity equation. LLP provides information on the asset quality of banks, and a higher LLP indicates lower asset quality. High leverage indicates high credit risk. Z-score is a proxy of banks' capital adequacy and distant to default. A high z-score indicates that banks are safer. A high REL indicates banks are involved in risky activities. Conc measures the concentration in the banking system. Higher values of concentration indicate banks have a higher likelihood of collusion and of earning monopoly profit. Leverage measures the capital structure of banks. MktPow measures the market power of each bank. A summary of the definitions is provided for all control variables in Appendix 3.A.

The model for testing the impact of bank liquidity creation on banks' profitability is:

$$\begin{cases} Profitability_{i,t} = \alpha Liquidity_{i,t} + \beta Controls_{i,t} + \varepsilon_{i,t} \\ Liquidity_{i,t} = \gamma Profitability_{i,t} + \delta Controls_{i,t} + \xi_{i,t} \end{cases} \quad (3)$$

where, α andβ (γ and δ) reflect the extent to which the relative factor of the model contributes to the change in the dependent variable in the performance (liquidity creation) equation, and $\varepsilon_{i,t}$and $\xi_{i,t}$ represent the error term for bank *i* in quarter *t* in the performance equation and liquidity creation equation respectively. Banks' profitability is measured by the net interest margin and return on equity.

The model developed to test the impact of banks' liquidity creation on banks' market-to-book value of equity is:

$$\begin{cases} Market\text{-}to\text{-}Book_{i,t} = \alpha Liquidity_{i,t} + \beta Controls_{i,t} + \varepsilon_{i,t} \\ Liquidity_{i,t} = \gamma Market\text{-}to\text{-}Book_{i,t} + \delta Controls_{i,t} + \xi_{i,t} \end{cases} \quad (4)$$

where, α and β(γ and δ) reflect the extent to which the relative factor of the model contributes to the change in the dependent variable in the market-to-book value of equity (liquidity) equation, and $\varepsilon_{i,t}$and $\xi_{i,t}$ represent the error term for bank *i* in quarter *t* in the market-to-book value of equity equation and the liquidity equation respectively.

We extend the model to test the relationship between bank liquidity and banks' costs of funds and then profitability and market value for large banks and banks with high capital buffers and the profitability of banks during the global financial crisis by generating test dummies and the following models:

$$\begin{cases} Cost\ of\ Funds_{i,t} = \alpha_1 Liquidity_{i,t} + \alpha_2 Testdummy_{i,t} + \alpha_3 Testdummy_{i,t} \times Liquidity_{i,t} + \beta Controls_{i,t} + \varepsilon_{i,t} \\ Liquidity_{i,t} = \gamma_1 Cost\ of\ Funds_{i,t} + \gamma_2 Testdummy_{i,t} + \gamma_3 Testdummy_{i,t} \times Performance_{i,t} + \delta Controls_{i,t} + \xi_{i,t} \end{cases}$$

(5)

$$\begin{cases} Performance_{i,t} = \alpha_1 Liquidity_{i,t} + \alpha_2 Testdummy_{i,t} + \alpha_3 Testdummy_{i,t} \times Liquidity_{i,t} + \beta Controls_{i,t} + \varepsilon_{i,t} \\ Liquidity_{i,t} = \gamma_1 Performance_{i,t} + \gamma_2 Testdummy_{i,t} + \gamma_3 Testdummy_{i,t} \times Performance_{i,t} + \delta Controls_{i,t} + \xi_{i,t} \end{cases}$$

(6)

$$\begin{cases} Market\text{-}to\text{-}Book_{i,t} = \alpha_1 Liquidity_{i,t} + \alpha_2 Testdummy_{i,t} + \alpha_3 Testdummy_{i,t} \times Liquidity_{i,t} + \beta Controls_{i,t} + \varepsilon_{i,t} \\ Liquidity_{i,t} = \gamma_1 Market\text{-}to\text{-}Book_{i,t} + \gamma_2 Testdummy_{i,t} + \gamma_3 Testdummy_{i,t} \times Performance_{i,t} + \delta Controls_{i,t} + \xi_{i,t} \end{cases}$$

(7)

We use *Testdummy* to capture the effect of bank type. *Big* is an indicator variable taking on a value of 1 for the banks in the top decile by total asset value and zero otherwise. *HCNF* is an indicator variable with 1 for the highest quartile CATNOFAT banks and 0 otherwise. *GFC* is an indicator variable with 1 for the period from 2007: Q4 to 2009: Q3 and 0 otherwise.

We use 3SLS simultaneous equation regressions to account for potential reverse causality between bank liquidity and banks' costs of funds and financial performance. There is a possibility that banks' financial performance and costs of funds may affect their levels of liquidity. The 3SLS simultaneous equation regression addresses the potential endogeneity and cross-correlation between equations. Our 3SLS regressions capture the reverse causality between liquidity, cost of funds, profitability and market value. In our 3SLS regressions cost of funds, profitability, market value and liquidity creation are endogenous variables and all bank characteristics and macroeconomic variables are used as instruments. The 3SLS simultaneous equation regressions are widely used in the literature to address endogeneity concerns (Aggarwal and Jacques (2001); Bhagat and Bolton (2008); Distinguin, Roulet and Tarazi (2013); Shrieves and Dahl (1992)).

Proxies for bank liquidity

Berger and Bouwman (2009) introduce a measure for banks' liquidity creation, which effectively measures the extent to which banks finance relatively illiquid assets with relatively liquid liabilities. Banks creating more liquidity are taking more financial intermediation risk as a result of increasing the mismatch between the maturity of banks' assets and liabilities. Liquidity creation has been widely used in the literature as a measure of banks' liquidity risk (Berger and Bouwman (2009); Berger, Bouwman, Kick and Schaeck (2016); Distinguin, Roulet and Tarazi (2013); Horváth, Seidler and Weill (2014)). Liquidity creation considers a large number of banks' balance sheet items which are shown in Appendix 3.B. We consider two measures of liquidity creation, CATNOFAT and CATFAT.

Specifically, we follow Berger and Bouwman (2009) to compute liquidity creation as follows:

$$CATNOFAT=0.5\times Illiquid\ Assets+0.5\times Liquid\ Liabilities-0.5\times Liquid\ Assets-0.5\times Illiquid\ Liabilities-0.5\times Equity \quad (7)$$

$$CATFAT=0.5\times Illiquid\ Assets+0.5\times Liquid\ Liabilities+0.5\times Illiquid\ Guarantees-0.5\times Liquid\ Assets-0.5\times Illiquid\ Liabilities-0.5\times Equity-0.5\times Liquid\ Guarantees-0.5\times Liquid\ Derivatives \quad (8)$$

Proxies for banks' costs of funds

We use total interest expense to total liabilities and interest expenses on total deposits to total interest bearing deposits as proxies for costs of funds.

Proxies for banks' profitability

We consider the net interest margin and return on equity as proxies for banks' profitability. Net interest margin and return on assets are widely used in the literature for assessing the financial performances of banks (Angbazo (1997); Bordeleau and Graham (2010); Dietrich, Hess and Wanzenried (2014); King (2013)).

Proxies for banks' market valuation

We consider banks' adjusted market-to-book value of equity as the banks' market valuation. Banks' financial statement data are generally available within two months from the fiscal quarter end. Therefore, we calculate the adjusted market-to-book value of equity by multiplying the end-of-quarter market value of common equity by one plus cumulative stock return over the subsequent three months. Adjusted market-to-book value of equity has been widely used in the literature to consider banks' valuation (Calomiris and Nissim (2014)).

3.5 Empirical Results

3.5.1 Cost of debt funding for all banks

We first examine the effect of liquidity creation on the costs of funds for all banks. The 3SLS simultaneous equation regression results are reported in Table 3.3.

<Insert Table 3.3>

The cost of funds equation in Table 3.3 shows that increases in CATNOFAT and CATFAT reduce the cost of funds proxied by the interest expenses-to-total liabilities and interest expenses on deposits to total deposits. The liquidity equation in Table 3.3 shows that on balance, increases in the interest expenses-to-total liabilities and interest expenses on deposits to total deposits also decrease liquidity creation at a 1% level of significance. Therefore, increases in liquidity creation reduce the banks' funding costs, and costs of funds also reduce liquidity creation. Our results support the view that banks funding longer-term assets with

shorter-term liabilities pay lower rates to fund suppliers. We multiplied the coefficient of liquidity creation measures of each bank cost of funds proxy regressions with the standard deviation of liquidity creation to get the magnitude of changes and to identify the economic significance of the effects of liquidity creation. The impact of liquidity creation on banks' costs of funds is economically significant as a one standard deviation increase in a bank's CATNOFAT and CATFAT decreases the bank's interest expenses-to-total liabilities by 0.0056 and 0.0040 respectively, and the banks interest expenses on deposits to total deposits by 0.0054 and 0.0039 respectively.

The control variables in Table 3.3 are significant, as expected. The cost of funds equation results in Table 3.3 show that assets, real estate loans, z-scores, loan loss provisions and inflation increase banks' costs of funds, whereas leverage, concentration and growth rate of GDP reduce the costs of funds. Our results show that large banks face higher costs of funds which is consistent with the existing literature (Binsbergen, Jules, Graham and Yang (2010); Faulkender and Petersen (2006)). We also find that lower asset quality and inflation increase costs of funds. Our results also show that if there is a high possibility of collusion this reduces banks' costs of funds. We find that the growth rate of real GDP reduces banks' costs of funds by increasing the availability of funds. The liquidity equation results in Table 3.3 show that banks with a higher market power reduce the liquidity creation of banks and this is consistent with the existing literature which finds that market power reduces liquidity creation (Distinguin, Roulet and Tarazi (2013)). However, larger banks have more liquidity creation which is consistent with findings in the existing literature that bank size is positively related to liquidity creation (Berger and Bouwman (2009)).

In summary, our results support the view that banks can reduce costs of funds through liquidity transformation by paying lower costs for short-term funds.

3.5.2 Profitability and market value for all banks

We examine the effect of Basel III liquidity measures on profitability and market value for all banks. The 3SLS simultaneous equation regression results are also reported in Table 3.3.

<Insert Table 3.3>

The profitability equation in Table 3.3 shows that increases in CATNOFAT and CATFAT increase the net interest margin and the return on equity at a 1% level of significance. The market-to-book equation in Table 3.3 shows that increases in CATNOFAT and CATFAT

increase the adjusted market-to-book value of equity at a 1% level of significance. The liquidity equation in Table 3.3 shows that increases in net interest margins, returns on equity and market value also reduce liquidity creation at a 1% level of significance. Therefore, our results show that liquidity creation increases profitability and market value, but profitability and market value reduce liquidity creation. The impacts of liquidity creation on banks' profitability and market values are economically significant as a one standard deviation increase in a bank's CATNOFAT and CATFAT increases the net interest margin by 0.0001 and 0.0001respectively, and the return on equity by 0.0007 and 0.0005 respectively, and the market value by 0.4094 and 0.2657 respectively.

The profitability equation and market-to-book equation results in Table 3.3 show that bank size and leverage are negatively related to net interest margin but positively related to return on equity and market value, indicating that on balance size and credit risk are positively related to bank performance. However, real estate loans and loan loss provisions increase net interest margins but reduce returns on equity and market value, indicating that on balance, banks' risky activities and lower asset quality are negatively related to bank performance. Concentration reduces profitability and market value but z-scores, growth rate of real GDP and inflation increase profitability and market value. Hence, the possibility of collusion lowers bank performance whereas capital adequacy raises it. The liquidity equation results for profitability and market value are similar to those for costs of funds. The liquidity equation for profitability and market value in Table 3.3 shows that market power reduces banks' liquidity creation but bank size increases it. We also find that on balance, the growth rate of GDP increases liquidity creation.

Liquidity creation increases the investment in long-term assets and short-term funding. Long-term investment and the increased maturity gap between assets and liabilities should increase profitability as the longer-term investment, and the mismatch of maturity, are positively related to the bank profitability. We find evidence that a reduction in liquidity risk, proxied by low Berger-Bouwman liquidity creation, adversely affects banks' market-to-book values of equity consistent with Bai et al. (2016) who find that that liquidity risk is positively associated with banks' market value during normal times.

3.5.3 Cost of debt funding for big banks

The effect of bank size on the relationship between liquidity creation and cost of funds is reported in Table 3.4.

<Insert Table 3.4>

Table 3.4 shows that the interactive terms for bank size with CATNOFAT and CATFAT are positively related to the interest expenses-to-total liabilities and interest expenses on deposits to total deposits at the 1% significance level. We also find evidence that the indicator variable for bank size, *Big*, is negatively related to banks' costs of funds. Table 3.4 shows that increases in CATNOFAT and CATFAT reduce banks' costs of funds. These results indicate that the banks' costs of funds increase more in response to increases in liquidity creation for larger banks than they do for smaller banks. The liquidity equation in Table 3.4 shows that the interest expenses-to-total liabilities and interest expenses-to-total deposits of larger banks reduce the banks' CATNOFAT more in response to increases in CATNOFAT than they do for smaller banks.

Our results provide empirical evidence that costs of funds of larger banks increase more in response to increases in liquidity creation, which is consistent with the recent literature documenting that larger firms face higher costs of debt (Binsbergen, Jules, Graham and Yang (2010); Faulkender and Petersen (2006)). Our results are consistent with the idea that larger banks need to raise more funds and hence pay more for funds because price and quantity are positively related.

3.5.4 Profitability and market value for big banks

The effect of bank size on the relationship between liquidity creation and banks' profitability and market value is also reported in Table 3.4. The profitability and market-to-book equation in Table 3.4 shows that the interactive term for bank size with CATNOFAT and CATFAT is positively related to banks' profitability proxied by net interest margin and return on equity and market-to-book value at a 1% level of significance. We also find evidence that the indicator variable for bank size, *Big,* is negatively related to bank profitability and market value. Table 3.4 shows that increases in CATNOFAT and CATFAT reduce banks' profitability and market value. However, the sums of the coefficients of liquidity creation, the intercept dummy and the interaction dummy are positive which confirms our baseline finding that liquidity creation increases profitability and market value. We find evidence that liquidity creation increases the

profitability and market value of larger banks more than it does for smaller banks. The liquidity equation in Table 3.4 shows that the net interest margin, return on equity and market value of larger banks increases CATNOFAT and CATFAT more than it does for other banks based on the interactive term for bank size with profitability and market value.

We find evidence that large banks obtain the most benefit from liquidity creation, which is consistent with the view that larger banks may have better usage of scale and scope of economies, implicit subsidies ('too big to fail') and higher market power.

3.5.5 Cost of debt funding in banks with high liquidity creation

The effect of bank liquidity creation level on the relationship between liquidity creation and cost of funds is reported in Table 3.5.

<Insert Table 3.5>

Table 3.5 shows that the interactive terms for bank liquidity creation with CATNOFAT and CATFAT are negatively related to the interest expenses-to-total liabilities and interest expenses-to-total deposits at the 1% significance level. We find evidence that the indicator variable for banks' capital buffers, *HCNF*, is positively related to banks' costs of funds. Table 3.5 shows that increases in CATNOFAT and CATFAT reduce banks' costs of funds. These results indicate that banks' costs of funds decrease in response to increases in liquidity creation in banks with high liquidity creation. The liquidity equation in Table 3.5 shows that the costs of funds in banks with high liquidity creation reduce the banks' liquidity creation more based on the interactive term between high liquidity creation and cost of funds.

Our results provide empirical evidence to indicate that banks with high liquidity creation will experience a lower cost of funds in response to increases in banks' liquidity creation compared to banks with lower liquidity creation.

3.5.6 Profitability and market value in banks with high liquidity creation

The effect of bank liquidity creation level on the relationship between liquidity creation and banks' profitability and market values is also reported in Table 3.5. The profitability equation and the market-to-book equation in Table 3.5 show that the interaction term for bank liquidity creation with CATNOFAT and CATFAT is negatively related to banks' profitability proxied by net interest margin and return on equity and market value at a 1% level of significance. We

find evidence that the indicator variable for banks' liquidity creation, *HCNF,* is positively related to bank profitability on balance. Table 3.5 shows that increases in CATNOFAT and CATFAT increase banks' profitability and market values. Therefore, we find evidence that liquidity creation reduces the profitability and market values of banks with high liquidity creation more than it does for banks with low liquidity creation. The liquidity equation in Table 3.5 shows that banks' profitability and market values increase the liquidity creation more than they do for banks with high liquidity creation based on the interactive term for bank capital buffers with profitability and market value.

We find evidence that banks with high levels of liquidity creation experience lower profitability and market values. Banks creating excessive liquidity are taking more liquidity risk and their profitability and market values may decrease because they are taking more liquidity risk.

3.5.7 Cost of debt funding in banks during the global financial crisis

The relationship between liquidity creation and cost of funds during global financial crisis is reported in Table 3.6.

<Insert Table 3.6>

Table 3.6 shows that the interactive terms for the global financial crisis with CATNOFAT and with CATFAT are negatively related to the interest expenses-to-total liabilities and interest expenses-to-total deposits at a 1% significance level. We find evidence that the indicator variable for the global financial crisis, GFC, is positively related to banks' costs of funds. Table 3.6 shows that increases in CATNOFAT and CATFAT reduce banks' costs of funds. These results indicate that the banks' costs of funds decreased in response to increases in liquidity creation during the global financial crisis. The liquidity equation in Table 3.6 shows that the costs of funds decrease the banks' liquidity creation more based on the interactive term between global financial crisis and cost of funds during the global financial crisis.

During global financial crisis the federal funds rate was low. As a result, banks faced lower costs of funds in repsonse to increases in liquidity creation during the global financial crisis.

3.5.8 Profitability and market value during global crisis

The effect of the global financial crisis on the relationship between liquidity creation and banks' profitability and market value is also reported in Table 3.6. The profitability equation

and market-to-book equation in Table 3.6 show that the interaction term for the global financial crisis with CATNOFAT and CATFAT is negatively related to banks' profitability proxied by net interest margin and returns on equity and market value at the 1% level of significance. We find evidence that the indicator variable for the global financial crisis, *GFC,* is positively related to bank profitability and market value. Table 3.6 shows that increases in CATNOFAT and CATFAT increase banks' profitability and market value. Therefore, we find evidence that liquidity creation decreases profitability and market value during crisis times compared to normal times. The liquidity equation in Table 3.6 shows that banks' profitability and market value increased liquidity creation more during the global financial crisis based on the interactive term for global financial crisis with profitability and market value.

We find evidence that banks experience worse profitability and lower market values during crises.

3.6 Conclusion

In this study we calculated the liquidity creation measures of US bank holding companies using historical call report data over the period from 1995 to 2014 to investigate the impact of liquidity creation on banks' debt funding costs, profitability and market value.

We find empirical evidence to suggest that increases in liquidity creation measures generally increase banks' profitability and market value but decrease their funding costs. We find evidence that the costs of funds, profitability and value in turn also affect liquidity creation. In addition, larger banks face higher costs of debt funding, profitability and market value. However, banks with the highest liquidity creation levels face lower costs of debt funding, profitability and market value. Moreover, banks faced lower funding costs, profitability and market value during the global financial crisis compared to normal times. Our results show that liquidity creation improves bank performance. In summary, banks benefit from transforming liquidity. However, it has been documented in recent studies that too much liquidity creation increases the probability of bank failures (Fungáčová, Turk and Weill (2013)) and the likelihood of a financial crisis (Berger and Bouwman (2017)). Liquidity creation is good for banks, as liquidity creation reduces banks' funding costs but increases bank performance as captured by profitability and value creation.

There are important policy implications from our findings. As the NSFR and LCR introduced under new Basel III rules are inversely related to liquidity creation, it is not clear whether the required ratio of 100% will be sufficient for managing bank liquidity risk.

Our findings from US bank holding companies is heavily influenced by the provision of deposit insurance as part of the financial safety net. Future research on liquidity creation should focus on other economies where deposit and liability guarantee schemes are less pervasive.

Figures

The grey shaded areas, 2002: Q1–2002: Q4 and 2007: Q4–2009: Q3, in Figures 2 to 7 show economic recession periods as indicated by the National Bureau of Economic Research (NBER).

Figure 3.1: Liquidity, cost of funds and profitability

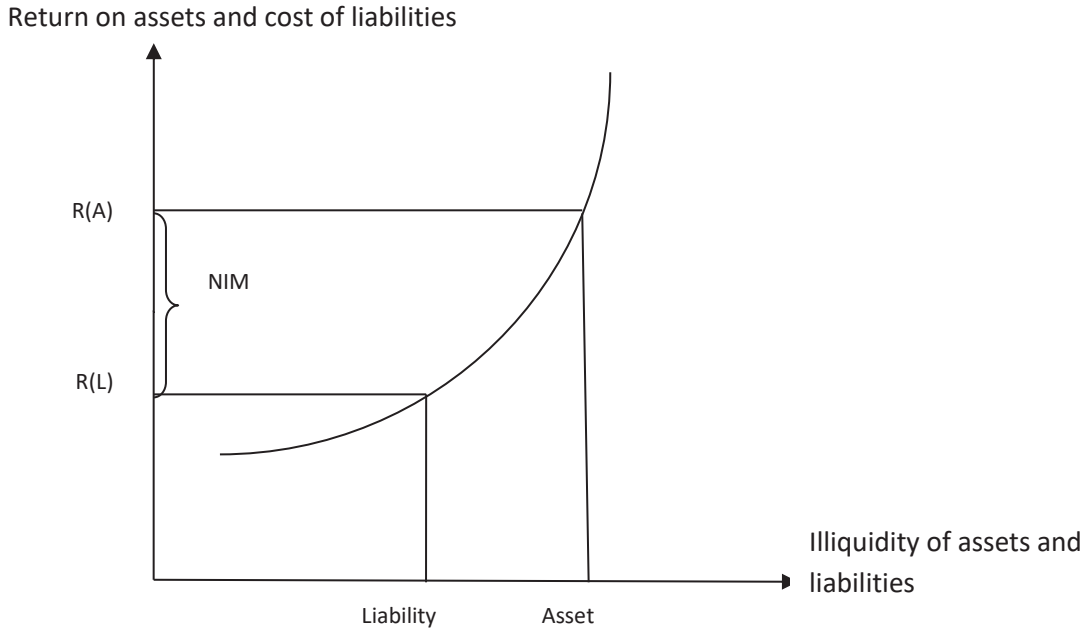

Figure 3.2: CATNOFAT/total assets and CATFAT/total assets

Figure 3.2 shows the CATNOFAT-to-total assets and CATFAT-to-total assets of US bank holding companies from 1995 to 2014.

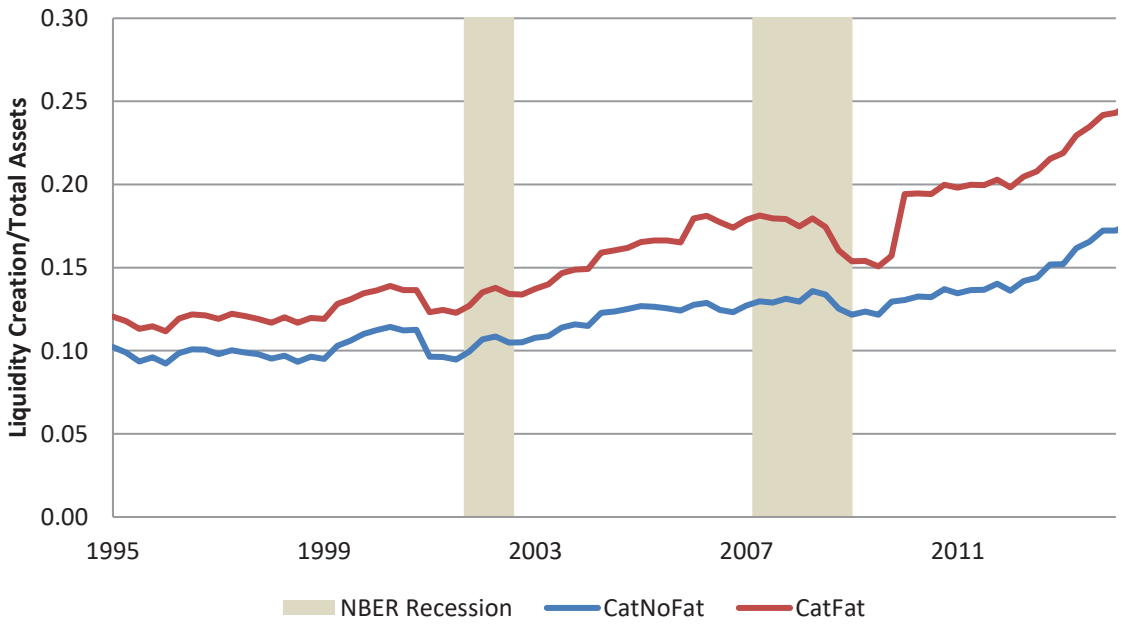

Figure 3.3: Interest expenses to total liabilities of high CATNOFAT and low CATNOFAT banks

Figure 3.3 shows the interest expenses-to-total liabilities of US bank holding companies with high and low CATNOFAT, from 1995 to 2014. High indicates above the median value. IntExp_LCNF and Intexp_HCNF indicate the interest expenses-to-total liabilities of high and low CATNOFAT banks respectively.

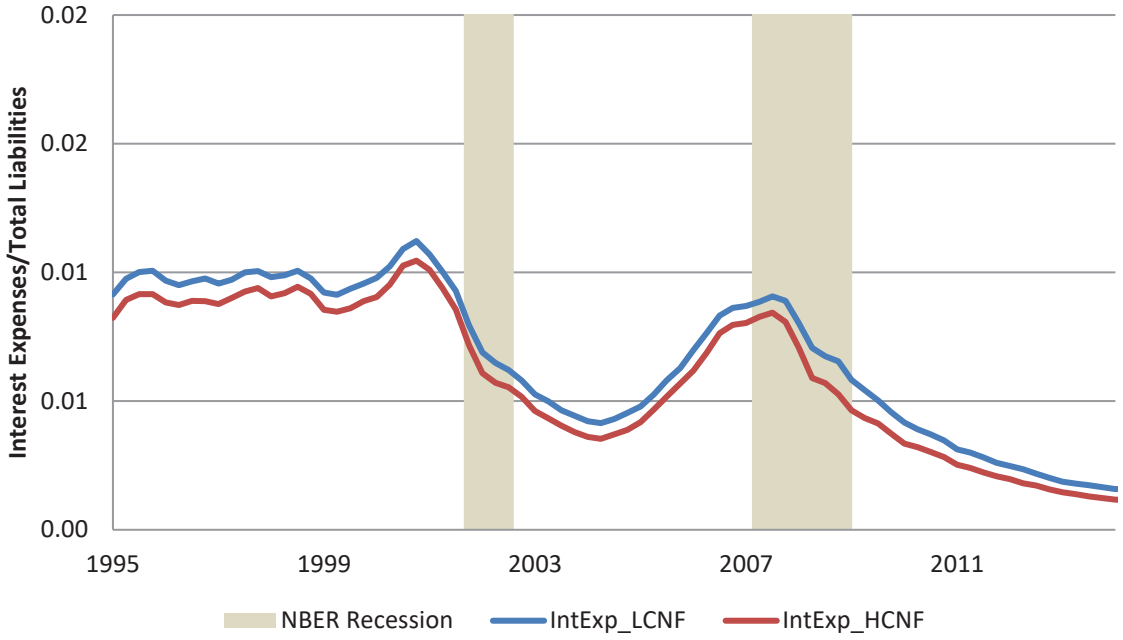

Figure 3.4: Net interest margin of high CATNOFAT and low CATNOFAT banks

Figure 3.4 shows the net interest margins of US bank holding companies with high and low CATNOFAT, from 1995 to 2014. High indicates above the median value. NIM_LCNF and NIM_HCNF indicate the net interest margins of high and low CATNOFAT banks respectively.

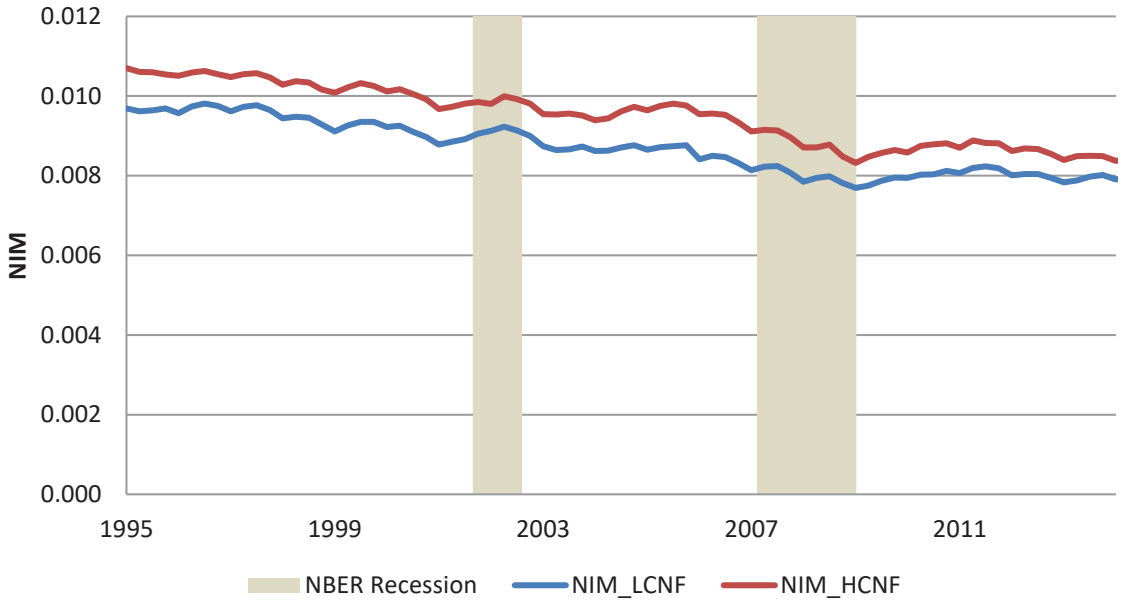

Figure 3.5: Market-to-book values of equity of high CATNOFAT and low CATNOFAT banks

Figure 3.5 shows the market-to-book values of equity of US bank holding companies with high and low CATNOFAT, from 1995 to 2014. High indicates above the median value. MTB_LCNF and MTB_HCNF indicate market-to-book values of equity of high and low CATNOFAT banks respectively.

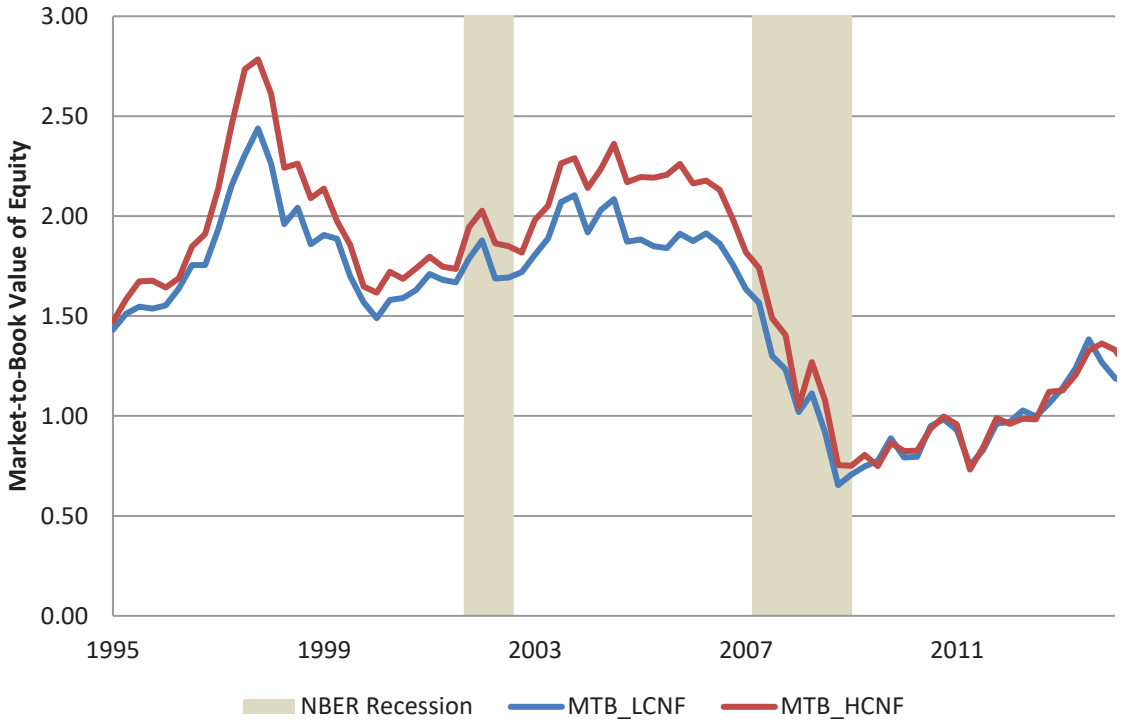

Table 3.1: Summary statistics

Table 3.1 reports the summary statistics of quarterly data for 3,770 bank holding companies from 1995: Q1 to 2014: Q4. The top and bottom 1% of all observations for all variables except the macroeconomic factors have been winsorised to limit the extreme values.

Variable	Mean	Std. Dev.	Min	Max	Obs
		Dependent Variable			
IntLiab	0.0063	0.0033	0.0006	0.0173	115,908
IntDep	0.0058	0.0032	0.0000	0.0198	115,825
NIM	0.0092	0.0015	0.0070	0.0117	115,910
ROE	0.0252	0.0118	0.0053	0.0435	106,123
MTB	1.6263	0.8201	0.1697	4.5002	32,482
		Independent Variable			
CATNOFAT	0.1187	0.1104	-0.2027	0.4273	117,323
CATFAT	0.1560	0.1268	-0.2073	0.4748	117,323
		Control Variable			
Asset	13.4748	1.3708	10.5768	18.4258	117,323
LLP	0.0013	0.0024	-0.0011	0.0174	115,617
Leverage	0.9063	0.0294	0.7962	0.9808	117,323
REL	0.6890	0.1746	0.1152	0.9817	117,280
Z-Score	5.2404	1.1371	1.3736	7.5053	109,457
Conc	0.3391	0.1195	0.2085	0.5562	117,323
MktPow	0.0001	0.0002	0.0000	0.0006	117,323
GDP	0.0266	0.0242	-0.0819	0.0777	117,323
Inflation	0.0242	0.0100	-0.0162	0.0530	117,323

Table 3.2: Pairwise Pearson correlation coefficients

Table 2 reports the correlation coefficients of quarterly data for 3,770 bank holding companies from 1995: Q1 to 2014: Q4. The top and bottom 1% of all observations for all variables except the macroeconomic factors have been winsorised to limit the extreme values.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1IntLiab	1.00															
2IntDep	0.97	1.00														
3NIM	0.12	0.15	1.00													
4ROE	0.15	0.16	0.39	1.00												
5MTB	0.06	0.03	0.02	0.15	1.00											
6CATNOFAT	-0.27	-0.26	0.29	0.04	-0.01	1.00										
7CATFAT	-0.33	-0.32	0.24	0.01	0.02	0.96	1.00									
8Asset	-0.18	-0.21	-0.28	-0.04	0.45	0.04	0.11	1.00								
9LLP	-0.03	-0.03	-0.05	-0.33	-0.04	0.01	0.01	0.13	1.00							
10Leverage	0.14	0.12	-0.12	0.04	0.00	0.22	0.19	-0.01	0.05	1.00						
11REL	-0.15	-0.14	-0.12	-0.18	-0.04	-0.15	-0.08	-0.12	-0.04	0.06	1.00					
12Z-Score	0.05	0.06	0.10	0.26	0.18	-0.05	-0.04	0.01	-0.41	-0.25	-0.02	1.00				
13Conc	-0.40	-0.39	-0.34	-0.35	-0.06	0.15	0.23	0.34	0.21	0.00	0.21	-0.18	1.00			
14MktPow	0.01	-0.03	-0.16	0.06	0.47	-0.02	0.03	0.90	0.08	-0.02	-0.22	0.06	0.11	1.00		
15GDP	0.11	0.10	0.20	0.20	0.06	-0.03	-0.06	-0.13	-0.15	-0.01	-0.11	0.14	-0.36	-0.02	1.00	
16Inflation	0.23	0.22	0.08	0.11	0.02	-0.02	-0.03	-0.07	-0.15	0.05	-0.01	0.11	-0.12	-0.03	0.04	1.00

Table 3.3: Cost of funds, profitability and market value of all banks

Table 3.3 reports 3SLS simultaneous regression results to test the impact of liquidity creation (CATNOFAT and CATFAT) on banks' costs of funds, profitability and market values. We use 3SLS simultaneous regressions to capture potential reverse causality. Banks' costs of funds are proxied by the interest expenses-to-total liabilities (IntLiab) and interest expenses-to-total deposits (IntDep). Banks' profitability is proxied by the net interest margin (NIM) and return on equity (ROE) whereas banks' market value is proxied by adjusted market-to-book value of equity (MTB). Bank characteristics and macroeconomic factors are used as control variables in the cost of funds equation and the liquidity equation. Quarterly data of US bank holding companies over the period from 1995: Q1 to 2014: Q4 has been used. P-values are computed using heteroskedasticity-robust standard errors and are presented in parentheses. *, **, and *** represent statistical significance at the 10%, 5% and 1% levels, respectively.

	1	2	3	4	5	6	7	8	9	10
	Cost of Funds equation				***Profitability equation***				***Market-to-Book equation***	
	IntLiab	IntDep	IntLiab	IntDep	NIM	ROE	NIM	ROE	MTB	MTB
CATNOFAT	-0.0504***	-0.0488***			0.0009***	0.0063***			3.7084***	
	(0.0000)	(0.0000)			(0.0010)	(0.0076)			(0.0000)	
CATFAT			-0.0318***	-0.0304***			0.0006***	0.0037***		2.0963***
			(0.0000)	(0.0000)			(0.0002)	(0.0095)		(0.0000)
Asset	0.0001***	0.0000	0.0003***	0.0002***	-0.0002***	0.0007***	-0.0002***	0.0007***	0.1215***	0.1197***
	(0.0000)	(0.8975)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Leverage	0.0018	0.0008	-0.0080***	-0.0093***	-0.0100***	0.0297***	-0.0093***	0.0235***	3.0743***	3.0120***
	(0.5647)	(0.7855)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
REL	0.0019***	0.0016***	0.0021***	0.0020***	0.0002***	-0.0076***	0.0001***	-0.0069***	-0.2307***	-0.2228***
	(0.0002)	(0.0008)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Z-Score	0.0001***	0.0001***	0.0000	0.0000***	0.0000***	0.0013***	0.0000***	0.0012***	0.0727***	0.0665***
	(0.0000)	(0.0000)	(0.7604)	(0.0095)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
LLP	0.2135***	0.2037***	0.1938***	0.1815***	0.0547***	-1.1234***	0.0525***	-1.0921***	-49.8616***	-47.3749***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Conc	-0.0139***	-0.0120***	-0.0137***	-0.0122***	-0.0038***	-0.0270***	-0.0039***	-0.0289***	-2.7793***	-2.8910***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
GDP	-0.0126***	-0.0117***	-0.0122***	-0.0114***	0.0041***	0.0221***	0.0040***	0.0201***	3.2400***	3.0804***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Inflation	0.0832***	0.0714***	0.0597***	0.0502***	0.0076***	0.0315***	0.0063***	0.0318***	1.3291***	1.0620***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0009)	(0.0066)
Constant	0.0097***	0.0114***	0.0164***	0.0184***	0.0212***	-0.0036*	0.0209***	0.0022	-2.6157***	-2.3648***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0583)	(0.0000)	(0.1742)	(0.0000)	(0.0000)
	Liquidity equation				***Liquidity equation***				***Liquidity equation***	
	CATNOFAT	CATNOFAT	CATFAT	CATFAT	CATNOFAT	CATNOFAT	CATFAT	CATFAT	CATNOFAT	CATFAT
IntLiab	4.9963***		-0.4599							
	(0.0000)		(0.1759)							
IntDep		5.0193***		-1.2495***						
		(0.0000)		(0.0012)						
NIM					-32.2196***		-54.3608***			
					(0.0000)		(0.0000)			
ROE						-0.0018		-1.0850***		
						(0.9785)		(0.0000)		
MTB									-0.0271***	-0.0516***
									(0.0000)	(0.0000)
Asset	0.0332***	0.0327***	0.0395***	0.0376***	-0.0022***	0.0066***	0.0016***	0.0170***	0.0112***	0.0218***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0015)	(0.0000)	(0.0000)	(0.0000)
MktPow	-270.9683***	-260.4629***	-286.9387***	-271.5043***	-2.2454***	-2.4993***	-4.2293***	-4.4875***	-2.3374***	-4.2046***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
GDP	-0.0170	-0.0124	-0.0273*	-0.0264*	0.1970***	-0.1120***	0.3348***	-0.0744***	0.1064***	0.2593***
	(0.2431)	(0.3948)	(0.0858)	(0.0941)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0004)	(0.0000)
Constant	-0.3292***	-0.3214***	-0.3395***	-0.3119***	0.4414***	0.0371***	0.6295***	-0.0373***	0.0019	-0.0666***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.7793)	(0.0000)
Observations	109,184	109,125	109,184	109,125	109,184	100,662	109,184	100,662	31,209	31,209

Table 3.4: Cost of funds, profitability and market value of big banks

Table 3.4 reports 3SLS simultaneous regression results to test the impact of liquidity creation (CATNOFAT and CATFAT) on the costs of funds, profitability and market value of large banks. We use 3SLS simultaneous regressions to capture potential reverse causality. Big is an indicator variable which takes on values of 1 for banks in the top quartile by total asset value and zero otherwise. Banks' costs of funds are proxied by the interest expenses-to-total liabilities (IntLiab) and interest expenses-to-total deposits (IntDep). Banks' profitability is proxied by the net interest margin (NIM) and return on equity (ROE) whereas banks' market value is proxied by the adjusted market-to-book value of equity (MTB). Bank characteristics and macroeconomic factors are used as control variables in the cost of funds equation, the profitability equation, the market-to-book equation and the liquidity equation. Quarterly data of US bank holding companies over the period from 1995: Q1 to 2014: Q4 has been used. P-values are computed using heteroskedasticity-robust standard errors and are presented in parentheses. *, **, and *** represent statistical significance at the 10%, 5% and 1% levels, respectively.

	1	2	3	4	5	6	7	8	9	10
	Cost of Funds equation				***Profitability equation***				***Market-to-Book equation***	
	IntLiab	IntDep	IntLiab	IntDep	NIM	ROE	NIM	ROE	MTB	MTB
CATNOFAT×Big	0.0050	0.0118***			0.0796***	0.0405***			13.9259***	
	(0.2339)	(0.0008)			(0.0000)	(0.0000)			(0.0000)	
CATFAT×Big			0.0139***	0.0109***			0.0406***	0.2129***		68.2571***
			(0.0000)	(0.0000)			(0.0000)	(0.0000)		(0.0000)
Big	-0.0011**	-0.0017***	-0.0023***	-0.0017***	-0.0092***	-0.0035***	-0.0063***	-0.0324***	-1.3866***	-10.5013***
	(0.0373)	(0.0001)	(0.0000)	(0.0000)	(0.0000)	(0.0004)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
CATNOFAT	-0.0693***	-0.0658***			-0.0438***	-0.0222***			-10.3907***	
	(0.0000)	(0.0000)			(0.0000)	(0.0063)			(0.0000)	
CATFAT			-0.0406***	-0.0327***			-0.0170***	-0.1305***		-56.2026***
			(0.0000)	(0.0000)			(0.0000)	(0.0000)		(0.0000)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	Liquidity equation				***Liquidity equation***				***Liquidity equation***	
	CATNOFAT	CATNOFAT	CATNOFAT	CATNOFAT	CATNOFAT	CATFAT	CATNOFAT	CATFAT	CATNOFAT	CATNOFAT
IntLiab×Big	-15.6884***		-25.2354***							
	(0.0000)		(0.0000)							
IntDep×Big		-17.6810***		-27.9322***						
		(0.0000)		(0.0000)						
NIM×Big					47.3787***		70.0510***			
					(0.0000)		(0.0000)			
ROE×Big						0.4135***		3.8565***		
						(0.0001)		(0.0000)		
MTB×Big									0.0848***	0.0469***
									(0.0000)	(0.0000)
Big	0.0886***	0.0919***	0.1498***	0.1533***	-0.4487***	-0.0397***	-0.6616***	-0.1371***	-0.1453***	-0.0973***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
IntLiab	6.1640***		5.6118***							
	(0.0000)		(0.0000)							
IntDep		6.7416***		6.3857***						
		(0.0000)		(0.0000)						
NIM					-19.8363***		-36.0068***			
					(0.0000)		(0.0000)			
ROE						0.9266***		-0.6797***		
						(0.0000)		(0.0000)		
MTB									-0.0574***	-0.0400***
									(0.0000)	(0.0000)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	109,184	109,125	109,184	109,125	109,184	100,662	109,184	100,662	31,209	31,209

Table 3.5: Cost of funds, profitability and market value of banks having high liquidity creation

Table 3.5 reports 3SLS simultaneous regression results to test the impact of liquidity creation (CATNOFAT and CATFAT) on the costs of funds, profitability and market value of banks with high capital buffers. We use 3SLS simultaneous regressions to capture potential reverse causality. HCNF is an indicator variable taking on values of 1 for the top quartile banks in terms of the size of their liquidity creation measured by CATNOFAT and zero otherwise. Banks' costs of funds are proxied by the interest expenses-to-total liabilities (IntLiab) and interest expenses-to-total deposits (IntDep). Banks' profitability is proxied by the net interest margin (NIM) and return on equity (ROE) whereas banks' market value is proxied by adjusted market-to-book value of equity (MTB). Bank characteristics and macroeconomic factors are used as control variables in the cost of funds equation, the profitability equation, the market-to-book equation and the liquidity equation. Quarterly data of US bank holding companies over the period from 1995: Q1 to 2014: Q4 has been used. P-values are computed using heteroskedasticity-robust standard errors and are presented in parentheses. *, **, and *** represent statistical significance at the 10%, 5% and 1% levels, respectively.

	1	2	3	4	5	6	7	8	9	10
	Cost of Funds equation				***Profitability equation***				***Market-to-Book equation***	
	IntLiab	IntDep	IntLiab	IntDep	NIM	ROE	NIM	ROE	MTB	MTB
CATNOFAT×HCNF	-0.0678***	-0.1014***			-0.0119***	-0.0357***			-3.6807***	
	(0.0000)	(0.0000)			(0.0000)	(0.0000)			(0.0000)	
CATFAT×HCNF			-0.0109***	-0.0179***			-0.0082***	-0.0376***		-3.5184***
			(0.0000)	(0.0000)			(0.0000)	(0.0000)		(0.0000)
HCNF	0.0198***	0.0242***	0.0062***	0.0072***	0.0004***	-0.0048***	0.0017***	0.0046***	-0.6770***	0.3660***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
CATNOFAT	-0.0207***	0.0041			0.0209***	0.0881***			9.7627***	
	(0.0011)	(0.5792)			(0.0000)	(0.0000)			(0.0000)	
CATFAT			-0.0212***	-0.0148***			0.0093***	0.0437***		4.3209***
			(0.0000)	(0.0000)			(0.0000)	(0.0000)		(0.0000)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	Liquidity equation				***Liquidity equation***				***Liquidity equation***	
	CATNOFAT	CATNOFAT	CATNOFAT	CATNOFAT	CATNOFAT	CATFAT	CATNOFAT	CATFAT	CATNOFAT	CATNOFAT
IntLiab×HCNF	-7.8165***		-17.4058***							
	(0.0000)		(0.0000)							
IntDep×HCNF		-7.0308***		-17.0674***						
		(0.0000)		(0.0000)						
NIM×HCNF					57.7753***		37.1495***			
					(0.0000)		(0.0000)			
ROE×HCNF						3.6039***		2.5321***		
						(0.0000)		(0.0000)		
MTB×HCNF									0.0699***	0.0660***
									(0.0000)	(0.0000)
HCNF	0.2175***	0.2090***	0.2858***	0.2751***	-0.3554***	0.0787***	-0.1352***	0.1219***	0.0563***	0.0801***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
IntLiab	1.3621***		1.5324***							
	(0.0000)		(0.0000)							
IntDep		0.7755***		1.0529***						
		(0.0093)		(0.0023)						
NIM					-46.3075***		-51.4416***			
					(0.0000)		(0.0000)			
ROE						-1.9703***		-2.6308***		
						(0.0000)		(0.0000)		
MTB									-0.0509***	-0.0735***
									(0.0000)	(0.0000)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	109,184	109,125	109,184	109,125	109,184	100,662	109,184	100,662	31,209	31,209

Table 3.6: Cost of funds, profitability and market value during global financial crisis

Table 3.6 reports 3SLS simultaneous regression results to test the impact of liquidity creation (CATNOFAT and CATFAT) on the costs of funds, profitability and market value of banks during the global financial crisis. We use 3SLS simultaneous regressions to capture potential reverse causality. GFC is an indicator variable taking on values of 1 for the period from 2007: Q4 to 2009: Q3 and zero otherwise. Banks' costs of funds are proxied by the interest expenses-to-total liabilities (IntLiab) and interest expenses-to-total deposits (IntDep). Banks' profitability is proxied by the net interest margin (NIM) and return on equity (ROE) whereas banks' market value is proxied by adjusted market-to-book value of equity (MTB). Bank characteristics and macroeconomic factors are used as control variables in the cost of funds equation, the profitability equation, the market-to-book equation and the liquidity equation. Quarterly data of US bank holding companies over the period from 1995: Q1 to 2014: Q4 has been used. P-values are computed using heteroskedasticity-robust standard errors and are presented in parentheses. *, **, and *** represent statistical significance at the 10%, 5% and 1% levels, respectively.

	1	2	3	4	5	6	7	8	9	10
	Cost of Funds equation				***Profitability equation***				***Market-to-Book equation***	
	IntLiab	IntDep	IntLiab	IntDep	NIM	ROE	NIM	ROE	MTB	MTB
CATNOFAT×GFC	-0.0184***	-0.0142***			-0.0028***	-0.0067**			-2.0646***	
	(0.0000)	(0.0000)			(0.0000)	(0.0162)			(0.0000)	
CATFAT×GFC			-0.0223***	-0.0189***			-0.0033***	-0.0197***		-2.3189***
			(0.0000)	(0.0000)			(0.0000)	(0.0000)		(0.0000)
GFC	0.0052***	0.0046***	0.0060***	0.0053***	0.0005***	0.0005	0.0007***	0.0033***	0.3067***	0.4863***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.2821)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
CATNOFAT	-0.0561***	-0.0541***			0.0043***	-0.0071***			3.5253***	
	(0.0000)	(0.0000)			(0.0000)	(0.0088)			(0.0000)	
CATFAT			-0.0359***	-0.0343***			0.0024***	0.0016		2.2093***
			(0.0000)	(0.0000)			(0.0000)	(0.3232)		(0.0000)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	Liquidity equation				***Liquidity equation***				***Liquidity equation***	
	CATNOFAT	CATNOFAT	CATNOFAT	CATNOFAT	CATNOFAT	CATFAT	CATNOFAT	CATFAT	CATNOFAT	CATNOFAT
IntLiab×GFC	-11.2756***		-7.1573***							
	(0.0000)		(0.0000)							
IntDep×GFC		-12.2697***		-7.5139***						
		(0.0000)		(0.0000)						
NIM×GFC					29.4854***		15.2967***			
					(0.0000)		(0.0000)			
ROE×GFC						-0.5136***		0.3041**		
						(0.0001)		(0.0392)		
MTB×GFC									0.0583***	0.0627***
									(0.0000)	(0.0000)
GFC	0.0661***	0.0676***	0.0358***	0.0374***	-0.2583***	0.0080***	-0.1639***	-0.0307***	-0.0730***	-0.1074***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0060)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
IntLiab	2.4679***		-4.3754***							
	(0.0000)		(0.0000)							
IntDep		2.0710***		-5.7645***						
		(0.0000)		(0.0000)						
NIM					-34.3696***		-59.2621***			
					(0.0000)		(0.0000)			
ROE						-0.1975***		-1.8367***		
						(0.0093)		(0.0000)		
MTB									-0.0364***	-0.0698***
									(0.0000)	(0.0000)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	109,184	109,125	109,184	109,125	109,184	100,662	109,184	100,662	31,209	31,209

Appendix – Chapter 3

Appendix 3.A Variable Names and Construction of Variables

Variable	Construction	Data Source
IntLiab	Total interest expense/total liabilities	Federal Reserve Bank
IntDep	Total interest expense on deposits/total deposits	Federal Reserve Bank
NIM	Net Interest Margin=Net interest income / Total Assets	Federal Reserve Bank
ROE	Return on Equity=Net income / risk-based equity	Federal Reserve Bank
MTB	(Market Value of Equity / Book Value of Equity)×(1+Cumlative Stock Return over the subsequent three Months)	Federal Reserve Bank and CRSP
CATNOFAT	CATNOFAT/Total Assets. CATNOFAT=0.5×Illiquid Assets+0.5×Liquid Liabilities-0.5×Liquid Assets-0.5×Illiquid Liabilities-0.5×Equity	Federal Reserve Bank
CATFAT	CATFAT/Total Assets. CATFAT=0.5×Illiquid Assets+0.5×Liquid Liabilities+0.5×Illiquid Guarantees-0.5×Liquid Assets-0.5×Illiquid Liabilities-0.5×Equity-0.5×Liquid Guarantees-0.5×Liquid Derivatives	Federal Reserve Bank
Asset	Natural Logarithm of Total Assets	Federal Reserve Bank
LLP	Loan Loss Provisions/Total Assets	Federal Reserve Bank
Leverage	Total Liabilities/Total Assets	Federal Reserve Bank
REL	Real Estate Loans / Total Loans	Federal Reserve Bank
Z-Score	Log [{Return on Assets+(Equity/Asset)}/Standard Deviation of Return on Assets]. Standard Deviation of Return on Assets is calculated using 1-year rolling window.	Federal Reserve Bank
AssGDP	Total Assets of Banking System in quarter *t* / Real Gross Domestic Product in quarter t	Federal Reserve Bank and Datastream
Conc	Total Assets of the Five Largest Banks in quarter *t* / Total Assets of Banking System in quarter *t*	Federal Reserve Bank
MktPow	Total Assets of Bank *i* in quarter *t* / Total Assets of Banking System in quarter *t*	Federal Reserve Bank
GDP	Annual Growth Rate of Real Gross Domestic Product	Datastream
Inflation	Annual Inflation Rate	Datastream
Big	Indicator variable with 1 for the biggest quartile bank holding companies and 0 otherwise	Federal Reserve Bank
HCB	HCB is an indicator variable with 1 for the highest quartile capital buffer Commercial Banks and 0 otherwise. Capital Buffer = (Actual Regulatory Capital – Risk-Weighted Assets×0.08) / Risk-Weighted Assets.	Federal Reserve Bank
HCNF	HCNF is an indicator variable with 1 for the highest quartile CATNOFAT Commercial Banks and 0 otherwise.	Federal Reserve Bank
GFC	Indicator variable with 1 for the period from 2007: Q4 to 2009: Q3 and 0 otherwise.	

Appendix 3.B: Summary of liquidity creation calculation of US commercial banks

Illiquid assets	
Commercial real estate loans (CRE)	Loans to finance commercial real estate, construction and land development activities (not secured by real estate)
Loans to finance agricultural production	Loans to finance agricultural production and other loans to farmers
Commercial and industrial loans (C&I)	Commercial and industrial loans
Other loans and lease financing receivables	
	Other loans for purchasing or carrying securities
	All other loans
	All other leases
Other real estate owned (OREO)	Other real estate owned
Investment in unconsolidated subsidiaries	Investments in unconsolidated subsidiaries and associated companies
Intangible assets	
	Goodwill
	Other intangible assets
Premises	Premises and fixed assets
Other assets	Other assets
Liquid assets	
Cash and due from other institutions	Cash and due from depository institutions
All securities (regardless of maturity)	
	Held-to-maturity securities
	Available-for-sale securities
Trading assets	Trading assets
Fed funds sold	Federal funds sold and securities purchased under agreements to resell
Liquid liabilities	
Transactions deposits	
	Noninterest-bearing balances
	Interest-bearing demand deposits, now, ATS, and other transaction accounts
Savings deposits	Money market deposit accounts and other savings accounts
Overnight federal funds purchased	Federal funds purchased in domestic offices
Trading liabilities	Trading liabilities
Illiquid liabilities	
Subordinated debt	
	Subordinated notes and debentures
	Subordinated notes payable to unconsolidated trusts issuing trust preferred securities, and trust preferred securities issued by consolidated special purpose entities
Other liabilities	Other liabilities
Equity	
Total equity	Total equity
Illiquid guarantees	
	Unused commitments
	Financial standby letters of credit and foreign office guarantees
	Performance standby letters of credit and foreign office guarantees
	Commercial and similar letters of credit
	All other off-balance sheet liabilities
Liquid guarantees notional values	Risk participations in bankers acceptances acquired by the reporting institution
Liquid derivatives gross fair values	
	Interest rate derivatives
	Foreign exchange derivatives
	Equity and commodity derivatives

4 Investors' perceptions of bank liquidity[11]

4.1 Introduction

The Basel Committee on Banking Supervision (BCBS) introduced new liquidity standards in global banking regulation due to the serious liquidity disruptions which occurred during the global financial crisis of 2007–2008. In 2010, the BCBS proposed two new liquidity requirements – the liquidity coverage ratio (LCR) and the net stable funding ratio (NSFR). The former is designed to increase banks' liquidity to enable them to better weather stressful situations and the latter is designed to enhance funding stability. The LCR requires banks to maintain sufficient high-quality liquid assets to meet their liquidity needs when there is likely to be a significant proportion of cash outflow. The NSFR requires banks to use more stable funding sources like long-term debt for supporting their assets and off-balance sheet activities, and to hold more high-quality liquid assets. Conceptually, the LCR reduces banks' liquidity risk by increasing their high-quality liquid assets, and the NSFR reduces funding and interest rate risks originating from the maturity mismatch between assets and liabilities (King (2013)).

It is not clear how these new liquidity standards will affect the market valuation of banks' equity. On the one hand, more liquid banks earn a lower return due to maintaining more high-quality liquid assets and because they are subject to higher costs for stable funding. As a result, markets may consider the high LCR and NSFR banks to be less valuable because of their lower profitability. The anticipation of tighter Basel III liquidity regulations may trigger large negative cumulative abnormal returns (Bruno, Onali and Schaeck (2016)). Higher funding stability will reduce financial performance, increase interest expenses and reduce interest income (Dietrich, Hess and Wanzenried (2014); King (2013)). It has been found in the existing literature that profitability is positively associated with market value (Abuzayed, Molyneux and Al-Fayoumi (2009); Cummins, Lewis and Wei (2006)). On the other hand, fund suppliers may consider more liquid banks to be less likely to default. The objective of the LCR and NSFR is to enhance the stability of the overall financial system. The increased stability may also increase banks' charter value (King (2013)). In the extant literature it is found that a number of different variables which might affect the market value of banks' equity (Calomiris and

[11] We thank Charles Calomiris, Iftekhar Hasan and other seminar participants at the University of Technology Sydney for useful suggestions and comments. We also wish to thank participants at the IFABS 2016 Barcelona Conference for helpful comments that have improved our paper. All errors remain our own.

Nissim (2014); Caprio, Laeven and Levine (2007); Laeven and Levine (2007)), but no existing research investigates the association between liquidity risk and banks' market values of equity. To the best of our knowledge, this is the first empirical study to investigate stock market investors' perceptions of banks' liquidity risk.

Hence, this study uses historical data to calculate the LCR and NSFR for US bank holding companies from 2001 to 2014 in order to examine the relationship between these liquidity risk measures and banks' market-to-book values of equity. We apply the Basel III liquidity measures metric by looking back in time and examining how these proxies for liquidity risk have been historically related to banks' market valuation of equity.

Using 3SLS simultaneous equations to capture reverse causality, we present empirical evidence in this study that the reduction in liquidity risk destroys the banks' adjusted market-to-book value of equity. The decrease in the banks' liquidity risk harms their financial performance, which in turn reduces banks' market values. However, for larger banks and banks with higher capital buffers, profitability and liquidity provide benefits because they create higher market-to-book value of equity and reduce liquidity risk. Our results are consistent with the existing literature in that the market value of equity is positively related to size, capital, profitability and levels of liquidity risk (Bertay, Demirgüç-Kunt and Huizinga (2013); Calomiris and Nissim (2014); Cornett, McNutt, Strahan and Tehranian (2011); Cummins, Lewis and Wei (2006); Lindquist (2004)). We also find that during the global financial crisis and in the post-Basel III announcement period, the market-to-book values of equity increased in response to higher Basel III liquidity measures, a finding which is also consistent with the existing literature (Bai, Krishnamurthy and Weymuller (2016); Parwada, Lau and Ruenzi (2015); Roggi and Giannozzi (2015)). These results indicate that the liquidity shortfall of banks during the global financial crisis caused investors to pay more attention to liquidity risk, such that investors considered banks with low liquidity risk to be more valuable. Our findings are consistent with the prediction that tighter liquidity standards harm banks' financial performance (Basel Committee on Banking Supervision (2016)).

4.2 Literature review and hypothesis development

4.2.1. Bank liquidity and market-to-book value of equity

Overall, there is a broad mix of variables which may affect the market value of banks, and as a result, their market-to-book equity ratios. Calomiris and Nissin (2014) investigate the factors influencing banks' market-to-book equity ratios over time by focusing on the period surrounding the global financial crisis. The authors find that substantial declines in loan and deposit intangibles were significant contributors to the reduction in the market value of banks' equity during the global financial crisis. Moreover, size and dividend payments are directly correlated with banks' market values of equity, whereas the effects of the capital structure, and of interest rate risk, are mixed. Furthermore, leverage is generally positively related to market value but it reduces market value during a financial crisis. Banks' corporate governance structures also affect their market values. for example, larger cash flow rights by controlling shareholder's increase the market value of equity whereas weaker shareholder protection reduces market value (Caprio, Laeven and Levine (2007)). During the global financial crisis banks' market-to-book ratios were negatively associated with their participation in the Troubled Asset Relief Program, but positively associated with lower relative costs, higher non-interest income, and lower assets in non-accruals (Jordan, Rice, Sanchez and Wort (2011)). Another factor which can boost the market-to-book equity ratios of banks is their degree of diversification. This is demonstrated by Elsas et al. (2010), who find that an increase in the diversity of a bank's revenue generating activities increases profitability and market-to-book equity ratios. A contrary result, however, is reported by Laeven and Levine (2007), who claim that the cost of diversification outweighs its positive influence on the market-to-book equity ratio of financial institutions.

Requirements for banks to increase their liquid assets, and to acquire more stable funding, have adverse effects on bank efficiency, as interest expenses increase with the greater reliance on longer-term stable funding, and interest income will reduce on the holdings of short-term liquid assets (King (2013)). These influences on earnings and efficiency have been found to explain the gap between the book value and market value of banks. For instance, Abuzayed, Molyneux and Al-Fayoumi (2009) show that the cost-efficiency of banks, as well as their earnings, are directly related to the resulting stock market valuations of banks. Reductions in profitability will also most probably give a negative spillover on the valuation of the companies' stocks by investors. This effect will be more pronounced for lower levels of earnings.

Another perspective on the influence of the Basel III liquidity requirements is suggested by Allen et al. (2012). The interpretation of "liquid assets" under the Basel III framework encourages greater credit exposure of banks to governments that are presumed to have either zero risk or very low risk. However, increasing government indebtedness may lead to widespread credit deterioration and as a result government securities will stop being eligible to be considered "liquid assets" under the Basel III rules. The authors suggest that under this probable scenario, both the market value of banks and their liquidity may deteriorate substantially and reduce their market-to-book value ratios.

Bai, Krishnamurthy and Weymuller (2016) apply a new measure of bank liquidity that they call the liquidity mismatch index (LMI). The LMI estimates the mismatch between the market liquidity of assets and the funding liquidity of liabilities. LMI is similar to Berger and Bouwman's liquidity creation measure but it also incorporates market liquidity conditions in the construction of the liquidity weights. LMI negatively influences the stock returns of banks in times of crisis, thus driving down market value. On the other hand, in non-crisis periods the lack of liquidity versus accepted benchmarks can produce positive abnormal returns. These effects also vary depending on whether there is an overall liquidity run on the market and negative shocks to returns can then be expected. Alternatively, liquidity injections by governments may occur and the market value of illiquid banks may increase.

Otker-Robe et al. (2010) claim that many banks will eventually be forced to update their business models due to the implementation of the Basel III liquidity measures. Furthermore, Bordeleau and Graham (2010) examine the performance of banks in Canada and the United States and show that high amounts of positive shifts in liquidity have the potential to reduce the profitability of banks. Given that profitability is a "signalling" variable which triggers positive or negative moves in investors, the market-to-book equity ratio can also suffer. Therefore, the existing literature indicates that banks with high asset liquidity and funding stability have a lower market-to-book value of equity.

Hypothesis 1: Reductions in banks' liquidity risk due to the adoption of the Basel III liquidity standards will have an adverse effect on banks' market-to-book equity ratios.

4.2.2 Bank size

Berger and Bouwman (2013) suggest that higher levels of capital requirements have the potential to disrupt deposits and decrease the levels of operations in smaller banks. At the same time, these same capital requirements reduce the risks faced by larger banks and eventually

increase their levels of operation, as well as facilitate the liquidity creation processes. All the above mentioned effects can also have implications for the market value of banks, to the extent of the spillover effects of operation efficiency and profitability. Furthermore, the logic of "too big to fail", even though tangibly undermined by the financial crisis of 2008, can still apply to investor sentiment regarding the market value of such institutions. An initial statement by the Comptroller of the Currency in the Congress on September 19, 1984, is found to have a prolonged positive effect on banking institutions in this category (O'Hara and Shaw (1990)). On the other hand, bank size has also been found to be positively related to levels of market discipline (Bertay, Demirgüç-Kunt and Huizinga (2013); Völz and Wedow (2011)). This may imply that bigger banks are more likely to comply with established liquidity risk requirements, and the adjustments banks need to make to comply with Basel III will, therefore, be less tangible. Given the lower levels of shocks to liquidity arising from higher levels of discipline, big banks may be expected to have fewer changes to their operational and financial strategies, which will produce earnings reports equal or exceeding investor expectations. As a result, the market price of these banks will not suffer and they will therefore have healthy market-to-book equity ratios.

Hypothesis 2: Larger banks will have higher market-to-book equity ratios in response to a decline in their liquidity risk.

4.2.3 Bank capital

Lindquist (2004) states that buffer capital maintained by banks can act as an insurance against the adverse event of not meeting the benchmark of capital requirements. Given that this risk is actualised with the demands of Basel III, levels of risks will be lower for banks with capital buffers, and this is likely be reflected in the market value of these banks. Furthermore, as claimed by Lindquist (2004), after a stream of banking crises in a number of countries, both regulators and shareholders have become increasingly conscious of the importance of the ratio of capital to assets. This information, therefore, can guide the market investment decisions and hence influence the share prices of banks. Furfine (2001) argues that the capital buffer of a bank, particularly in times of increased regulation, helps the institution to reduce its risk of harming its reputation and losing the confidence of investors. This is because improved capitalisation helps banks to cover possible loan losses, as well as ensure access to additional amounts of capital if the need arises. In addition, the market-to-book equity ratios of a bank can be negatively influenced by the increased levels of supervisory monitoring which a bank

incurs, decreasing the confidence of external investors. Furfine (2001) also claims that the levels of supervisory scrutiny experienced by a financial institution, and the size of its capital buffer, are inversely related, which also supports the third hypothesis of this study.

Hypothesis 3: Banks with larger capital buffers will have higher market-to-book equity ratios in response to a decline in their liquidity risk

4.2.4. Bank profitability

Like larger banks and banks with larger capital buffers, banks that are more profitable are expected to be more resilient to frictions caused by changes to liquidity levels. For example Cummins, Lewis and Wei (2006) find that if a bank is highly profitable it is much more likely to avoid reporting an operational loss, which is a strong and statistically significant predictor of a decrease in value of a bank's stock. The authors explore the publicly reported cases of operational risk which occurred in the US financial sector between 1978 and 2003. The result is significant because the reductions in the market capitalisation of banks are disproportionally larger than the associated operational losses. Similar studies of the influence of operational losses on stock prices have been conducted on a number of other occasions including Bhagat et al. (1994) and Palmrose et al. (2004). These authors also largely find that the reporting of operational losses has a disproportional effect on the market value of financial or non-financial institutions.

Hypothesis 4: Banks with high profitability will have higher market-to-book equity ratios in response to decline in their liquidity risks.

4.2.5 The global financial crisis

Bai et al. (2016) find higher levels of liquidity mismatch negatively influence the stock returns of banks. This relationship is exactly reverse of the relationship during times when there is no economic distress. Therefore, in times of crisis, higher liquidity levels become a more desirable trait of a bank as seen by investors. As a result, higher market-to-book values of equity in crises can be obtained by banks upon following the previously increased liquidity requirements. Similarly, Goh et al. (2015) find that in the global financial crisis investors placed a greater emphasis on the variables of asset liquidity and spillovers of liquidity-related information. In

addition, given that sufficient liquidity was largely lacking in the market during the global financial crisis, investors may discount the fair value estimate reported by financial institutions in order to account for the questionable liquidity of assets. The importance of holding a number of liquid assets in times when there is a high probability of liquidity shocks is also discussed in the literature (Holmström and Tirole (1996); Holmström and Tirole (1998); Holmström and Tirole (2001)). Roggi and Gianozzi (2015) find that during liquidity crises, investors have strong negative reactions to institutions with more illiquid assets and liabilities, whereas during liquidity-expanding events investors consider illiquid assets to be more valuable. Therefore, the literature suggests that investors consider liquidity to be more valuable during financial crises.

Hypothesis 5: Reduction in banks' liquidity risk from adopting Basel III liquidity standards will have a positive effect on banks' market-to-book equity ratios during the global financial crisis

4.2.6 Post-Basel III period

The Basel III liquidity standards were officially announced on 16 December 2010. In the post-Basel III period, liquidity may have had a positive association with banks' market values of equity due to the increased levels of transparency in the post-announcement period. Given that in addition to increased liquidity requirements, Pillar 3 of Basel III also suggests an increase in availability of risk-management information to investors (Parwada, Lau and Ruenzi (2015)), it can be hypothesised that nowadays investors will have a tangibly higher awareness of the liquidity handling practices of banks, and that they will incorporate this information into their decisions on their valuations of the stocks of banking institutions.

Hypothesis 6: Reductions in banks' liquidity risk as a result of adopting Basel III liquidity standards had a positive effect on banks' market-to-book equity ratios during the post-Basel III announcement period.

4.2.7 Banks with high Basel III liquidity measures

Cornett et al. (2011) find that banks which depend more heavily on liquid sources of finance manage to retain and expand their levels of lending due to their higher levels of stability. Banks with initially low liquidity indicators have to increase the liquidity of their assets at the expense of lending capacity and therefore, profitability. As a result, public banks with high liquidity

tend to suffer less than banks with low liquidity, due to the positive relationship between the earnings of the institutions and the stock prices.

Hypothesis 7: Banks with high Basel III liquidity measures will have relatively higher market-to-book equity ratios in response to declines in their liquidity risks.

4.3 Data

We use US commercial bank data and US bank holding company data from quarterly call reports provided by the Federal Reserve Bank. We exclude the bank quarters of commercial banks when total assets, total deposits, total loans and total liabilities are either missing or less than one million US dollars. Quarterly data for the sample period from 2001: Q1 to 2014: Q4 is used in this study. We choose 2001 as the start of our sample period because commercial banks did not report risk-weighted assets in different risk categories in their call reports before 2001, and this level of classification is necessary for calculating the LCR and NSFR (see Appendix 4.B and 4.C for a summary). We require commercial bank data to compute the two key Basel III liquidity ratios, namely the LCR and NSFR because US commercial bank data are more detailed than US bank holding company data. We took the average LCRs and NSFRs of all the commercial banks corresponding to each bank holding company as stock prices are generally available at the bank holding company level. We also computed the control variables at the bank holding company level. We obtained daily stock price data for bank holding companies from CRSP for computing the adjusted market-to-book value of equity. We matched the bank holding company data with the CRSP data. The final quarterly data set contains 22,448 bank quarters for 809 bank holding companies. To address outlier problems, all variables except the macroeconomic factors have been winsorised at the 1st and 99th percentiles, an approach which is widely adopted in the literature (Acharya and Mora (2015); Beltratti and Stulz (2012); Berger and Bouwman (2009)).

The quarterly descriptive statistics for our full sample of commercial banks used in the regressions are reported in Panel A of Table 4.1. The average adjusted market-to-book value of equity, the LCR and the NSFR for the sample of bank holding companies are 148%, 195% and 99% respectively. On average, the equally weighted average of the LCRs and NSFRs of our sample bank holding companies is 147%. The average natural logarithm of total assets, the natural logarithm of z-scores, the concentration (*CONC*) and the market power are 14.55, 5.32,

61.5%, and 0.25% respectively. On average, total liabilities and loan loss provisions for our sample of bank holding companies constitute 90.24% and 0.17% of total assets and total loans respectively. For the average bank holding companies, real estate loans, interest expenses and net income represent 73.98%, 0.49% and 2.3% of total loans, total liabilities and total equity respectively.

Panels B and C of Table 4.1 report the summary statistics for banks with LCRs above and below the median LCR in each quarter for high- and low-profit banks respectively.[12] Panels B and C of Table 1 show that irrespective of profitability, banks with LCRs above the median LCR (low liquidity risk) have low market values of equity compared to banks with LCR below the median LCR, and the results are statistically significant at the 1% level of significance. Our results show that irrespective of profitability, banks with low liquidity risk have low market values of equity. On balance, the results in Panels B and C of Table 1 show that banks with low liquidity risk have low assets, z-scores, profitability and market power but high real estate loans, cost of funds and capital buffers. These results indicate that irrespective of profitability, the Basel III liquidity measures lower financial performance but increase the costs of funds, as evidenced by low returns on equity and high costs of funds. These findings are supported by the literature (Dietrich, Hess and Wanzenried (2014)). Moreover, irrespective of profitability, banks with high Basel III liquidity measures are less risky. This is evidenced by low z-scores but high capital buffers.

Panel D of Table 4.1 shows that during the global financial crisis banks with a high NSFR had high market values of equity irrespective of profitability, indicating that the during crisis investors considered low liquidity risk more valuable. However, in normal times high NSFR banks have low market values of equity. Moreover, high LCR banks have low market value during normal times and crises regardless of their profitability.

<Insert Table 4.1>

Table 4.2 reports the pair-wise correlation coefficients of the variables used in this study. We do not find bank variables employed as explanatory variables to be highly correlated, indicating that multicollinearity is not a major problem in our empirical analysis.

[12] We found qualitatively similar results for NSFR.

The correlation coefficient between mutually exclusive test variables LCR and NSFR is 0.37 which means that the two Basel III liquidity measures are somewhat related. The correlation coefficients of the banks' adjusted market-to-book values of equity with LCR and NSFR are -0.18, and 0.05 respectively.

<Insert Table 4.2>

Figures 4.1, 4.2, and 4.3 depict the means, 5th percentiles and 95th percentiles for LCR and NSFR, and adjusted market-to-book values of equity of US bank holding companies for the period 2001 to 2014. Figure 4.1 shows that the mean LCR decreases from 2001: Q1 to 2005: Q4, increases from 2006: Q1 to 2010: Q4 and again decreases from 2011: Q1 to 2014: Q4, indicating that banks' asset liquidity varies significantly over time. Figure 4.2 shows that the mean NSFR decreases from 2001: Q1 to 2008: Q4 and increases from 2009: Q1 to 2014: Q4, indicating that banks' funding stability changes over time. Figure 4.3 shows that the mean market value increases from 2001: Q1 to 2006: Q4 and decreases from 2007: Q1 to 2009: Q4 and again increases from 2010: Q1 to 2014: Q4, indicating that banks' market value was low during the global financial crisis.

<Insert Figure 4.1-4.3>

Figure 4.4 shows that banks with low LCR have high market value regardless of their profitability, but during the global financial crisis the difference between the market-to-book equity of high and low LCR banks decreased.

<Insert Figure 4.4>

Figure 4.5 shows that high-profit banks with low NSFR had low market value during the crisis, but there was no difference in market value for the low-profit banks. However, during normal times low NSFR banks have high market value.

<Insert Figure 4.5>

Figures 4.4 and 4.5 show that liquidity risk is positively associated with banks' market-to-book value during normal times and the relationship was the reverse during the global financial crisis. The grey shaded area in Figures 4.1–4.5 show economic recession periods as indicated by the National Bureau of Economic Research (NBER).

4.4 Model

In order to test the impact of banks' liquidity risk on banks' market-to-book values of equity, we use 3SLS simultaneous regression equations to capture potential reverse causality. The market-to-book value of equity and the liquidity equations include a number of control variables for bank characteristics and activities, which may influence banks' market-to-book values of equity.

The model developed to test the impact of banks' liquidity risk on banks' market-to-book value of equity is:

$$\begin{cases} Market\text{-}to\text{-}Book_{i,t} = \alpha\ Liquidity_{i,t} + \beta\ Controls_{i,t} + \varepsilon_{i,t} \\ Liquidity_{i,t} = \gamma\ Market\text{-}to\text{-}Book_{i,t} + \delta\ Controls_{i,t} + \xi_{i,t} \end{cases} \quad (1)$$

where, α and β (γ and δ) reflect the extent to which the relative factor of the model contributes to the change in the dependent variable in the market-to-book value of equity (liquidity) equation, and $\varepsilon_{i,t}$ and $\xi_{i,t}$ represent the error term for bank *i* in quarter *t* in the market-to-book value of the equity equation and the liquidity equation respectively.

The dependent variable, Market-to-Book, in the market-to-book equity equation, is the adjusted market-to-book value of equity for bank *i* in quarter *t*.

The independent test variable, Liquidity, in the market-to-book equity equation, is a vector of the alternative Basel III liquidity measures for bank *i* in quarter *t*. We use LCR and NSFR as proxies for banks' liquidity risk. Summaries for the calculations of these measures are provided in Appendices 4.B and 4.C.

The dependent test variable, Liquidity, in the liquidity equation, is a vector of the alternative Basel III liquidity measures for bank *i* in quarter *t*.

The independent variable, Market-to-Book, in the liquidity equation, is the adjusted market-to-book value of equity for bank *i* in quarter *t*.

The independent control variables are bank characteristics for bank *i* in quarter *t*. In all 3SLS regressions, we include bank characteristics as well as some macroeconomic factors that affect banks' market-to-book values of equity. The list of control variables for bank characteristics, activities and CAMELS indicators used in this study are commonly adopted in the literature. Consistent with the literature[13], we consider the natural logarithm of total assets (Asset), the ratio of total liabilities divided by total assets (Leverage), real estate loans divided by total loans (REL), the natural logarithm of z-score (z-score), loan loss provisions divided by total loans (LLP), total interest expenses divided by total liabilities (CostFund), net income divided by total equity (ROE), total assets of the five largest banks in quarter *t* divided by the total assets of the banking system in quarter *t* (CONC), the natural logarithm of z-score (z-score), the growth rate of real gross domestic product (GDP), the inflation rate (Inflation), the ratios of total assets of bank *i* in quarter *t* divided by total assets of the banking system in quarter *t* (MktPow), and the federal funds rate (Fed) as the potential determinants of banks' liquidity risk in the liquidity equation.[14] A summary of the definitions for all control variables is provided in Appendix 4.A.

We extend the model to test the relationship between banks' liquidity risk and banks' market-to-book values of equity for large banks, banks with higher capital buffers, banks with high profitability, banks with high liquidity, banks during the global financial crisis and banks during the post-Basel III announcement period by generating test dummies and the following models:

$$\begin{cases} Market\text{-}to\text{-}Book_{i,t} = \alpha_1 Liquidity_{i,t} + \alpha_2 Testdummy_{i,t} + \alpha_3 Testdummy_{i,t} \times Liquidity_{i,t} + \beta\ Controls_{i,t} + \varepsilon_{i,t} \\ Liquidity_{i,t} = \gamma_1\ Market\text{-}to\text{-}Book_{i,t} + \gamma_2 Testdummy_{i,t} + \gamma_3 Testdummy_{i,t} \times Performance_{i,t} + \delta\ Controls_{i,t} + \xi_{i,t} \end{cases} \quad (2)$$

[13] See Berger and Bouwman (2009), Binsbergen et al. (2010), Bordeleau and Graham (2010), Calomiris and Nissim (2014), Díaz and Huang (2013), Dietrich et al. (2014), Distinguin et al. (2013), Fungáčová et al. (2010), Hasan et al. (2015), Ortiz-Molina and Phillips (2014) and Pasiouras and Kosmidou (2007).

[14] Note, z-score is a proxy for banks' capital adequacy and distant to default. A high z-score indicates that banks are safer. LLP provides information on the asset quality of banks, and a higher LLP indicates lower asset quality. High REL indicates banks are involved in risky activities. CONC measures the concentration in the banking system. Higher values of concentration indicate banks have a higher likelihood of collusion and of earning monopoly profit. MktPow measures the market power of each bank.

We use *Testdummy* to capture the effects of bank types and sub-periods. Firstly, *Big* is an indicator variable taking on a value of 1 for the banks in the top decile by total asset value in each quarter and zero otherwise whilst *HCB* is an indicator variable taking on a value of 1 for the top decile banks in terms of the size of their capital buffers in each quarter and zero otherwise. Secondly, *HROE* is an indicator variable taking on a value of 1 for the banks in the top decile of their return on equity in each quarter and zero otherwise. Thirdly, *GFC* is an indicator variable taking a value of 1 for the sub-period from 2007: Q1 to 2010: Q1 when the Federal Reserve injected liquidity through the Term Auction Facility program and zero for other times. Fourthly, *Basel3* is an indicator variable taking a value of 1 for the sub-period from 20011: Q1 to 2014: Q4 after the official announcement of Basel III liquidity standards on 16 December 2010 and zero for other times. Fifthly, *HLIQ* is an indicator variable taking on a value of 1 for banks with LCRs and NSFRs higher than 100% and zero otherwise.

We use 3SLS simultaneous equation regressions to account for potential reverse causality between banks' liquidity risk and their adjusted market-to-book values of equity. There is a possibility that banks' market-to-book values of equity may affect liquidity risk as well. The 3SLS simultaneous equation regression addresses the potential endogeneity and cross-correlation between equations. Our 3SLS regressions capture the reverse causality between banks' liquidity and adjusted market-to-book value of equity. The 3SLS simultaneous equation regressions are widely used in the literature to address endogeneity concerns (Aggarwal and Jacques (2001); Bhagat and Bolton (2008); Distinguin, Roulet and Tarazi (2013); Shrieves and Dahl (1992)).

4.4.1 Proxies for bank liquidity

We consider Basel III liquidity measures as our proxies for banks' liquidity risk.

Given their prominence within the Basel III new liquidity rules, in this study we use Basel III liquidity measures as proxies of banks' liquidity risk. Hence, LCR and NSFR are our liquidity risk measures.

LCR requires a bank to hold an adequate level of unencumbered, high-quality liquid assets that can be converted easily and immediately into cash to meet the bank's liquidity needs for the next 30 days under a severe liquidity stress scenario. The LCR is defined accordingly as the

ratio of the stock of high-quality liquid assets to the total net cash outflows over the next 30 calendar days:

$$\text{LCR} = \frac{Stock\ of\ High-Quality\ liquid\ assets}{Total\ net\ cash\ outflows\ over\ the\ next\ 30\ days} \qquad (3)$$

Banks are required to maintain an LCR of at least equal 100%. The value of the LCR depends on the assumptions used in the calculations of the stock of high-quality liquid assets (HQLA) and the cash inflows and outflows. HQLA are divided into Level 1 Assets and Level 2 Assets. While calculating LCR we need to make assumptions about the classification of Level 1 Assets and Level 2 Assets, the weights assigned to these asset categories, and rates of cash outflows and inflows for different liability and asset categories.

The NSFR requires banks to maintain medium- and long-term funding stability. The NSFR is defined as the ratio of available stable funding (ASF) to required stable funding (RSF).

$$\text{NSFR} = \frac{Available\ Stable\ Funding}{Required\ Stable\ Funding} \qquad (4)$$

Under Basel III liquidity rules, the NSFR should be at least equal to 100%. In calculating NSFR, we also need to make assumptions about the classifications of different assets and liabilities, and the weights assigned to different categories. We calculated the approximate measures of LCR and NSFR according to the revised versions of the LCR and NSFR made by the Basel Committee in January 2013 and January 2014 respectively.

We follow the assumptions of Hong, Hang and Wu (2014) for calculating the LCR and NSFR. Weights of assets and liabilities used to calculate LCR and NSFR are provided in Appendices 4.B and 4.C respectively. Insured deposits are stable deposits, and uninsured deposits are less stable deposits. US commercial banks only report the total uninsured deposits in their call reports. The uninsured deposits in each category of deposit are proportional to the size of that group. The maturity schedule of assets and liabilities is evenly distributed so that the amount of loans with a remaining maturity of less than one month equals one-twelfth of the amount of loans with a remaining maturity of one year or less. Savings and transaction deposits are equally divided into wholesale and retail deposits.

LCR and NSFR have also recently been used in the literature as proxies for bank liquidity (Dietrich, Hess and Wanzenried (2014); Distinguin, Roulet and Tarazi (2013); Hong, Huang and Wu (2014); King (2013)). We also use an equally weighted average of LCR and NSFR

(LCRNSFR) as our alternative proxy of bank liquidity.[15] We consider an equally weighted average of LCR and NSFR as a composite measure of asset liquidity and funding stability.

4.4.2 Proxies for banks' market valuations

We consider banks' adjusted market-to-book values of equity as their market valuation. Banks' financial statement data are generally available within two months of the end of the fiscal quarter. Therefore, we calculate adjusted market-to-book value of equity by multiplying the end-of-quarter market value of common equity by one plus cumulative stock return over the subsequent three months.[16] Adjusted market-to-book value of equity has been widely used in the literature to consider banks' valuations (Calomiris and Nissim (2014)).

4.5 Discussion of results

4.5.1 Market-to-book values of equity for all banks

We first examine the effect of Basel III liquidity measures on the market-to-book values of equity for all banks. The 3SLS simultaneous equation regression results are reported in Table 4.3.

<Insert Table 4.3>

The market-to-book equation in Table 4.3 shows that increases in LCR, NSFR, and LCRNSFR reduce the adjusted market-to-book values of equity of banks at the 1% level of significance. The liquidity equation in Table 4.3 shows that increases in the market-to-book equity ratio also reduces LCR and LCRNSFR, at the 1% level of significance whereas increases in market-to-book equity ratio increase NSFR. Therefore, our results show that a decrease in liquidity risk measured by high asset liquidity, funding stability and the composite measure of asset liquidity

[15] In the unreported regressions, we use the sums and products of LCR and NSFR and found similar results.

[16] We also consider banks' adjusted market-to-book value of equity using the cumulative return over the subsequent two months and found qualitatively similar results.

reduce the market-to-book equity ratio. Moreover, market-to-book equity reduces asset liquidity but increases funding stability.

We multiplied the coefficient of Basel III liquidity measures of the market-to-book equations with the standard deviation of Basel III liquidity measures to get the magnitude of changes, and to identify the economic significance of the effects of liquidity risk. The impact of liquidity risk on banks' market-to-book equity ratios is economically significant as a one standard deviation increase in a bank's LCR, NSFR and LCRNSFR reduces the banks' market-to-book equity ratios by 1.4625, 1.3777 and 1.4078 respectively.

The control variables in Table 4.3 are significant, as expected. The market-to-book equation results in Table 4.3 show that leverage increases the market-to-book equity ratio, which is consistent with the existing literature findings that leverage is positively associated with market value during normal times (Calomiris and Nissim (2014)). Real estate loans are negatively related to market value, indicating banks involved in risky activities have lower market values. Z-scores are also negatively related to market value, indicating the overall riskiness of banks increases market value, confirming a positive risk premium. Loss provision is negatively linked to market value, showing that low asset quality reduces market value. Banks' profitability, proxied by return on equity, increases market value which is consistent with the existing literature finding that profitability increases market value (Cummins, Lewis and Wei (2006)). Higher likelihood of collusion reduces market value whereas growth rate of GDP and inflation increase market value. Moreover, the relationship between asset and cost of funds with market-to-book equity are negative. The liquidity equation results in Table 4.3 show that banks with a higher market power increase their asset liquidity and funding stability, which is consistent with findings in the existing literature that market power increases funding stability but reduces liquidity creation (Distinguin, Roulet and Tarazi (2013)). However, bank size reduces Basel III liquidity measures which is consistent with findings in the existing literature that bank size is positively related to liquidity creation which is equivalent to the inverse of NSFR (Berger and Bouwman (2009)). We also find that the growth rate of GDP increases asset liquidity and funding stability. Finally, increases in the federal funds rate reduce asset liquidity and funding stability.

LCR increases with short-term liquidity, whereas NSFR decreases with decreases in the maturity mismatch between the banks' assets and liabilities. Holding shorter-term assets and longer-term liabilities in order to reduce liquidity risk reduces profitability. We find evidence that reductions in liquidity risk proxied by high Basel III liquidity measures adversely affects

banks' market-to-book values of equity. This is consistent with Bai et al.'s (2016) finding that liquidity risk is positively associated with banks' market value during normal times. Our results support the view that reductions in liquidity risk destroy banks' market values of equity because investors believe that lower liquidity risk reduces financial performance and hence reduces market value.

4.5.2 Market-to-book values of equity for big banks

The effect of bank size on the relationship between liquidity risk and banks' market-to-book values of equity is reported in Table 4.4.

<Insert Table 4.4>

The market-to-book equation in Table 4.4 shows that the interaction terms of bank size with LCR and NSFR are positively related to banks' adjusted market-to-book equity ratio at the 1% level of significance. We also find evidence that the indicator variable for bank size, *BIG,* is negatively related to market value in the case of Basel III liquidity measures.

Table 4 shows that an increase in Basel III liquidity measures reduces banks' market-to-book equity value of equity. Therefore, we find evidence that a decrease in liquidity risk, a measured by high asset liquidity, and funding stability relatively increase the market-to-book equity ratio of larger banks compared to smaller banks. The liquidity equation in Table 4.4 shows that the market-to-book equity ratio of large banks reduces asset liquidity and funding stability, relative to small banks based on the interactive term for bank size and the proxies for banks' liquidity risk.

We find evidence that large banks experience higher market values in response to reductions in liquidity risk, which is consistent with the existing literature showing that bank size is positively related to bank market value (Bertay, Demirgüç-Kunt and Huizinga (2013); Calomiris and Nissim (2014)). Our results show that investors consider low liquidity risk favourably for large banks because large banks are subject to a greater degree of scrutiny.

4.5.3 Market-to-book values of equity for banks with high capital buffers

The effect of banks' capital buffers on the relationship between liquidity risk and banks' market-to-book value of equity is reported in Table 4.5.

<Insert Table 4.5>

The market-to-book equation in Table 4.5 shows that the interactive terms for banks' capital buffers with LCR and NSFR are positively related to banks' adjusted market-to-book equity ratios at the 1% level of significance. We also find evidence that the indicator variable for banks' capital buffers, HCB, is positively related to market-to-book equity ratios in the case of LCR, but negatively related in the case of NSFR. Table 4.5 shows that an increase in Basel III liquidity measures reduces banks' market-to-book values of equity. Therefore, we find evidence that a decline in liquidity risk measured by high asset liquidity and funding stability increases the market-to-book equity ratios of banks with high capital buffers more than they do for other banks. The liquidity equation in Table 4.5 shows that the market-to-book equity ratios of banks with high capital buffers reduce asset liquidity and funding stability more than they do for banks with small capital buffers. This is based on the interactive term for banks' capital buffers and the proxies for bank liquidity risk.

We find evidence that banks with high capital buffers experience higher market values in response to reductions in liquidity risk which is consistent with the existing literature showing that capital buffers are positively related to banks' market values (Lindquist (2004)). Our results show that investors consider low liquidity risk favourably for banks with high capital buffers because of these banks' lower default risks.

4.5.4 Market-to-book values of equity for banks with high profitability

The effect of banks' profitability on the relationship between liquidity risk and banks' market-to-book value of equity is reported in Table 4.6.

<Insert Table 4.6>

The market-to-book equation in Table 4.6 shows that the interactive term for banks' profitability with LCR is positively related to banks' adjusted market-to-book equity ratio at the 1% level of significance. We also find evidence that the indicator variable for banks' profitability, HROE, is positively related to market value. Table 4.6 shows that an increase in Basel III liquidity measures reduces banks' market-to-book values of equity. Therefore, we find evidence that a decrease in liquidity risk, as measured by high asset liquidity and funding stability, increases the market-to-book equity of banks with high profitability more than it does for banks with low profitability. The liquidity equation in Table 4.6 shows that the market-to-book equity of banks with high profitability reduces asset liquidity and funding stability more than it does for banks with low profitability. This is based on the interactive term for banks' profitability and the proxies for bank liquidity risk.

We find evidence that banks with high profitability experience higher market values in response to reductions in liquidity risk. This is consistent with the existing literature showing that profitability is positively related to banks' market values (Abuzayed, Molyneux and Al-Fayoumi (2009); Cummins, Lewis and Wei (2006)). Our results confirm that investors consider low liquidity risk favourably for banks with high profitability because profitability is positively related to banks' market-to-book values of equity.

4.5.5 Market-to-book values of equity for banks during global financial crisis

The relationship between liquidity risk and banks' market-to-book values of equity during the global financial crisis is reported in Table 4.7.

<Insert Table 4.7>

The market-to-book equation in Table 4.7 shows that the interactive terms of the global financial crisis with LCR and NSFR are positively related to banks' adjusted market-to-book equity at the 1% level of significance. Therefore, we find evidence that a decrease in liquidity risk measured by high asset liquidity, and funding stability increased banks' market-to-book equity during the global financial crisis compared to normal times. We also find evidence that

the indicator variable for the global financial crisis, GFC, is negatively related to market value. Table 4.7 shows that increases in Basel III liquidity measures reduce banks' market-to-book values of equity. The liquidity equation in Table 4.7 indicates that market-to-book equity reduced asset liquidity and funding stability more during the crisis than in normal times based on the interactive term for crisis and the proxies for banks' liquidity risk.

We find evidence that banks with low liquidity risk experienced higher market values during the crisis which is consistent with the existing literature showing that increase in liquidity risk increase market value during crises (Bai, Krishnamurthy and Weymuller (2016); Goh, Li, Ng and Yong (2015)). During the global financial crisis, banks faced severe liquidity problems. Our results suggest that investors consider reductions in liquidity risk more valuable during crises and perceive banks with low liquidity risk as more valuable.

4.5.6 Market-to-book values of equity for banks during post-Basel III announcement period

The relationship between liquidity risk and banks' market-to-book values of equity during the post-Basel III announcement period is reported in Table 4.8.

<Insert Table 4.8>

The market-to-book equation in Table 4.8 shows that the interaction terms for the post-Basel III announcement period with LCR and NSFR are positively related to banks' adjusted market-to-book equity at the 1% level of significance. Therefore, we find evidence that a decrease in liquidity risk, measured by high asset liquidity and funding stability, increased banks' market-to-book equity during the post-Basel III announcement period compared to prior times. We also find evidence that the indicator variable for the post-Basel III period, BASEL3, is negatively related to market value. Table 4.8 shows that increases in Basel III liquidity measures are negatively associated with market-to-book values of equity. The liquidity equation in Table 4.8 shows that the market-to-book equity reduced asset liquidity and funding stability more during post-Basel III announcement period than it did at other period based on the interactive term for the post-Basel III period and the proxies for banks' liquidity risk.

We find evidence that banks with low liquidity risk experienced higher market value during the post-Basel III announcement period which is consistent with the existing literature showing that investors considered liquidity more valuable during the post-Basel III period (Parwada, Lau and Ruenzi (2015)).

4.5.7 Market-to-book values of equity for banks with high liquidity

The effect of banks' liquidity levels on the relationship between liquidity risk and banks' market-to-book value of equity is reported in Table 4.9.

<Insert Table 4.9>

The market-to-book equation in Table 4.9 shows that the interactive terms for banks' liquidity levels with LCR and NSFR are positively related to banks' adjusted market-to-book equity at the 1% level of significance. We also find evidence that the indicator variable for banks' liquidity level, HLIQ, is negatively related to market value. Table 4.9 shows that an increase in the Basel III liquidity measures reduced banks' market-to-book values of equity. Therefore, we find evidence that a decrease in liquidity risk, measured by high asset liquidity and funding stability, increase the market-to-book equity of banks with high liquidity more than it does for low liquidity banks. The liquidity equation in Table 4.9 shows that the market-to-book equity of banks with high liquidity reduces asset liquidity and funding stability, more than it does for banks with low liquidity based on the interaction term for banks' liquidity level and the proxies for banks' liquidity risk.

We find evidence that banks with high liquidity experience higher market values in response to reductions in liquidity risk, which is consistent with findings in the existing literature that banks with lower levels of liquidity need to reduce lending activities and profitability whereas banks with higher levels of liquidity can expand their lending activities and profitability (Cornett, McNutt, Strahan and Tehranian (2011)).

4.6 Conclusion

In this study, we calculated the approximate Basel III liquidity measures metric for US bank holding companies using historical call report data over the period from 2001 to 2014 to investigate the impact of increases in asset liquidity and funding stability required under Basel III on banks' adjusted market-to-book values of equity.

Increases in asset liquidity and funding stability reduce liquidity risk. We find empirical evidence to suggest that decreases in liquidity risk generally diminish banks' market values. We find evidence that the market-to-book value of equity in turn also affects liquidity risk. Importantly, we reveal that large banks, banks with high capital buffers, high profitability and high liquidity benefit from superior market valuations. We also find that reductions in liquidity risk increased banks' market value during the global financial crisis and in the post-Basel III announcement period.

The results support a partical appreciation of increased bank liquidity by investors and may smooth out bank valuations over the course of the business cycle. Furthermore, financial system resilience may be improved by increased liquidity as systemic risk is likely to be reduced by encouraging greater liquidity for larger banks, and prudent banking may be encouraged by improving market valuations for banks with higher capital buffers, profitability and liquidity.

Figures

The grey shaded area, 2002: Q1–2002: Q4 and 2007: Q4–2009: Q3, in Figures 1 to 5 show economic recession periods as indicated by the National Bureau of Economic Research (NBER).

Figure 4.1: LCR of US bank holding companies

Figure 4.1 shows the mean, 5th percentile and 95th percentile LCR of US bank holding companies from 2001 to 2014.

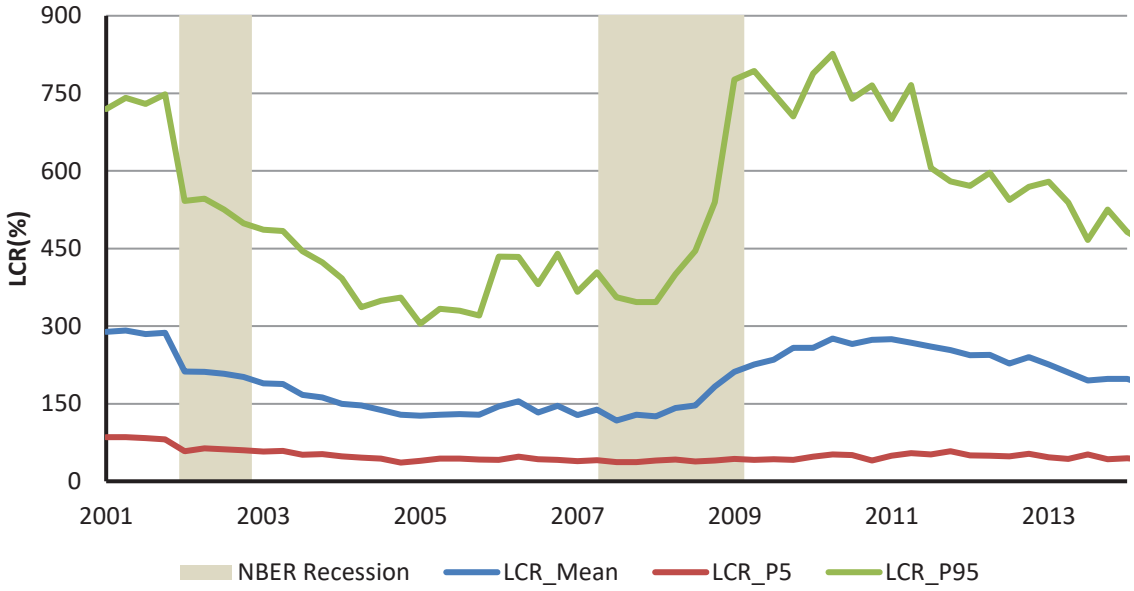

Figure 4.2: NSFR of US bank holding companies

Figure 4.2 shows the mean, 5th percentile and 95th percentile NSFR of US bank holding companies from 2001 to 2014.

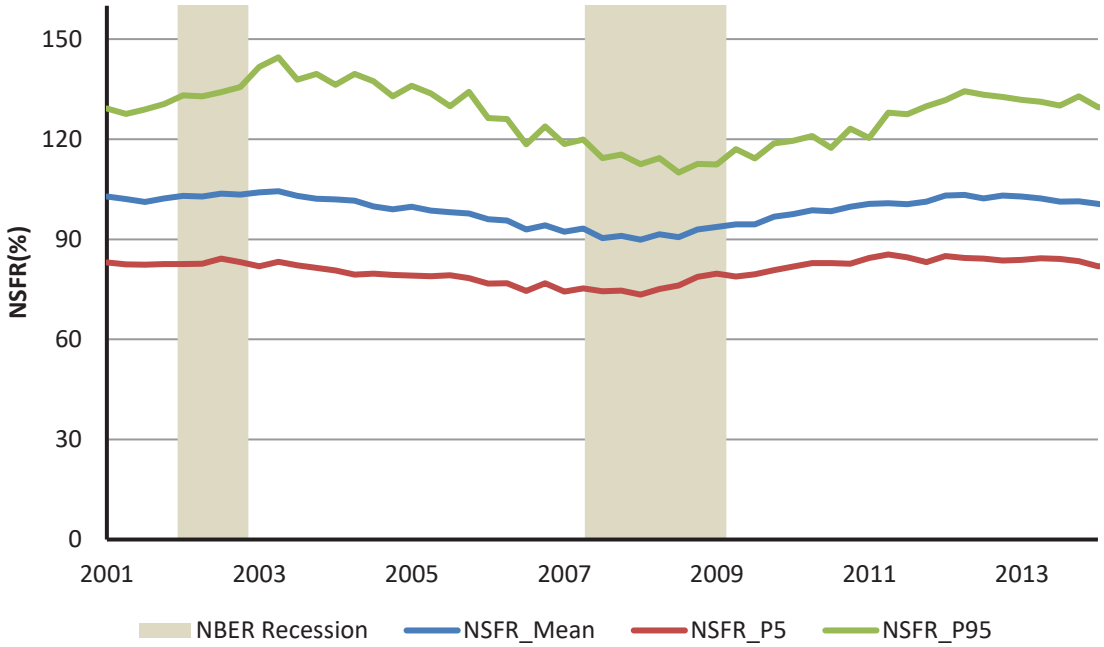

Figure 4.3: Adjusted market-to-book equity of US bank holding companies

Figure 4.3 shows the mean, 5th percentile and 95th percentile adjusted market-to-book values of equity of US bank holding companies from 2001 to 2014.

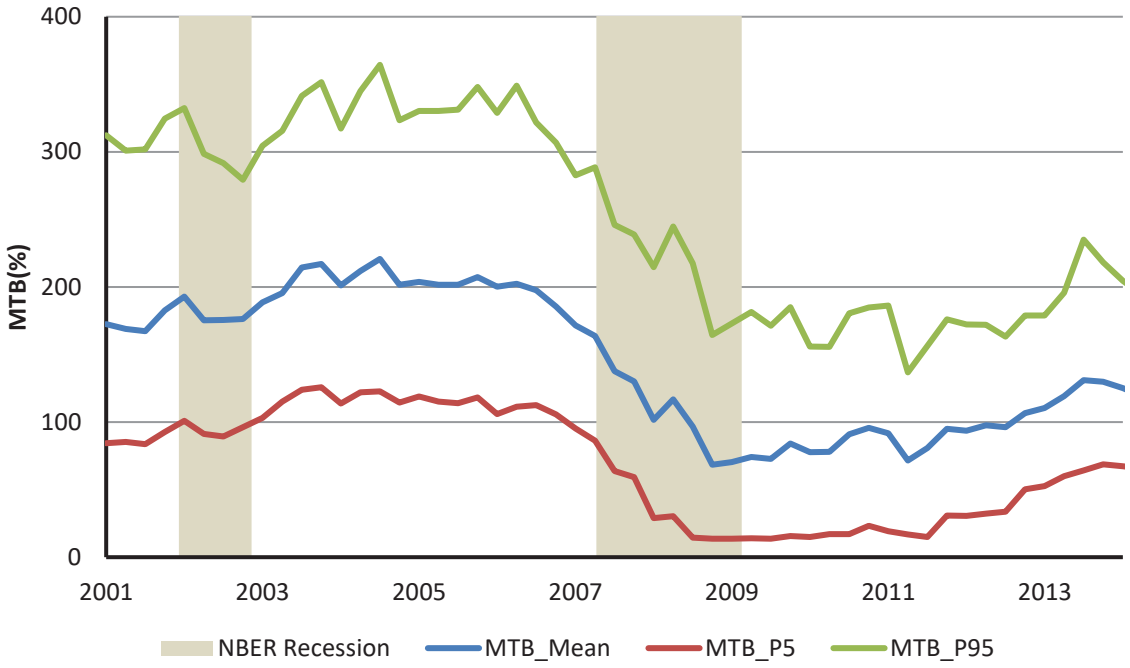

Figure 4.4: Adjusted market-to-book equity of US bank holding companies in terms of the interaction of ROE and LCR

Figure 4.4 shows the adjusted market-to-book values of equity of US bank holding companies with high profit-low LCR, high profit-high LCR, low profit-low LCR and low profit-high LCR, from 2001 to 2014. High indicates values above the median value and low indicates values below the median value of each quarter.

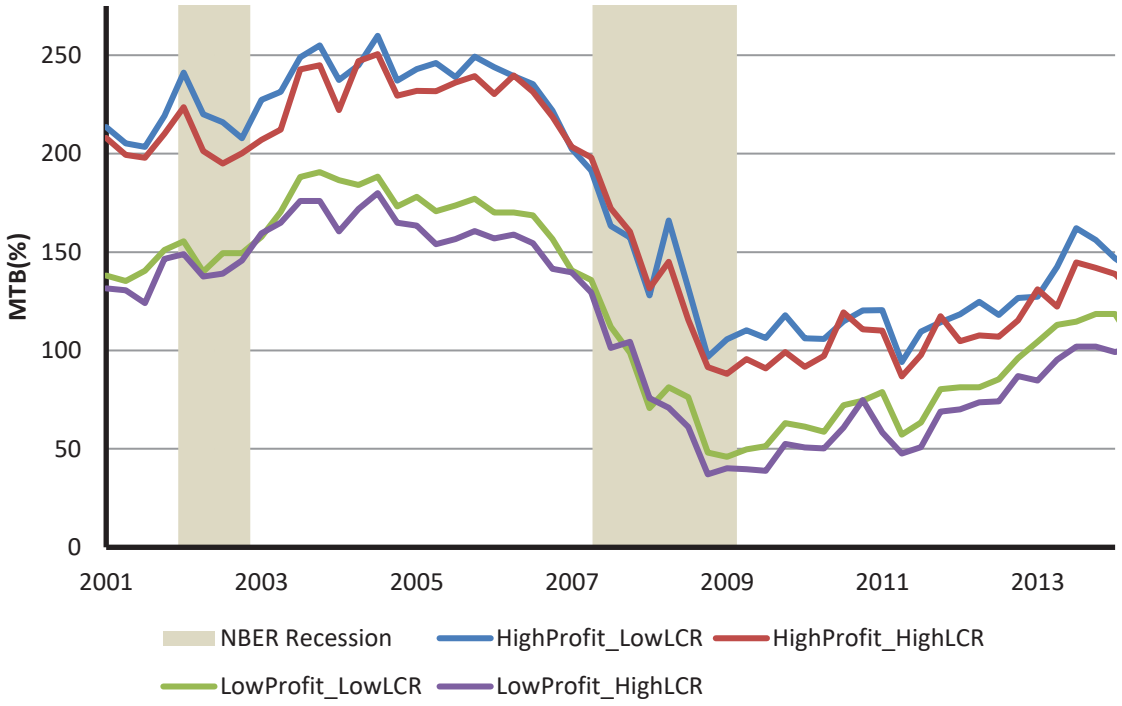

Figure 4.5: Adjusted market-to-book equity of US bank holding companies in terms of the interaction of ROE and NSFR

Figure 4.5 shows the adjusted market-to-book values of equity of US bank holding companies with high profit-low NSFR, high profit-high NSFR, low profit-low NSFR, and low profit-high NSFR, from 2001 to 2014. High indicates values above the median value and low indicates values below the median value of each quarter.

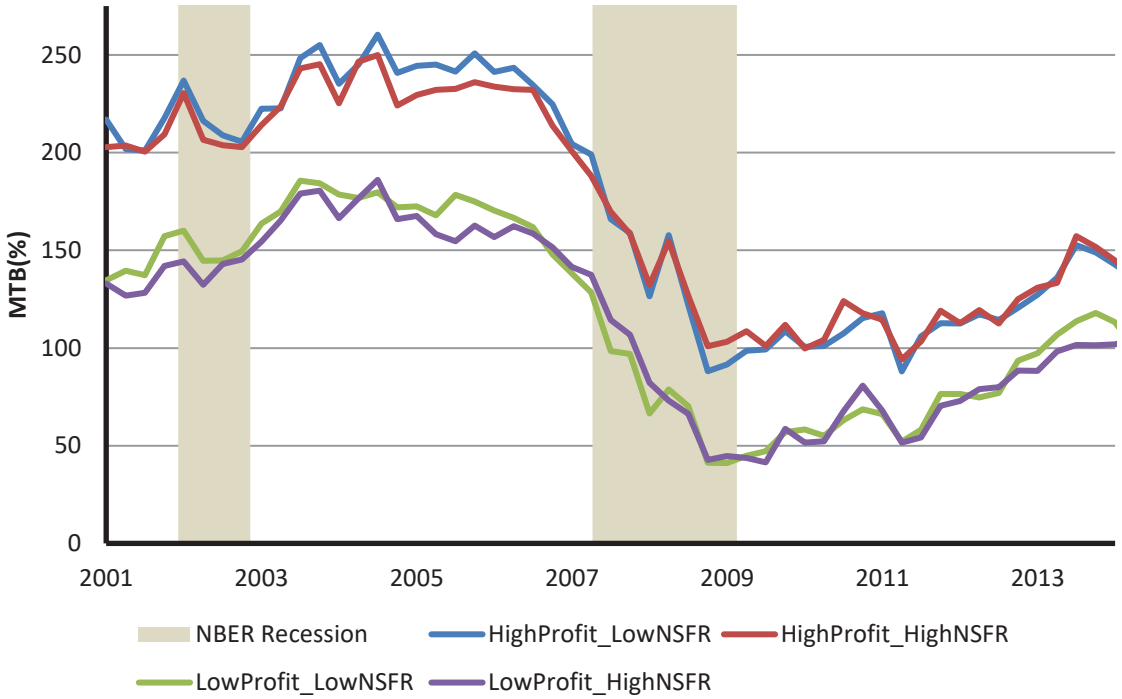

Table 4.1: Summary statistics

Panel A of Table 4.1 reports the summary statistics of quarterly data for 809 US bank holding companies from 2001: Q1 to 2014: Q4. All variables are taken from bank holding companies whereas LCR and NSFR are means for commercial banks that are subsidiaries of bank holding companies. The top and bottom 1% of all observations for all variables except the macroeconomic factors have been winsorised to limit the extreme values.

Panel A: Summary statistics for the full sample

Variable	Mean	Std. Dev.	Min	Max	Obs
		Dependent Variable			
MTB	1.4807	0.7727	0.1369	3.9980	21,350
		Independent Variable			
LCR	1.9544	1.7647	0.2976	10.5619	22,448
NSFR	0.9901	0.1596	0.6859	1.6587	22,448
LCRNSFR	1.4734	0.9177	0.5696	5.9037	22,448
		Control Variable			
Asset	14.5531	1.5695	12.2375	20.4997	21,398
Leverage	0.9024	0.0263	0.8009	0.9613	21,398
REL	0.7398	0.1703	0.0513	0.9942	21,398
Z-score	5.3235	1.3263	1.1079	7.7598	19,109
LLP	0.0017	0.0030	-0.0014	0.0184	21,216
CostFund	0.0049	0.0028	0.0004	0.0120	21,218
ROE	0.0230	0.0130	0.0007	0.0422	21,218
CONC	0.6150	0.0522	0.5117	0.7183	22,448
MktPow	0.0025	0.0152	0.0000	0.2309	22,448
GDP	1.8425	2.4742	-8.1900	6.8700	22,448
Inflation	2.3215	1.2003	-1.6200	5.3000	22,448
Fed	1.7801	1.8931	0.0100	5.5000	22,448

Panel B of Table 4.1 reports the means of the variables for banks with ROEs that are higher than the median ROEs and LCRs lower and higher than the median LCR. HighProfit_LowLCR indicates banks having ROEs higher than the median ROE and LCRs less than the median LCR in each quarter. HighProfit_HighLCR indicates banks having ROEs higher than the median ROE and LCRs higher than the median LCR of each quarter. Column 4 presents the difference in the means of these two groups of banks. Column 5 presents the results of P-values for the significance of the difference in means. *, **, and *** represent statistical significance at the 10%, 5%, and 1% levels, respectively.

Panel B: Mean of high-profit banks with low and high LCR

1	2	3	4	5
Variable	Mean for HighProfit_LowLCR	Mean for HighProfit_HighLCR	Difference	P-Values
Observations	6,491	5,316		
MTBM	1.7996	1.7293	0.0703***	(0.0000)
LCR	0.9119	2.9328	-2.0209***	(0.0000)
NSFR	0.9484	1.0325	-0.0841***	(0.0000)
Asset	14.9564	14.6720	0.2844***	(0.0000)
Leverage	0.9054	0.9061	-0.0007	(0.1041)
REL	0.7175	0.7133	0.0042	(0.2352)
Z-score	5.6963	5.5259	0.1704***	(0.0000)
LLP	0.0012	0.0011	0.0001*	(0.0552)
CostFund	0.0044	0.0048	-0.0004***	(0.0000)
ROE	0.0318	0.0319	-0.0001	(0.6232)
CapBuffer	0.0552	0.0593	-0.0040***	(0.0000)
CONC	0.6155	0.6169	-0.0014	(0.1535)
MktPow	0.0031	0.0032	-0.0001	(0.7455)

Panel C of Table 4.1 reports the means of the variables for banks with ROEs less than the median ROE and LCR lower and higher than the median LCR. LowProfit_LowLCR indicates banks having ROE less than the median ROE and LCR less than the median LCR of each quarter. LowProfit_HighLCR indicates banks having ROE less than the median ROE and LCR higher than the median LCR of each quarter. Column 4 presents the differences in the means of these two groups of banks. Column 5 presents the results of P-values for the significance of the differences in means. *, **, and *** represent statistical significance at the 10%, 5%, and 1% levels, respectively.

Panel C: Mean of low profitable banks with low and high LCR

1	2	3	4	5
Variable	Mean for LowProfit_LowLCR	Mean for LowProfit_HighLCR	Difference	P-Values
Observations	4,702	5,875		
MTB	1.2458	1.1395	0.1064***	(0.0000)
LCR	0.9375	3.0392	-2.1017***	(0.0000)
NSFR	0.9477	1.0320	-0.0843***	(0.0000)
Asset	14.5317	14.0567	0.4750***	(0.0000)
Leverage	0.8951	0.9022	-0.0071***	(0.0000)
REL	0.7549	0.7716	-0.0166***	(0.0000)
Z-score	5.1525	4.9035	0.2490***	(0.0000)
LLP	0.0022	0.0024	-0.0001**	(0.0441)
CostFund	0.0050	0.0052	-0.0002***	(0.0000)
ROE	0.0149	0.0136	0.0013***	(0.0000)
CapBuffer	0.0573	0.0620	-0.0047***	(0.0000)
CONC	0.6143	0.6133	0.0010	(0.3555)
MktPow	0.0021	0.0016	0.0006**	(0.0275)

Panel D of Table 4.1 reports the means of adjusted market-to-book values of equity of banks with ROEs below and above the median ROE; and LCRs and NSFRs below and above the median LCR and NSFR, respectively during global financial crisis (GFC) and other periods. GFC is considered for the period 2007: Q4 to 2010: Q4.

Panel D: Mean market-to-book values of equity of low- and high-profit banks with low and high LCR and NSFR banks during GFC and other period

Time	Banks with Low Profitability			
	Low LCR	High LCR	Low NSFR	High NSFR
Non-GFC	1.36	1.24	1.30	1.29
GFC	0.66	0.56	0.60	0.61
	Banks with High Profitability			
	Low LCR	High LCR	Low NSFR	High NSFR
Non-GFC	1.91	1.85	1.91	1.84
GFC	1.22	1.12	1.16	1.19

Table 4.2 Pairwise Pearson correlation coefficients

This table reports the correlation coefficients of quarterly data for 809 US bank holding companies from 2001: Q1 to 2014: Q4. The top and bottom 1% of all observations for all variables except the macroeconomic factors have been winsorised to limit the extreme values.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1 MTB	1.00															
2 LCR	-0.18	1.00														
3 NSFR	0.05	0.37	1.00													
4 LCRNSFR	-0.17	1.00	0.45	1.00												
5 Asset	0.06	-0.02	-0.12	-0.03	1.00											
6 Leverage	0.10	0.06	0.04	0.06	-0.09	1.00										
7 REL	-0.18	-0.03	-0.01	-0.03	-0.47	0.10	1.00									
8 Z-score	0.34	-0.20	0.04	-0.19	-0.02	-0.22	-0.05	1.00								
9 LLP	-0.34	0.11	-0.14	0.09	0.12	0.10	-0.04	-0.50	1.00							
10 CostFund	0.08	-0.04	-0.10	-0.04	-0.15	0.24	0.10	-0.05	0.05	1.00						
11 ROE	0.70	-0.18	0.01	-0.17	0.08	0.13	-0.17	0.42	-0.44	0.07	1.00					
12 CONC	-0.40	-0.03	-0.19	-0.05	0.14	-0.01	0.09	-0.20	0.20	-0.05	-0.38	1.00				
13 MktPow	-0.01	-0.01	-0.09	-0.02	0.53	0.04	-0.27	-0.03	0.08	-0.04	0.03	0.01	1.00			
14 GDP	0.30	-0.02	0.11	-0.01	-0.05	-0.03	-0.03	0.20	-0.21	-0.13	0.24	-0.38	-0.01	1.00		
15 Inflation	0.20	-0.13	-0.06	-0.13	-0.02	0.09	0.00	0.15	-0.19	0.27	0.18	0.07	0.00	0.11	1.00	
16 Fed	0.36	-0.18	-0.13	-0.19	-0.06	0.14	-0.01	0.17	-0.19	0.73	0.30	0.00	-0.01	0.06	0.44	1.00

Table 4.3: Market-to-book values of equity of all banks

Table 4.3 reports 3SLS simultaneous regression results to test the impact of the Basel III liquidity measures (LCR, NSFR and equally weighted LCR and NSFR (LCTNSFR)) on banks' adjusted market-to-book values of equity. We use 3SLS simultaneous regressions to capture potential reverse causality. Bank characteristics and macroeconomic factors are used as control variables in the market-to-book equation and the liquidity equation. Quarterly data of US commercial banks over the period from 2001: Q1 to 2014: Q4 has been used. P-values are computed using heteroskedasticity-robust standard errors and are presented in parentheses. *, **, and *** represent statistical significance at the 10%, 5%, and 1% levels, respectively.

	1	2	3
	Market-to-Book equation		
	MTB	MTB	MTB
LCR	-0.8288***		
	(0.0000)		
NSFR		-8.6348***	
		(0.0000)	
LCRNSFR			-1.5341***
			(0.0000)
Asset	-0.0016	-0.0934***	-0.0092*
	(0.7685)	(0.0000)	(0.0864)
Leverage	1.9450***	3.5817***	2.0875***
	(0.0000)	(0.0000)	(0.0000)
REL	-0.3171***	-0.5116***	-0.3336***
	(0.0000)	(0.0000)	(0.0000)
Z-score	-0.0255***	0.0054	-0.0243***
	(0.0000)	(0.2172)	(0.0000)
LLP	-5.2327***	-28.9815***	-6.6189***
	(0.0012)	(0.0000)	(0.0002)
CostFund	-31.8547***	-63.5014***	-34.9157***
	(0.0000)	(0.0000)	(0.0000)
ROE	18.6451***	31.0063***	19.7418***
	(0.0000)	(0.0000)	(0.0000)
CONC	-2.7256***	-5.1856***	-2.9258***
	(0.0000)	(0.0000)	(0.0000)
GDP	0.0349***	0.0541***	0.0370***
	(0.0000)	(0.0000)	(0.0000)
Inflation	-0.0008	0.0177***	-0.0000
	(0.8173)	(0.0001)	(0.9964)
Constant	2.9838***	11.1394***	3.7238***
	(0.0000)	(0.0000)	(0.0000)
	Liquidity equation		
	LCR	NSFR	LCRNSFR
MTB	-0.4069***	0.0291***	-0.1885***
	(0.0000)	(0.0000)	(0.0000)
Asset	-0.0331***	-0.0172***	-0.0242***
	(0.0000)	(0.0000)	(0.0000)
MktPow	4.1796***	0.6600***	2.3789***
	(0.0000)	(0.0000)	(0.0000)
GDP	0.0281***	0.0045***	0.0163***
	(0.0000)	(0.0000)	(0.0000)
Fed	-0.1159***	-0.0204***	-0.0674***
	(0.0000)	(0.0000)	(0.0000)
Constant	3.0342***	1.2123***	2.1097***
	(0.0000)	(0.0000)	(0.0000)
Observations	19,070	19,070	19,070

Table 4.4: Market-to-book values of equity in big banks

Table 4.4 reports 3SLS simultaneous regression results to test the impact of the Basel III liquidity measures (LCR and NSFR) on the adjusted market-to-book values of equity of big banks. We use 3SLS simultaneous regressions to capture potential reverse causality. BIG is an indicator variable taking on values of 1 for banks in the top decile by total asset value and zero otherwise. Bank characteristics and macroeconomic factors are used as control variables in the market-to-book equation and the liquidity equation. Quarterly data of US commercial banks over the period from 2001: Q1 to 2014: Q4 has been used. P-values are computed using heteroskedasticity-robust standard errors and are presented in parentheses. *, **, and *** represent statistical significance at the 10%, 5%, and 1% levels, respectively.

	1	2
	Market-to-Book equation	
	MTB	MTB
LCR×BIG	0.2504***	
	(0.0000)	
NSFR×BIG		6.9110***
		(0.0000)
BIG	0.0376	-5.6652***
	(0.4801)	(0.0000)
LCR	-0.7123***	
	(0.0000)	
NSFR		-15.2266***
		(0.0000)
Controls	Yes	Yes
	Liquidity equation	
	LCR	NSFR
MTB×BIG	-0.4400***	-0.0252***
	(0.0000)	(0.0000)
BIG	1.6988***	0.1355***
	(0.0000)	(0.0000)
MTB3M	-0.3236***	0.0327***
	(0.0000)	(0.0000)
Controls	Yes	Yes
Observations	19,070	19,070

Table 4.5: Market-to-book values of equity in banks with high capital buffers

Table 4.5 reports 3SLS simultaneous regression results to test the impact of the Basel III liquidity measures (LCR and NSFR) on the adjusted market-to-book values of equity of banks high capital buffers. We use 3SLS simultaneous regressions to capture potential reverse causality. HCB is an indicator variable taking on values of 1 for the top decile banks in terms of the size of capital buffer and zero otherwise. Bank characteristics and macroeconomic factors are used as control variables in the market-to-book equation and the liquidity equation. Quarterly data of US commercial banks over the period from 2001: Q1 to 2014: Q4 has been used. P-values are computed using heteroskedasticity-robust standard errors and are presented in parentheses. *, **, and *** represent statistical significance at the 10%, 5%, and 1% levels, respectively.

	1	2
	Market-to-Book equation	
	MTB	MTB
LCR×HCB	0.2259***	
	(0.0000)	
NSFR×HCB		2.4652***
		(0.0000)
HCB	0.1045**	-1.8188***
	(0.0358)	(0.0000)
LCR	-0.7773***	
	(0.0000)	
NSFR		-5.2377***
		(0.0000)
Controls	Yes	Yes
	Liquidity equation	
	LCR	NSFR
MTB×HCB	-0.5130***	-0.0268***
	(0.0000)	(0.0000)
HCB	1.3693***	0.1720***
	(0.0000)	(0.0000)
MTB	-0.3550***	0.0370***
	(0.0000)	(0.0000)
Controls	Yes	Yes
Observations	18,517	18,517

Table 4.6: Market-to-book values of equity in banks with high profitability

Table 4.6 reports 3SLS simultaneous regression results to test the impact of the Basel III liquidity measures (LCR and NSFR) on the adjusted market-to-book values of equity of high-profit banks. We use 3SLS simultaneous regressions to capture potential reverse causality. HROE is an indicator variable taking on values of 1 for the top decile banks in terms of the size of their return on equity and zero otherwise. Bank characteristics and macroeconomic factors are used as control variables in the market-to-book equation and the liquidity equation. Quarterly data of US commercial banks over the period from 2001: Q1 to 2014: Q4 has been used. P-values are computed using heteroskedasticity-robust standard errors and are presented in parentheses. *, **, and *** represent statistical significance at the 10%, 5%, and 1% levels, respectively.

	1	2
	Market-to-Book equation	
	MTB	MTB
LCR×HROE	0.1663***	
	(0.0000)	
NSFR×HROE		-0.5671
		(0.6172)
HROE	0.1849***	0.6111
	(0.0002)	(0.5735)
LCR	-0.7302***	
	(0.0000)	
NSFR		-11.6632***
		(0.0000)
Controls	Yes	Yes
	Liquidity equation	
	LCR	NSFR
MTB×HROE	-0.7615***	-0.0750***
	(0.0000)	(0.0000)
HROE	2.0551***	0.1369***
	(0.0000)	(0.0000)
MTB	-0.4760***	0.0385***
	(0.0000)	(0.0000)
Controls	Yes	Yes
Observations	19,070	19,070

Table 4.7: Market-to-book value of equity during global financial crisis

Table 4.7 reports 3SLS simultaneous regression results to test the impact of the Basel III liquidity measures (LCR and NSFR) on banks' adjusted market-to-book values of equity during global financial crisis. We use 3SLS simultaneous regressions to capture potential reverse causality. GFC is an indicator variable with 1 for the period from 2007: Q4 to 2010: Q4 and 0 otherwise. Bank characteristics and macroeconomic factors are used as control variables in the market-to-book equation and the liquidity equation. Quarterly data of US commercial banks over the period from 2001: Q1 to 2014: Q4 has been used. P-values are computed using heteroskedasticity-robust standard errors and are presented in parentheses. *, **, and *** represent statistical significance at the 10%, 5%, and 1% levels, respectively.

	1	2
	Market-to-Book equation	
	MTB	MTB
LCR×GFC	0.2147***	
	(0.0000)	
NSFR×GFC		2.8161***
		(0.0000)
GFC	-0.6115***	-3.0433***
	(0.0000)	(0.0000)
LCR	-0.4825***	
	(0.0000)	
NSFR		-8.1285***
		(0.0000)
Controls	Yes	Yes
	Liquidity equation	
	LCR	NSFR
MTB×GFC	-0.6954***	-0.0461***
	(0.0000)	(0.0000)
GFC	0.2623***	-0.0195***
	(0.0000)	(0.0002)
MTB	-0.3734***	0.0200***
	(0.0000)	(0.0000)
Controls	Yes	Yes
Observations	19,070	19,070

Table 4.8: Market-to-book value of equity during post-Basel III announcement period

Table 4.8 reports 3SLS simultaneous regression results to test the impact of the Basel III liquidity measures (LCR and NSFR) on banks' adjusted market-to-book value of equity during global financial crisis. We use 3SLS simultaneous regressions to capture potential reverse causality. BASEL3 is an indicator variable with 1 for the period from 2007: Q4 to 2010: Q4 and 0 otherwise. Bank characteristics and macroeconomic factors are used as control variables in the market-to-book equation and the liquidity equation. Quarterly data of US commercial banks over the period from 2001: Q1 to 2014: Q4 has been used. P-values are computed using heteroskedasticity-robust standard errors and are presented in parentheses. *, **, and *** represent statistical significance at the 10%, 5%, and 1% levels, respectively.

	1	2
	Market-to-Book equation	
	MTB	MTB
LCR×BASEL3	0.2918***	
	(0.0000)	
NSFR×BASEL3		2.9447***
		(0.0000)
BASEL3	-0.8187***	-3.3255***
	(0.0000)	(0.0000)
LCR	-0.6568***	
	(0.0000)	
NSFR		-5.4354***
		(0.0000)
Controls	Yes	Yes
	Liquidity equation	
	LCR	NSFR
MTB×BASEL3	-1.0785***	-0.0980***
	(0.0000)	(0.0000)
BASEL3	1.1502***	0.1197***
	(0.0000)	(0.0000)
MTB	-0.3019***	0.0425***
	(0.0000)	(0.0000)
Controls	Yes	Yes
Observations	19,070	19,070

Table 4.9: Market-to-book value of equity in the banks with high Basel III liquidity measures

Table 4.9 reports 3SLS simultaneous regression results to test the impact of the Basel III liquidity measures (LCR and NSFR) on the adjusted market-to-book values of equity of banks with high Basel III liquidity measures. We use 3SLS simultaneous regressions to capture potential reverse causality. HLIQ is an indicator variable with 1 for banks having LCR≥100% and NSFR≥100% and 0 otherwise. Bank characteristics and macroeconomic factors are used as control variables in the market-to-book equation and the liquidity equation. Quarterly data of US commercial banks over the period from 2001: Q1 to 2014: Q4 has been used. P-values are computed using heteroskedasticity-robust standard errors and are presented in parentheses. *, **, and *** represent statistical significance at the 10%, 5%, and 1% levels, respectively.

	1	2
	Market-to-Book equation	
	MTB	MTB
LCR×HLIQ	15.9425***	
	(0.0000)	
NSFR×HLIQ		9.9667***
		(0.0000)
HLIQ	-10.7218***	-8.8616***
	(0.0000)	(0.0000)
LCR	-16.0656***	
	(0.0000)	
NSFR		-10.2017***
		(0.0000)
Controls	Yes	Yes
	Liquidity equation	
	LCR	NSFR
MTB×HLIQ	-0.6278***	-0.0035
	(0.0000)	(0.4949)
HLIQ	2.5583***	0.1500***
	(0.0000)	(0.0000)
MTB	0.2373***	0.0296***
	(0.0000)	(0.0000)
Controls	Yes	Yes
Observations	19,070	19,070

Appendix-Chapter 4

Appendix 4.A: Definition of Variables

Variable	Definition	Data Source
MTB	(Market Value of Equity / Book Value of Equity)×(1+Cumlative Stock Return over the subsequent three Months)	Federal Reserve Bank
LCR	Liquidity Coverage Ratio	Federal Reserve Bank
NSFR	Net Stable Funding Ratio	Federal Reserve Bank
LCRNSFR	LCRNSFR=0.50×LCR+0.50×NSFR	Federal Reserve Bank
Asset	Natural Logarithm of Total Assets	Federal Reserve Bank
Leverage	Total Liabilities / Total Assets	Federal Reserve Bank
REL	Real Estate Loans / Total Loans	Federal Reserve Bank
Z-score	Log [{Return on Assets+(Equity/Asset)}/Standard Deviation of Return on Assets]. Standard Deviation of Return on Assets is calculated using 1-year rolling window.	Federal Reserve Bank
LLP	Loan Loss Provisions / Total Loans	Federal Reserve Bank
ROE	Net Income / Total Equity	Federal Reserve Bank
CostFund	Total Interest Expense / Total Liabilities	Federal Reserve Bank
CONC	Total Assets of the Five Largest Banks in quarter *t* / Total Assets of Banking System in quarter *t*	Federal Reserve Bank
MktPow	Total Assets of Bank *i* in quarter *t* / Total Assets of Banking System in quarter *t*	Federal Reserve Bank
GDP	Annual Growth Rate of Real GDP	Datastream
Inflation	Annual Inflation Rate	Datastream
Fed	Federal Funds Rate	Datastream
BIG	Indicator variable with 1 for the biggest decile Commercial Banks and 0 otherwise.	Federal Reserve Bank
HCB	HCB is an indicator variable with 1 for the highest decile capital buffer Commercial Banks and 0 otherwise. Capital Buffer = (Actual Regulatory Capital – Risk-Weighted Assets×0.08) / Risk-Weighted Assets.	Federal Reserve Bank
HROE	Indicator variable with 1 for banks in the top quartile in terms of the size of their profitability measured by return on equity (ROE) and 0 otherwise.	Federal Reserve Bank
GFC	Indicator variable with 1 for the period from 2007: Q4 to 2010: Q4 and 0 otherwise. Term Auction Facility was operated by Federal Reserve to provide liquidity during this period.	Federal Reserve Bank
BASEL3	Indicator variable with 1 for the period from 2011: Q1 to 2014: Q4 and 0 otherwise. Basel III officially announced the liquidity requirements date on 16 Dec 2010.	Federal Reserve Bank
HLIQ	Indicator variable with 1 for banks having LCR≥100% and NSFR≥100% and 0 otherwise.	Federal Reserve Bank

Appendix 4.B Summary of liquidity coverage ratio calculation

Panel 1: Stock of High-Quality liquidity assets	
A. Level1Assets	100%
Cash	
Securities in 0% risk weight category	
Reverse Repos in 0% risk weight category	
B. Level2Assets	85%
Securities in 0% risk weight category	
Reverse Repos in 20% and 100% risk weight category	
Panel 2: Cash Outflows	
Stable retail transaction deposits	3%
Stable small time deposits with a remaining maturity of one month or less	
Stable retail savings deposit	
Stable foreign deposits with a remaining maturity of one month or less	5%
Less stable retail transaction deposits	10%
Less stable small time deposits with a remaining maturity of one month or less	
Less stable retail savings deposits	
Less stable foreign deposits with a remaining maturity of one month or less	25%
Stable wholesale transaction deposits	5%
Less stable wholesale transaction deposits	25%
Stable wholesale saving deposits	20%
Stable large time deposits with a remaining maturity of one month or less	
Less stable wholesale saving deposits	40%
Less stable large time deposits with a remaining maturity of one month or less	
Securities lent in 20% risk weight category	15%
Securities lent in 50% and 100% risk weight category	100%
Other liabilities	
Negative fair value Derivatives	
Unused commitments of home-equity line of credit	5%
Unused commitments of credit cards	
Unused commitments of commercial real estate	10%
Unused commitments for securities underwriting	
Other unused commitment	
Letters of credit	5%
Panel 3: Cash Inflows	
50% of loans with a remaining maturity less than one month	100%
Positive fair value of Derivatives	

Appendix 4.C Summary of net stable funding ratio calculation

Available Stable Funding (Sources)	
Tier 1 Capital	100%
Tier 2 capital	
Time deposits with a remaining maturity of over one year	
Other borrowed money with a remaining maturity of over one year	
Stable retail transaction deposits	95%
Small time deposits with a remaining maturity of less than one year	
Stable Retail Savings deposit	
Less Stable retail transaction deposits	90%
Less Stable Retail Savings deposits	
Wholesale transaction deposits	50%
Wholesale Savings deposits	
Large time deposits with a remaining maturity of less than one year	
Foreign deposits	
Other borrowed money with a remaining maturity of less than one year	
Transaction deposits of US government	
Transaction deposits of states and political subdivisions in the United States	
Transaction deposits of foreign governments and official institutions	
Required Stable Funding (Uses)	
Unused commitments	5%
Letters of credit	
Securities in 0% risk weight category	
Securities in 20% risk weight category	20%
Securities in 50% risk weight category	50%
Loans in 0% risk weight category	
Trading assets in 0% risk category	
Other assets in 0% risk category	
Loans in 20% risk weight category	65%
Trading assets in 20% risk category	
Other assets in 20% risk category	
Loans in 50% risk weight category	85%
Trading assets in 50% risk category	
Other assets in 50% risk category	
Securities in 100% risk weight category and no risk weight category	100%
Loans in 100% risk weight category and no risk weight category	
Trading assets in 100% risk category and no risk weight category	
Other assets in 100% risk category and no risk weight category	

5 Bank liquidity risk and credit risk[17]

5.1 Introduction

The Basel Committee on Banking Supervision (BCBS) introduced new liquidity standards in global banking regulations due to the serious liquidity disruptions occurring during the global financial crisis of 2007–2008. In 2010, the BCBS proposed two new liquidity requirements – the liquidity coverage ratio (LCR) and the net stable funding ratio (NSFR) which are designed to increase banks' liquidity in order to increase their ability to weather stressful conditions and to enhance funding stability, respectively. Berger and Bouwman (2009) introduced liquidity creation which measures the degree of maturity mismatch between banks' assets and liabilities. It follows that banks creating more liquidity are subject to higher liquidity risk. NSFR reduces with the maturity mismatch between assets and liabilities whereas liquidity creation increases with the maturity mismatch. Banks maintaining high Basel III liquidity measures and low liquidity creation have low credit risk. We empirically investigate the link between bank liquidity risk and credit risk analysing probabilities of failure and CDS spreads. LCR requires banks to maintain sufficient high-quality liquid assets to meet their liquidity needs under a serious liquidity stress scenario when there is likely to be a significant proportion of cash outflow. The NSFR requires banks to use more stable funding sources like long-term debt for supporting their assets and off-balance sheet activities, and to hold more high-quality liquid assets. Conceptually, LCR reduces banks' liquidity risk by increasing their high-quality liquid assets, and NSFR reduces the funding and interest rate risks originating from maturity mismatches between assets and liabilities (King (2013)). However, it is not clear how banks meeting these new liquidity standards will affect banks' credit risks. We empirically explore these issues in this study. Banks who use unstable funding and do not maintain enough high-quality liquid assets may fail as a result of a fund withdrawal pressure from their creditors.

The objective of LCR and NSFR is to enhance the stability of the overall financial system. Systemic liquidity risk is a major contributor to bank failures, but LCR and NSFR had minor impacts on bank failures during the global financial crisis (Hong, Huang and Wu (2014)). CDS spreads represent default-related information more efficiently than bond and stock markets and

[17] We thank Tony Hall, Iftekhar Hasan and other seminar participants at the University of Technology Sydney. All errors remain ours.

rating agencies (Blanco, Brennan and Marsh (2005); Hull, Predescu and White (2004)). Leverage, equity return volatility, risk-free rates, some CAMELS indicators, stock market volatility and deposit insurance determine global bank CDS spreads (Hasan, Liu and Zhang (2016)).

The objective of this study is to investigate the link between banks' liquidity risk and credit risk. We also investigated whether the weights used to calculate NSFR are appropriate. Using logit regressions, we find that reductions in liquidity risk, proxied by high funding stability and low liquidity creation, reduced the probability of failure among US commercial banks for the period from 2001–2014. We also find that increases in NSFR and decreases in liquidity creation of banks with low funding stability and high liquidity creation have a lower probability of failure. Using 3SLS simultaneous regressions, we find evidence that reductions in liquidity risk reduce banks' credit risk proxied by CDS spreads. Our findings are consistent with the objective of Basel III liquidity measures which was to improve funding stability by high NSFR. We also find that low liquidity creation reduces banks' credit risk proxied by probability of failure and CDS spreads.

The remainder of this article is organised as follows. Section 2 summarises the Basel III liquidity standards, liquidity creation and related literature. Section 3 describes the data used. Section 4 presents our empirical model. Section 5 discusses the empirical results. Conclusions are provided in Section 6.

5.2 Background and hypothesis development

5.2.1 Definitions of Basel III liquidity risk measures

The objective of the Basel III LCR standard is to require banks to hold an adequate level of unencumbered, high-quality liquid assets that can be converted easily and immediately into cash to meet liquidity needs for the next 30 days in a severe liquidity stress scenario. The LCR is defined as the ratio of the stock of high-quality liquid assets to the total net cash outflows over the next 30 calendar days:

$$\text{LCR} = \frac{Stock of High-Quality liquid assets}{Total net cash\ outflows over the next\ 30\ days} \qquad (1)$$

Banks are required to maintain an LCR of at least 100%. The value of an LCR depends on the assumptions used in the calculations of the stock of high-quality liquid assets (HQLA) and the cash inflows and outflows. HQLA are divided into Level 1 Assets and Level 2 Assets. When calculating LCR we need to make assumptions about the classification of Level 1 Assets and Level 2 Assets, the weights assigned to these asset categories, and the rates of cash outflows and inflows for different liability and asset categories.

The objective of the NSFR is to maintain medium- and long-term funding stability. The NSFR is defined as the ratio of available stable funding (ASF) to required stable funding (RSF).

$$\text{NSFR} = \frac{AvailableStableFunding}{RequiredStableFunding} \qquad (2)$$

Under Basel III liquidity rules, an NSFR should be at least 100%. In calculating NSFR, we also need to make assumptions about the classifications of different assets and liabilities, and the weights assigned to different categories. We calculated the approximate measures of LCR and NSFR according to the revised versions of the LCR and NSFR made in January 2013 and January 2014 by the Basel Committee respectively.

We follow the assumptions of Hong, Hang and Wu (2014) for calculating the LCR and NSFR. Weights of assets and liabilities used to calculate NSFR are provided in Appendix 5.B. Insured deposits are stable deposits, and uninsured deposits are less stable deposits. US commercial banks only report total uninsured deposits in their call reports. The uninsured deposits in each category of deposits are proportional to the size of that category. The maturity schedule of assets and liabilities is evenly distributed so that the amount of loans with a remaining maturity of less than one month equals one-twelfth of the amount of loans with a remaining maturity within one year. Savings and transaction deposits are equally divided into wholesale and retail deposits.

5.2.2 Definition of liquidity creation

Berger and Bouwman (2009) introduce a measure for banks' liquidity creation, which effectively measures the extent to which banks finance relatively illiquid assets with relatively liquid liabilities. Banks creating more liquidity are taking more financial intermediation risk as a result of increasing the mismatch between the maturities of banks' assets and liabilities. Liquidity creation has been widely used in the literature as a measure of banks' liquidity risk

(Berger and Bouwman (2009); Berger, Bouwman, Kick and Schaeck (2016); Distinguin, Roulet and Tarazi (2013); Horváth, Seidler and Weill (2014)). Liquidity creation considers a large number of banks' balance sheet items which are shown in Appendix 5.C. We consider two measures of liquidity creation, CATNOFAT and CATFAT.
Specifically, we follow Berger and Bouwman (2009) to compute liquidity creation as follows:

$$CATNOFAT=0.5\times Illiquid\ \ Assets+0.5\times Liquid\ \ Liabilities-0.5\times Liquid\ \ Assets-0.5\times Illiquid\ \ Liabilities-0.5\times Equity \quad (3)$$

$$CATFAT=0.5\times Illiquid\ \ Assets+0.5\times Liquid\ \ Liabilities+0.5\times Illiquid\ \ Guarantees-0.5\times Liquid\ \ Assets-0.5\times Illiquid\ Liabilities-0.5\times Equity-0.5\times Liquid\ Guarantees-0.5\times Liquid\ Derivatives \quad (4)$$

5.2.3 Related literature

Elliott (2014) suggests that banks have a crucial role in the national and international financial system. For banks to operate optimally and minimise inefficiencies, they should be safe, and they should be perceived to be safe (Lee (2009)). One of the paramount qualities of an optimally performing bank is having the value of its assets significantly higher than the value of its liabilities. This provides a capital cushion that is available to cover any kind of loss (De Nicolò, Dell'Ariccia, Laeven and Valencia (2010)). However, the recent financial crisis underscored the importance of having a liquidity buffer to cover expected cash flows (Ivashina and Scharfstein (2010)). It was against this backdrop that the Basel Committee on Banking Supervision developed Basel III to improve banks' governance and risk management, and their ability to absorb shock, and to strengthen their disclosure and reporting (Basel (2013)).

Cole and White (2012) investigate bank-specific factors for a banking failure and reveal that five aspects of CAMEL, as well as commercial real estate investment, are the key bank-specific factors associated with banking failure. Waemustafa and Sukri (2015) note that earnings and capital levels are the relevant bank-specific factors, but they also argue that management efficiency is the most important bank-specific factor associated with banking failure because all the other bank-specific factors depend on the bank's management. According to Saunders and Cornett (2003), bank failures take place when the bank cannot meet its obligations to

creditors or depositors because it is too illiquid or insolvent to be able to cover all its liabilities. Specifically, the failure of a bank occurs when the total market value of the assets falls to a value less than the market value of its liabilities. Bank failure is more important due to contagion effects resulting from the fragility and interconnectedness of these institutions. A banking failure could spread in the economy very easily which may result in a multiplier effect upon other banks and this may ultimately create severe distress in the economy.

Liquidity creation is an important function of the banks and is even more important during periods of financial crisis (Berger and Bouwman (2008)), and a bank's liquidity creation is positively correlated to its value (Berger and Bouwman (2009)). However, liquidity creation predisposes the bank to various risks including liquidity risks (Acharya, Shin and Yorulmazer (2009)). Even though liquidity creation is portrayed as an important role of banks by modern theory, there are no comprehensive measures of bank liquidity creation (Berger and Bouwman (2009)). According to Bouwman (2013) , liquidity risk in banks can be mitigated to a certain degree by holding liquid assets such as cash and cash equivalents. This safety net creates a moral hazard where banks have a perverse incentive to increase the level of risk at the expense of the deposit insurer. Empirical studies suggest that liquidity problems in banks are often triggered by concerns that a bank may have poor asset quality, making it insolvent (Strahan (2008)). This creates the need for the capital requirements and regulatory monitoring to improve risk management and banks' asset portfolios (Demyanyk and Hasan (2010)).

During economic crises, banks are faced with different regulatory interventions and may get capital injections. Capital injections and regulatory interventions lead to lower liquidity creation, the risk of the bank failing decreases and this reduces the bank's risk exposure. According to Hartlage (2012), the issue of capital and liquidity creation is important because the tighter capital requirement in Basel III has a potentially major effect on banks' liquidity. Berger and Bouwman (2017) suggest that the tightening of monetary policy is linked to decreases in small banks' liquidity creation. The effect of monetary policy on liquidity creation by the banks during a financial crisis is weaker than it is in normal times. Further, liquidity creation has a tendency to rise before financial crises. This means that high aggregate bank liquidity creation can be a sign of an impending financial crisis. This is corroborated by a study by Horváth, Seidler and Weill (2014) which finds out that capital has a negative effect on banking liquidity creation, especially for the small banks, but also that liquidity creation may lead to a reduction in capital. This finding means that higher the capital requirement of Basel

III may lead to a reduction in liquidity creation (Berger, Bouwman, Kick and Schaeck (2016)) but greater liquidity creation may lead to a reduction in bank solvency (Matz and Neu (2006)). The reverse causality involved creates a trade-off between the advantages of financial stability that are encouraged by stronger capital requirements and the advantages of increased liquidity creation (Aizenman, Hutchison and Jinjarak (2013); Distinguin, Roulet and Tarazi (2013)).

Schmitz, Sigmund and Valderrama (2017) estimate the contemporaneous interaction between liquidity and solvency and reveal that a 100 basis points increase in the regulatory capital ratios might lead to a decline in banking funding costs by about 105 basis points NSFR ensures that banks maintain stable funding profiles in relation to off-balance activities and the composition of their assets. The sustainable funding structure requirement aims at minimising the probability that the liquidity position of a bank will be eroded by the regular sourcing of funds in a way that potentially heightens risk of failure and result in a broader systematic stress (Basel (2014)). According to Borio and Zhu (2012) banks increase their liquidity ratios when there is a decline in the capital ratios and they reduce their capital when there is an increase in liquidity. This is because an increase in capital creates an incentive for banks to reduce their liquidity and minimise risk taking. This finding is consistent with the findings of (Cornett, McNutt, Strahan and Tehranian (2011)). However, there is a difference between the ways in which the banks adjust their capital, risk and liquidity during normal times and crisis times. During the crises the rates of risk and liquidity adjustment are generally higher, which means that banks are inclined to attain the desired level of risk and liquidity during the crisis period (Anbar and Alper (2011)).

One of the commonly used proxies for bank credit risk is CDS spreads. This CDS is usually designed to transfer fixed income products' credit exposure (the CDS seller agrees to compensate buyer if the loan defaults which insures the buyer against loan defaults). Casu and Chiaramonte (2012) investigate whether CDS spreads may be regarded as a good proxy for the risk of a bank. The empirical analysis indicates that a bank's CDS spreads during financial crises usually reflect the risk which may be captured by balance sheet ratios. CDS spreads imply credit risk and the liquidity of both CDS spreads and risk premiums can be explained by bid-ask spreads (Arakelyan and Serrano (2016)) and may not be explained fully by credit risk factors which are related to the underlying entity (Giglio (2011)). According to Aizenman, Hutchison and Jinjarak (2013) CDS spreads help to indicate whether a bank has taken excessive risk, which jeopardises its sustainability. Excessive risk taking of banks is the main reason

behind corporate failure, and it is determined by various factors including board characteristics (Adams and Mehran (2012)), low-interest rates over an extended period (Altunbas, Gambacorta and Marques-Ibanez (2014)) and prudential regulation (Kashyap, Rajan and Stein (2008)).

Theoretically, CDS spreads represent the firm's pure credit risk (Annaert, De Ceuster, Van Roy and Vespro (2013)). Gali, Shapir, Amiram and Ben-Zion (2014) observe that even though CDS premiums have a relationship with credit ratings that are issued by ratings agencies, wider CDS spreads variations are observed for firms that have a given rate. An empirical study by Jacobs, Karagozoglu and Peluso (2010) finds that after controlling for interest rates, market volatility and market returns, CDS spreads increase with the deterioration of credit quality of the reference firm, the put-implied volatility or the subordination of the debt instrument. However, according to Ahmadian (2015), this does not mean that CDS markets are able to anticipate future risks accurately. Srivastava, Lin, Premachandra and Roberts (2016) note that CDS spreads are directly proportional to the risk associated with the investors/market to the underlying assets. This is reinforced by the empirical study of Kieseland Spohnholtz (2017), which reveals that credit ratings and logarithmised CDS spreads by rating agencies have a linear relationship. Their study underscores the relevance of CDS spreads analysis in measuring credit worthiness. This is because markets react to favourable news by decreasing the spread and to unfavourable news by increasing the spread.

Hypothesis 1: High net stable funding ratios and low liquidity creation reduce banks' credit risks.

5.3 Data

We use US commercial bank data as opposed to bank holding company data to calculate NSFR because commercial bank data are more detailed. We obtained US commercial bank data from the Federal Reserve Bank of Chicago. Quarterly data for the sample period from 2001: Q1 to 2014: Q4 is used in this study. We obtain CDS spreads data from Markit. US commercial bank failure data was obtained from the Federal Deposit Insurance Corporation (FDIC) and matched with call report data obtained from the Federal Reserve Bank. We use five-year CDS spreads because these contracts are the most liquid. The final quarterly data set contains 412,244 bank

quarters for 10,393 commercial banks. We find 475 commercial bank failures during our sample period. We match the five-year CDS spreads data in 1,124 bank quarters for 38 commercial banks. We use the CDS spreads of the last trading day in each quarter. To address outlier problems, all variables except the CDS spreads, and macroeconomic factors are winsorised at the 1st and 99th percentiles which is a widely approach adopted in the literature (Acharya and Mora (2015); Beltratti and Stulz (2012); Berger and Bouwman (2009)).

The quarterly descriptive statistics for our full sample of commercial banks used in the regressions are reported in Panel A of Table 5.1. The average CDS spreads, and the NSFR for the sample of commercial banks are 2.04% and 113% respectively. For the average commercial banks, two liquidity creation measures CATNOFAT and CATFAT constitute 5.86% and 8.64% of total assets respectively. Panels B and C of Table 5.1 report the means of variables of the failed and non-failed banks respectively. We find that failed banks have low NSFR but high CATNOFAT and CATFAT values, and the results are statistically significant at the 1% level of significance. Table 5.2 reports the pair-wise correlation coefficients of the variables used in this study. We do not find bank variables employed as explanatory variables to be highly correlated, indicating that multicollinearity is not a major problem in our empirical analysis. We find that NSFR, CATNOFAT and CATFAT are negatively and highly correlated. Table 5.3 lists the number of failed banks in the next quarter during our sample period.

<Insert Table 5.1-5.3>

Figures 5.1 and 5.2 show that failed banks have low NSFRs but high CATNOFATs which indicates that failed banks have high liquidity risk. Figure 5.3 shows that ASF weights are negatively related to the coefficients of the probability of bank failure. Figure 5.4 shows that RSF weights are positively related to the coefficients of the probability of bank failure. Figure 5.5 shows assets other than real estate loans, non-real estate loans and cash and securities make a higher contribution to the probability of bank failure. Figure 5.6 shows equity reduces the probability of bank failure to a greater extent. Figure 5.7 shows CDS spreads varied over time during our sample period.

5.4 Model

In order to test the link between liquidity risk and the probability of bank failure, we developed the following discrete-time logistic hazard model.

$$\lambda_{i,t+1} = \text{Prob}\left(\text{D}_{i,t+1} = 1\right) = \frac{\exp(lp_{i,t})}{1+\exp(lp_{i,t})} \qquad (5)$$

With the linear predictor

$$lp_{i,t} = \beta_0 + \beta_1 Liquidity_{i,t} + \beta_2 Equity_{i,t} + \beta_3 LLP_{i,t} + \beta_4 ROA_{i,t} + \beta_5 NIM_{i,t} + \beta_6 NPA_{i,t} + \beta_7 Asset_{i,t} + + \beta_8 Intangible_{i,t} + \beta_9 REL_{i,t} + \beta_{10} C\&ILoan_{i,t} + \beta_{11} ConsLoan_{i,t} \qquad (6)$$

and the default indicator:

$$\text{D}_{i,t+1} = 0, if\ a\ bank\ i\ does\ not\ default\ in\ period\ t+1$$

$$\text{D}_{i,t+1} = 1, if\ a\ bank\ i\ does\ default\ in\ period\ t+1$$

$\lambda_{i,t+1}$ is the conditional probability that bank *i* fails at time *t*+1 but has not failed at time *t*. The independent test variable, *Liquidity*, in the panel logit regressions is a vector of the alternative liquidity risk measures and their underlying components for bank *i* in quarter *t*. We use the Basel III liquidity measure, NSFR, and the liquidity creation measures, CATNOFAT and CATFAT, as the proxies for banks' liquidity risk. As liquidity creation is inversely related to Basel III liquidity measures, we multiply the values for banks' liquidity creation by -1 to facilitate a more consistent interpretation of liquidity risk proxies such that a higher value indicates lower liquidity risk for all test variables.

Consistent with Cole and White (2012) and Hong et al. (2014) we consider the natural logarithm of total assets (Asset), the ratios of total equity divided by total assets (Equity), loan loss provisions divided by total loans (LLP), net income divided by total assets (ROA), net interest margin divided by total assets (NIM), non-performing assets divided by total assets (NPA), total intangible assets divided by total assets (Intangible), real estate loans divided by total assets (REL), commercial and industrial loans divided by total assets (C&I Loan) and consumer loans divided by total assets as the potential determinants of banks' probability of failures.

In order to test the impact of Basel III liquidity measures on banks' CDS spreads we use 3SLS simultaneous regression equations to capture potential reverse causality. The CDS spreads and liquidity equations include a number of control variables for bank characteristics and activities, which may influence banks' CDS spreads and liquidity risk. We use 3SLS simultaneous equation regressions to account for potential reverse causality between bank liquidity risk and banks' CDS spreads. There is a possibility that banks' CDS spreads may affect liquidity risk

as well. The 3SLS simultaneous equation regression addresses the potential endogeneity and cross-correlation between equations. Our 3SLS regressions capture the reverse causality between banks' liquidity, the market-to-book value of equity and CDS spreads. The 3SLS simultaneous equation regressions are widely used in the literature to address endogeneity concerns (Aggarwal and Jacques (2001); Bhagat and Bolton (2008); Distinguin, Roulet and Tarazi (2013); Shrieves and Dahl (1992)).

The model developed to test the impact of bank liquidity on banks' credit risk is:

$$\begin{cases} CDS_{i,t+1} = \alpha Liquidity_{i,t} + \beta Controls_{i,t} + \varepsilon_{i,t} \\ Liquidity_{i,t+1} = \gamma CDS_{i,t} + \delta Controls_{i,t} + \xi_{i,t} \end{cases} \quad (7)$$

where α and β (γ and δ) reflect the extent to which the relative factor of the model contributes to the change in the dependent variable in the CDS (liquidity) equation, and $\varepsilon_{i,t}$ and $\xi_{i,t}$represent the error term for bank *i* in quarter *t* in the CDS equation and the liquidity equation respectively.

The dependent variable, *CDS Spreads*, in the CDS equation is the banks' five-year CDS spread for bank *i* in quarter *t*+1. CDS spreads are a measure of a bank's credit risk and cost of wholesale funding. The buyer pays the CDS spreads to the seller, and the seller protects the buyer for the possible loss from the default of the reference entity.

The independent test variable, *Liquidity*, in the CDS equation is one of three alternative liquidity risk measures and their underlying components for bank *i* in quarter *t*. We use the Basel III liquidity measure (NSFR) and liquidity creation (CATNOFAT and CATFAT) as the proxies of banks' liquidity risk.

The independent control variables are bank characteristics for bank *i* in quarter *t*. In all 3SLS regressions, we include bank characteristics as well as some macroeconomic factors that affect banks' CDS spreads. The list of control variables for bank characteristics, activities and CAMELS indicators used in this study are commonly adopted in the literature. Consistent with Cole and White (2012), Dietrich et al. (2014), Distinguin et al. (2013), Hasan et al. (2015) and Hong et al. (2014) we consider a natural logarithm of total assets (Asset), a natural logarithm of z-score (z-score), the ratios of total liabilities divided by total assets (Leverage), loan loss provisions divided by total loans (LLP), net income divided by total assets (ROA), real estate loans divided by total loans (REL), total interest expense divided by total liabilities (CostFund), the total assets of the five largest banks in quarter *t* divided by the total assets of banking system

in quarter *t* (CONC), growth rate of real gross domestic product (GDP) and inflation rate (Inflation) as the potential determinants of banks' CDS spreads in the CDS spreads equation. Consistent with Berger and Bouwman (2009), Díaz and Huang (2013), Distinguin et. al. (2013) and Fungáčová et al. (2010) we consider natural logarithms of total assets (Asset), the ratios of total assets of bank *i* in quarter *t* divided by total assets of the banking system in quarter *t* (MktPow), the growth rate of real gross domestic product (GDP) and the federal funds rate (Fed) as the potential determinants of banks' liquidity in the liquidity equation. Z-score is a proxy of banks' capital adequacy. LLP and NPA provide information on the asset quality of banks and higher LLP, and NPA indicates lower asset quality. CONC measures the concentration in the banking system. Higher values of concentration indicate banks have a higher possibility of collusion and of earning monopoly profit. MktPow measures the market power of each bank.

5.5 Discussion of results

5.5.1 Liquidity risk and bank failure for all banks

Table 5.4 reports the logit regression results to test the impact of liquidity risk on the probability of bank failure of all banks.

<Insert Table 5.4>

Table 5.4 shows that increases in NSFR and decreases in liquidity creation (CATNOFAT and CATFAT) reduce the probability of failure of US commercial banks at a 1% level of significance. Therefore, a decrease in liquidity risk reduces the probability of bank failure. We find the control variables significantly affect the probability of failure and in line with our prior expectations and the literature. We find that equity, loan loss provisions, return on assets, net interest margin, assets and real estate loans are negatively related to the probability of bank failure. Therefore, well-capitalised banks, high-profit and big banks are less likely to fail. However, non-performing assets, intangible assets and commercial and industrial loans are positively related to the probability of bank failure. Therefore, banks with low asset quality and risky assets are more likely to fail.

5.5.2 Liquidity risk and bank failure for the banks with high liquidity risk

Table 5.5 reports the logit regression results to test the impact of liquidity risk on the probability of bank failure of the banks with high liquidity risk.

<Insert Table 5.5>

Banks with low NSFR and high CATNOFAT and CATFAT are subject to high liquidity risk. Table 5.5 shows that the interaction term for NSFR and high NSFR is negatively related to bank failure, indicating that increases in the NSFRs of banks with low NSFRs reduce the probability of failure more than increases in the NSFRs of other banks. The indicator variable for the level of liquidity risk, LNSFR, is positively related to the probability of bank failure indicating banks with low NSFR have high credit risk. Moreover, the interaction term for CATNOFAT and CATFAT with high liquidity creation is negatively related to bank failure, indicating that decreases in the liquidity creation of banks with high liquidity creation reduces the probability of failure more than decreases in the liquidity creation of other banks. However, the indicator variable for high liquidity creation is negatively related to the probability of failure.

5.5.3 Components of NSFR

5.5.3.1 ASF and bank failure for all banks

Table 5.6 shows the logit regression results for testing the impact of the components of available stable funding (ASF) on the probability of bank failure for all banks.

<Insert Table 5.6>

ASF is positively related to NSFR. Liabilities and equity with high ASF weights indicate the high importance in constructing ASF. The components of ASF have been standardised to make them comparable. Column 5 of Table 5.6 shows that ASFs with different weights are negatively related to bank failure, indicating that increases in ASF reduce the likelihood of bank failure. Figure 5.3 shows regression coefficients of column 5 of Table 5.6. Figure 5.3 shows that on balance, the higher the ASF weight, the lower (more negative) the coefficients, indicating that higher ASF weights reduce the likelihood of bank failure more.

5.5.3.2 RSF and bank failure for all banks

Table 5.7 reports the logit regression results to test the impact of the components of required stable funding (RSF) on the probability of bank failure for all banks.

<Insert Table 5.7>

RSF is inversely related to NSFR. Assets with high RSF weights indicate the high importance of constructing RSF. The components of RSF have been standardised to make them comparable. Column 5 of Table 5.7 shows that the higher the RSF weights, the higher the probability of bank failure. Figure 5.4 shows regression coefficients of column 5 of Table 5.7. Figure 5.4 shows that the higher the RSF weight, the higher (more positive) the coefficients indicating that higher RSF weights increase the likelihood of bank failure.

5.5.3.3 Balance sheet components

Table 5.8 shows the logit regression results used to test the impacts of the components of the balance sheet on the probability of bank failure of all banks.

<Insert Table 5.8>

Components of NSFR are different from balance sheet components. NSFR components are calculated based on the weights used to calculate the NSFR, whereas balance sheet components are categorised based on the riskiness of assets and liabilities. Assets are equivalent to required stable funding, whereas liabilities and equity are equivalent to available stable funding. Assets are categorised into four groups: 1) Cash, Securities and Federal Funds (CashSecFed); 2) Non-real estate loans (NonRel); 3) Real estate loans (REL); and 4) Other assets (OtherAsset). Table 3 shows that all groups of assets are positively related to bank failure, which is consistent with the RSF results. Column 3 of Table 5.8 shows other assets make the highest contribution to bank failure, followed by real-estate loans, non-real estate loans and cash, securities and federal funds. These results indicate that bank liquidity risk is positively associated with probability of failure because non-lending activities are more risky, followed by real estate loans, non-real estate loans and cash, securities and federal funds. Liabilities and equity are categorised into six groups: 1) Equity (Equity); 2) Insured savings and transaction deposits (InSavTrnDep); 3) Uninsured savings and transaction deposits (UinSavTrnDep); 4) Time deposits greater than 1 year (TDG1yr); 5) Time deposits less than 1 year (TDL1yr); and 6) Other liabilities

(OtherLiab). In terms of stability of funding, Equity is the most stable form of funding followed by InSavTrnDep, UinSavTrnDep, TDG1yr, TDL1yr, and OtherLiab. Table 5.8 shows that equity reduces the probability of failure more as it is the most stable source of funding. Insured savings and transaction deposits have a lower impact on bank failure than uninsured savings and transaction deposits. The reason may be that banks free ride on the cost of deposit insurance schemes. However, time deposits of less than one year increase the probability of failure. Overall, the results show that more stable sources of funds reduce the probability of failure more than unstable sources.

5.5.4 Liquidity risk and CDS spreads

Table 5.9 reports the 3SLS regression results to test the impact of liquidity risk on the CDS spreads of all banks.

<Insert Table 5.9>

CDS spread is considered an alternative proxy for a bank's credit risk. The CDS equation in Table 5.9 shows that increases in NSFR and decreases in CATNOFAT in the last quarter reduce the CDS spreads. In the CDS equation we use control variables similar to those in the bank failure equation. Moreover, the liquidity equation in Table 5.9 shows that CDS spreads are positively related to CATNOFAT. CDS results confirm that banks' liquidity risk and credit risk are positively associated.

5.6 Conclusion

In this study, we calculate the net stable funding ratio and liquidity creation using historical call report data over the period from 2001 to 2014 to investigate the link between banks' liquidity risk and credit risk. We find that increases in Basel III liquidity standards and reductions in banks' liquidity creation are associated with a lower probability of failure and CDS spreads for US commercial banks. Our findings provide evidence that banks' liquidity risk and credit are positively associated. We also find that a decrease in liquidity risk reduces the credit risk more in the banks with high liquidity risk having lower levels of NSFR and higher liquidity creation. We also test the impact of the components of NSFR on credit risk. We find evidence that components of ASF and RSF affect the probability of failure according to their weights. For example, higher ASF weights reduce the risk of bank failure more, and higher RSF weights increase the bank failure more. Therefore, the weights of assets, liabilities

and equities used to calculate NSFR are appropriate. We also find that assets with more risk have a higher impact on the probability of bank failure. Moreover, equity reduces the probability of bank failure to a greater extent. The main policy implication of this study is that the Basel III liquidity requirements enhance the financial stability of banks by reducing the credit risk. The dark side of liquidity creation is that it increases credit risk.

Figures

The grey shaded area, 2002: Q1–2002: Q4 and 2007: Q4–2009: Q3, in Figures 1 to 3 show economic recession periods as indicated by the National Bureau of Economic Research (NBER).

Figure 5.1: Net stable funding ratio (NSFR) of failed and non-failed banks

Figure 5.1 shows the NSFR of the failed and non-failed US commercial banks.

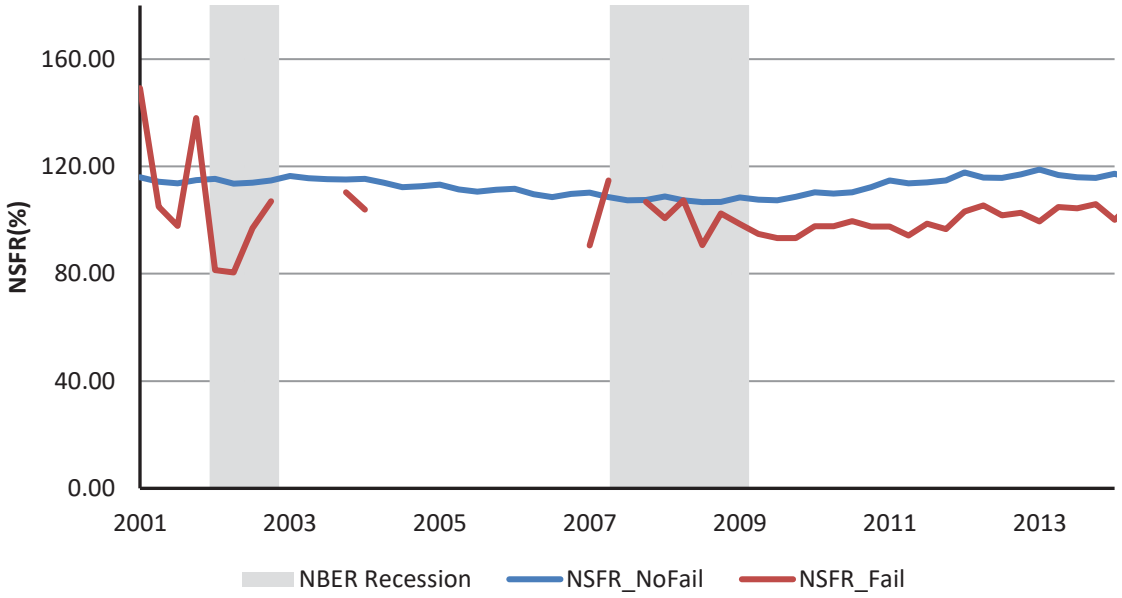

Figure 5.2: CATNOFAT-to-total assets of failed and non-failed banks

Figure 5.2 shows the -CATNOFAT-to-total assets of the failed and non-failed US commercial banks.

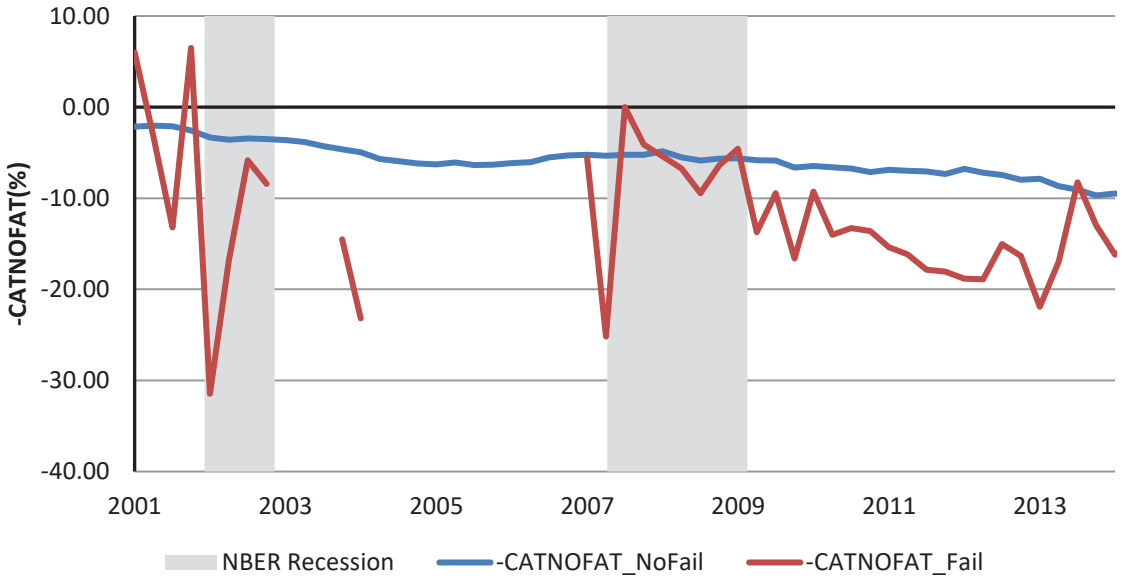

Figure 5.3: ASF weights and coefficients for failed banks

Figure 5.3 shows the ASF weights and the coefficients of bank failure. The value of coefficients are taken from column 5 of table 5.6.

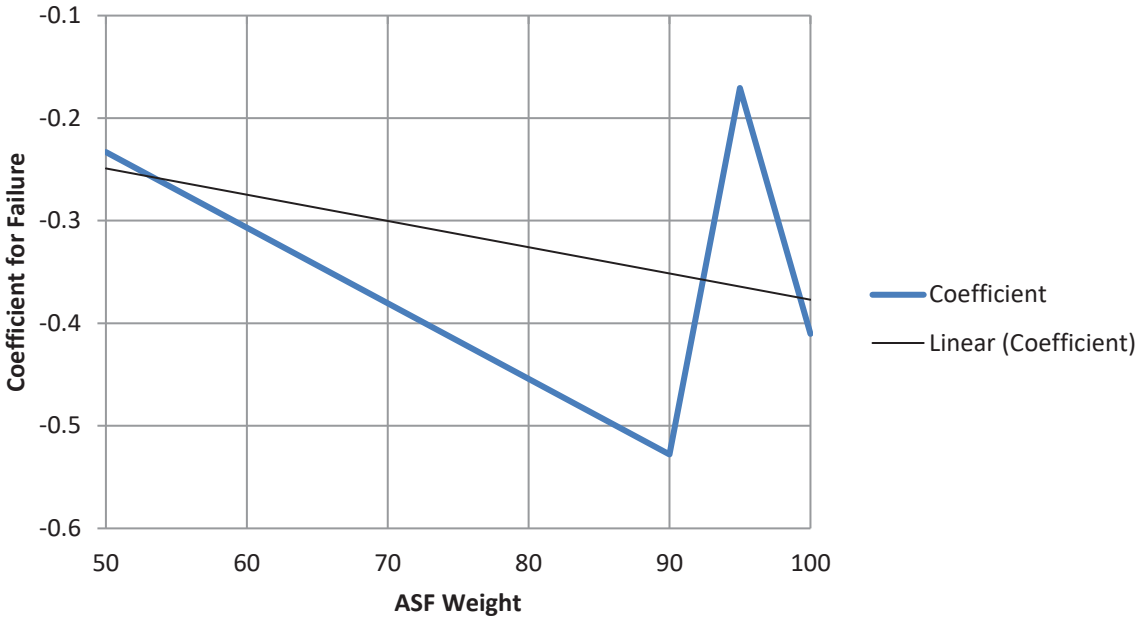

Figure 5.4: RSF weight for failed banks

Figure 5.4 shows the RSF weights and the coefficients of bank failure. The value of coefficients are taken from column 7 of table 5.7.

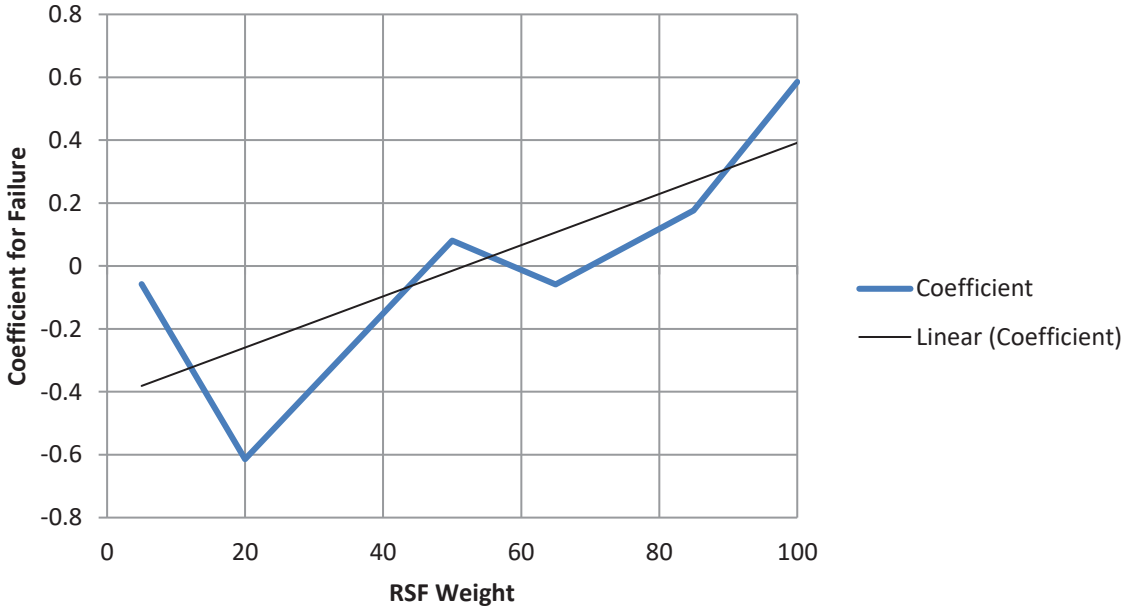

Figure 5.5: Components of assets for failed banks

Figure 5.5 shows the components of assets and the coefficients of bank failure. The value of coefficients are taken from column 3 of table 5.8.

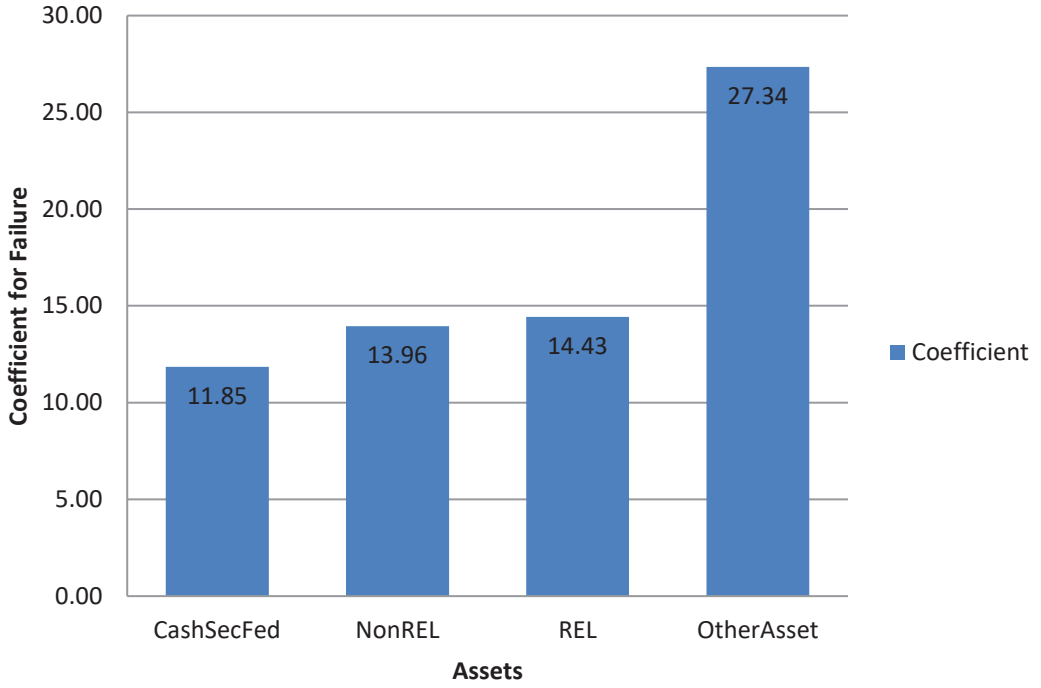

Figure 5.6: Components of liabilities and equity for failed banks

Figure 5.6 shows the components of liabilities and equity and the coefficients of bank failure. The value of coefficients are taken from column 3 of table 5.8.

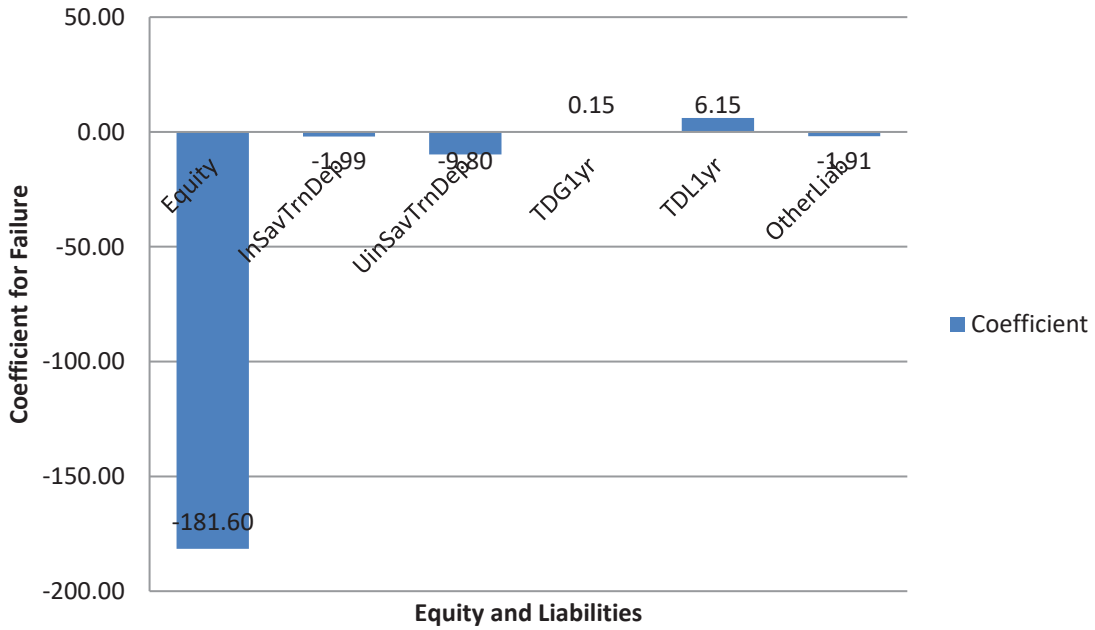

Figure 5.7: CDS spreads of US commercial banks

Figure 5.7 shows the median, 5th percentile and 95th percentile 5-year CDS spreads of US commercial banks from 2001 to 2014.

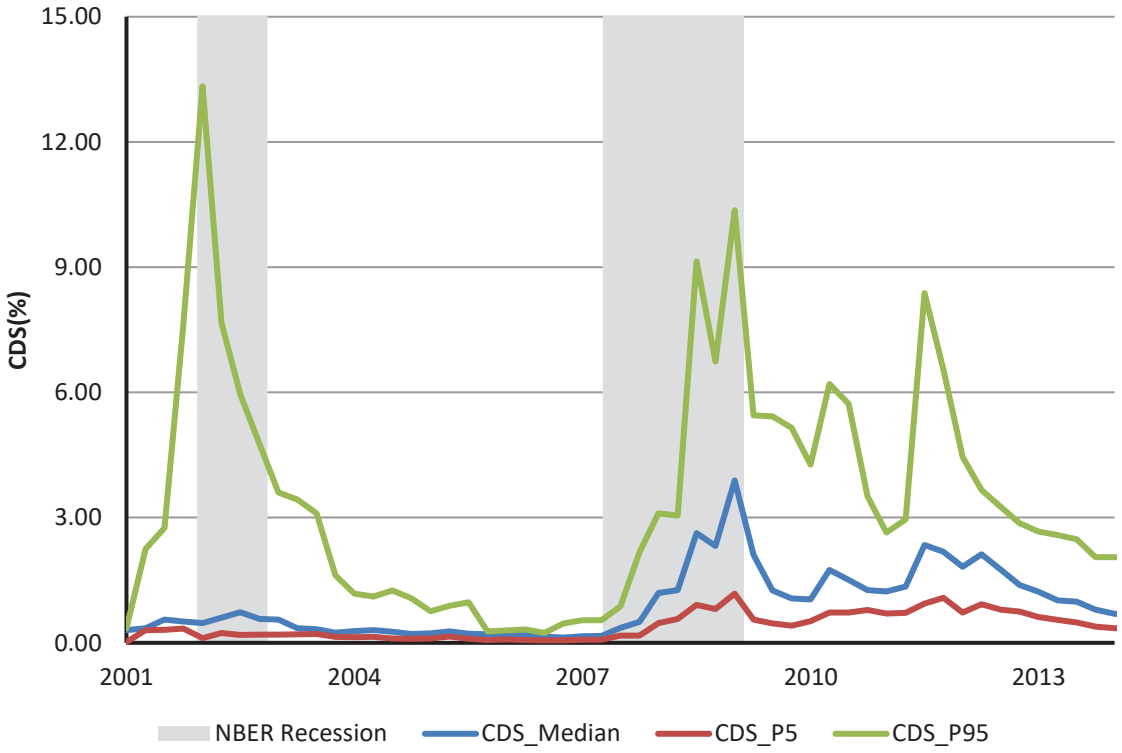

Table 5.1: Summary statistics

Panel A: Summary statistics of all banks

Panel A of Table 5.1 reports the summary statistics of quarterly data for 10,393 commercial banks from 2001: Q1 to 2014: Q4. The top and bottom 1% of all observations of all variables except the macroeconomic factors and CDS spreads have been winsorised to limit the extreme values.

Variable	Mean	Std. Dev.	Min	Max	Obs
Fail	0.0012	0.0339	0.0000	1.0000	412,244
CDS	0.0204	0.1051	0.0002	2.6990	1,124
NSFR	1.1260	0.2605	0.7509	2.2597	412,244
-CATNOFAT	-0.0586	0.1149	-0.3221	0.2687	412,244
-CATFAT	-0.0864	0.1310	-0.4271	0.2626	412,244
CashSecFed	0.3199	0.1568	0.0568	0.7707	412,244
NonREL	0.1943	0.1205	0.0027	0.5862	412,244
REL	0.4369	0.1739	0.0360	0.8037	412,244
OtherAsset	0.0463	0.0279	0.0032	0.1538	412,244
Equity	0.1087	0.0370	0.0527	0.2790	412,244
InSavTrnDep	0.3074	0.1077	0.0516	0.5879	412,244
UinSavTrnDep	0.1192	0.0886	0.0023	0.4616	412,244
TDG1yr	0.0729	0.0573	0.0000	0.2741	412,244
TDL1yr	0.0717	0.0523	0.0015	0.2659	412,244
OtherLiab	0.0836	0.0711	0.0020	0.3602	412,244
LLP	0.0008	0.0018	-0.0008	0.0118	411,068
ROA	0.0019	0.0030	-0.0138	0.0082	411,068
NIM	0.0091	0.0019	0.0039	0.0153	411,068
NPA	0.0136	0.0190	0.0000	0.1036	412,244
Asset	11.9040	1.2820	9.4279	16.3796	412,244
Intangible	0.0038	0.0108	0.0000	0.0694	412,244
C&I Loan	0.0223	0.0505	0.0000	0.2484	412,244
Cons Loan	0.0020	0.0046	0.0000	0.0337	412,244
Leverage	0.8912	0.0370	0.7209	0.9469	412,244
Z-score	5.0124	1.0849	1.7028	7.2828	380,452
CostFund	0.0047	0.0028	0.0004	0.0118	411,068
CONC	0.3981	0.0640	0.2776	0.4746	412,244
MktPow	0.0001	0.0024	0.0000	0.1450	412,244
GDP	1.7843	2.5193	-8.1900	6.8700	412,244
Inflation	2.3356	1.2288	-1.6200	5.3000	412,244
Fed	1.8028	1.8985	0.0100	5.5000	412,244

Panel B: Summary statistics of failed banks

Panel B of Table 5.1 reports the summary statistics of quarterly data of the quarter immediately before the failure for 475 commercial banks from 2001: Q1 to 2014: Q4. The top and bottom 1% of all observations of all variables except the macroeconomic factors and CDS spreads have been winsorised to limit the extreme values.

Variable	Mean	Std. Dev.	Min	Max	Obs
NSFR	0.9820	0.1389	0.7509	2.1835	475
-CATNOFAT	-0.1289	0.1033	-0.3221	0.2162	475
-CATFAT	-0.1545	0.1115	-0.4271	0.2141	475
CashSecFed	0.2243	0.1000	0.0568	0.6759	475
NonREL	0.1220	0.1092	0.0027	0.5862	475
REL	0.5814	0.1456	0.0360	0.8037	475
OtherAsset	0.0912	0.0413	0.0046	0.1538	475
Equity	0.0564	0.0128	0.0527	0.1681	475
InSavTrnDep	0.2375	0.1256	0.0516	0.5879	475
UinSavTrnDep	0.0565	0.0557	0.0023	0.4616	475

TDG1yr	0.1271	0.0823	0.0000	0.2741	475
TDL1yr	0.0826	0.0698	0.0015	0.2659	475
OtherLiab	0.0777	0.0678	0.0020	0.3602	475
LLP	0.0059	0.0051	-0.0008	0.0118	475
ROA	-0.0086	0.0059	-0.0138	0.0082	475
NIM	0.0062	0.0022	0.0039	0.0153	475
NPA	0.0880	0.0283	0.0000	0.1036	475
Asset	12.3065	1.2538	9.4279	16.3796	475
Intangible	0.0018	0.0072	0.0000	0.0694	475
C&I Loan	0.0339	0.0565	0.0000	0.2484	475
Cons Loan	0.0016	0.0038	0.0000	0.0337	475
Leverage	0.9433	0.0127	0.8319	0.9469	475
Z-score	1.9889	0.7496	1.7028	5.7866	259
CostFund	0.0053	0.0026	0.0004	0.0118	475
CONC	0.4491	0.0301	0.2776	0.4746	475
MktPow	0.0000	0.0001	0.0000	0.0021	475
GDP	1.0318	3.0951	-8.1900	4.7600	475
Inflation	1.5047	1.6594	-1.6200	5.3000	475
Fed	0.3375	0.8080	0.0100	5.5000	475

Panel C: Summary statistics of non-failed banks

Panel C of Table 5.1 reports the summary statistics of quarterly data for 9,918 non-failed commercial banks from 2001: Q1 to 2014: Q4. The top and bottom 1% of all observations of all variables except the macroeconomic factors and CDS spreads have been winsorised to limit the extreme values.

Variable	Mean	Std. Dev.	Min	Max	Obs
CDS	0.0204	0.1051	0.0002	2.6990	1,124
NSFR	1.1262	0.2605	0.7509	2.2597	411,769
-CATNOFAT	-0.0586	0.1148	-0.3221	0.2687	411,769
-CATFAT	-0.0864	0.1310	-0.4271	0.2626	411,769
CashSecFed	0.3200	0.1568	0.0568	0.7707	411,769
NonREL	0.1944	0.1205	0.0027	0.5862	411,769
REL	0.4367	0.1738	0.0360	0.8037	411,769
OtherAsset	0.0463	0.0278	0.0032	0.1538	411,769
Equity	0.1088	0.0370	0.0527	0.2790	411,769
InSavTrnDep	0.3075	0.1077	0.0516	0.5879	411,769
UinSavTrnDep	0.1193	0.0886	0.0023	0.4616	411,769
TDG1yr	0.0729	0.0572	0.0000	0.2741	411,769
TDL1yr	0.0717	0.0523	0.0015	0.2659	411,769
OtherLiab	0.0836	0.0711	0.0020	0.3602	411,769
LLP	0.0008	0.0017	-0.0008	0.0118	410,593
ROA	0.0019	0.0030	-0.0138	0.0082	410,593
NIM	0.0091	0.0019	0.0039	0.0153	410,593
NPA	0.0135	0.0189	0.0000	0.1036	411,769
Asset	11.9035	1.2819	9.4279	16.3796	411,769
Intangible	0.0038	0.0108	0.0000	0.0694	411,769
C&I Loan	0.0223	0.0505	0.0000	0.2484	411,769
Cons Loan	0.0020	0.0046	0.0000	0.0337	411,769
Leverage	0.8912	0.0370	0.7209	0.9469	411,769
Z-score	5.0144	1.0822	1.7028	7.2828	380,193
CostFund	0.0047	0.0028	0.0004	0.0118	410,593
CONC	0.3980	0.0641	0.2776	0.4746	411,769
MktPow	0.0001	0.0024	0.0000	0.1450	411,769
GDP	1.7852	2.5184	-8.1900	6.8700	411,769
Inflation	2.3366	1.2279	-1.6200	5.3000	411,769
Fed	1.8044	1.8987	0.0100	5.5000	411,769

Table 5.2: Pairwise Pearson correlation coefficients

Table 5.2 reports the correlation coefficients of quarterly data for 10,393 commercial banks from 2001: Q1 to 2014: Q4. The top and bottom 1% of all observations of all variables except the macroeconomic factors and CDS spreads have been winsorised to limit the extreme values.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
1CDS	1.00																													
2NSFR	0.06	1.00																												
3-CATNOFAT	-0.02	0.48	1.00																											
4-CATFAT	-0.02	0.33	0.63	1.00																										
5CashSecFed	0.03	0.76	0.66	0.56	1.00																									
6NonREL	-0.06	-0.47	-0.20	-0.52	-0.58	1.00																								
7REL	0.03	-0.15	-0.55	-0.22	-0.37	-0.41	1.00																							
8OtherAsset	0.04	-0.34	0.00	0.26	-0.02	-0.12	-0.19	1.00																						
9Equity	0.06	-0.09	0.06	-0.21	-0.20	0.32	-0.12	-0.10	1.00																					
10InSavTrnDep	0.06	0.16	-0.52	-0.31	-0.06	-0.19	0.45	-0.38	-0.08	1.00																				
11UinSavTrnDep	-0.01	-0.01	-0.56	-0.20	-0.06	-0.19	0.31	-0.02	-0.11	0.43	1.00																			
12TDG1yr	0.06	0.12	0.25	-0.16	-0.11	0.26	-0.03	-0.35	0.29	-0.02	-0.41	1.00																		
13TDL1yr	0.02	-0.07	-0.08	-0.03	-0.14	-0.14	0.35	-0.06	-0.06	-0.24	0.24	-0.15	1.00																	
14OtherLiab	-0.09	-0.26	0.29	0.31	0.05	0.14	-0.44	0.51	-0.25	-0.68	-0.38	-0.34	-0.12	1.00																
15LLP	0.01	-0.31	-0.06	-0.38	-0.39	0.56	-0.24	0.08	0.24	-0.25	-0.28	0.21	-0.02	0.12	1.00															
16ROA	-0.03	-0.18	0.08	-0.24	-0.19	0.43	-0.25	-0.16	0.18	-0.11	-0.20	0.16	-0.10	0.14	0.08	1.00														
17NIM	0.07	-0.35	-0.21	-0.59	-0.53	0.63	-0.04	-0.21	0.32	0.04	-0.23	0.35	0.02	-0.16	0.64	0.41	1.00													
18NPA	0.05	-0.19	-0.28	-0.20	-0.31	0.14	0.12	0.18	0.09	0.05	0.04	0.09	-0.06	-0.02	0.43	-0.19	0.25	1.00												
19Asset	-0.24	-0.27	-0.04	-0.08	-0.14	0.33	-0.38	0.38	-0.06	-0.37	-0.01	-0.15	-0.24	0.56	0.20	0.15	-0.13	0.11	1.00											
20Intangible	0.09	-0.24	-0.36	-0.09	-0.12	-0.09	0.10	0.54	0.08	-0.09	0.17	-0.36	0.02	0.21	0.04	-0.17	-0.07	0.34	0.32	1.00										
21C&I Loan	-0.11	-0.38	-0.60	-0.28	-0.46	0.27	0.22	0.11	-0.06	0.07	0.35	-0.29	0.02	0.12	-0.04	-0.09	-0.19	0.01	0.40	0.18	1.00									
22Cons Loan	-0.06	-0.40	-0.07	-0.28	-0.33	0.53	-0.29	0.11	0.09	-0.11	-0.16	0.01	-0.28	0.20	0.55	0.24	0.51	0.27	0.30	0.03	-0.02	1.00								
23Leverage	-0.05	0.10	-0.03	0.24	0.21	-0.33	0.12	0.09	-1.00	0.08	0.10	-0.29	0.06	0.24	-0.25	-0.18	-0.32	-0.09	0.04	-0.10	0.04	-0.08	1.00							
24Z-score	-0.03	-0.04	-0.21	-0.03	-0.06	-0.11	0.28	-0.20	0.00	0.27	0.20	-0.12	-0.01	-0.15	-0.41	0.26	-0.08	-0.23	-0.15	-0.02	0.14	-0.15	0.01	1.00						
25CostFund	-0.08	-0.17	0.13	-0.08	-0.20	0.14	0.06	0.08	0.03	-0.43	-0.29	0.16	0.38	0.12	0.22	0.06	0.16	-0.14	0.00	-0.09	0.03	0.02	-0.04	-0.12	1.00					
26CONC	0.10	0.17	0.00	-0.02	0.10	-0.08	-0.03	-0.04	0.08	0.10	0.15	0.07	-0.10	-0.08	0.02	-0.11	-0.06	0.46	0.07	0.15	-0.11	0.09	-0.08	-0.03	-0.23	1.00				
27MktPow	-0.07	-0.28	0.00	0.43	-0.04	-0.08	-0.10	0.48	-0.25	-0.15	0.03	-0.31	-0.21	0.40	-0.06	-0.05	-0.21	0.21	0.29	0.25	0.10	0.24	0.26	0.10	-0.15	0.03	1.00			
28GDP	-0.03	-0.02	0.00	-0.03	0.01	0.03	-0.02	-0.08	0.02	0.09	-0.01	0.02	-0.12	-0.03	-0.18	0.23	-0.01	-0.16	0.00	-0.12	0.01	-0.02	-0.02	0.23	-0.06	-0.26	0.00	1.00		
29Inflation	-0.05	-0.04	0.00	0.00	-0.04	0.00	0.04	0.06	-0.05	-0.12	-0.06	-0.08	0.15	0.10	-0.15	0.11	-0.05	-0.17	0.00	0.02	0.05	-0.04	0.05	0.20	0.35	-0.05	-0.02	0.11	1.00	
30Fed	-0.11	-0.18	0.00	0.00	-0.09	-0.03	0.11	0.16	-0.11	-0.29	-0.08	-0.20	0.37	0.17	-0.09	0.07	-0.05	-0.27	-0.02	0.06	0.10	-0.11	0.10	0.13	0.78	-0.25	-0.05	0.08	0.44	1.00

Table 5.3: Number of failed Banks by quarter from 2001 to 2014

Table 5.3 lists the number of failed and total banks by quarter. Column 2 reports the total number of banks of each quarter. Column 3 reports the number of banks failed in the next quarter. Bank failure data is obtained from the Federal Deposit Insurance Corporation (FDIC) and matched with call report data obtained from Federal Reserve Bank.

1	2	3
Quarter	Bank Count	Number of Failed Banks
2001Q1	8,228	1
2001Q2	8,177	1
2001Q3	8,161	3
2001Q4	8,116	2
2002Q1	8,288	1
2002Q2	8,238	1
2002Q3	8,202	3
2002Q4	8,158	1
2003Q1	8,133	0
2003Q2	8,091	0
2003Q3	8,088	0
2003Q4	8,047	2
2004Q1	7,993	1
2004Q2	7,957	0
2004Q3	7,900	0
2004Q4	7,858	0
2005Q1	7,835	0
2005Q2	7,785	0
2005Q3	7,787	1
2005Q4	7,761	0
2006Q1	7,729	0
2006Q2	7,719	1
2006Q3	7,691	0
2006Q4	7,637	0
2007Q1	7,613	1
2007Q2	7,568	1
2007Q3	7,516	0
2007Q4	7,493	2
2008Q1	7,469	3
2008Q2	7,431	8
2008Q3	7,385	12
2008Q4	7,284	21
2009Q1	7,224	26
2009Q2	7,146	40
2009Q3	7,075	39
2009Q4	6,997	40
2010Q1	6,935	41
2010Q2	6,834	35
2010Q3	6,751	25
2010Q4	6,685	24
2011Q1	6,610	16
2011Q2	6,559	22
2011Q3	6,511	17
2011Q4	6,465	15
2012Q1	6,952	11
2012Q2	6,905	11
2012Q3	6,836	7
2012Q4	6,741	3
2013Q1	6,691	10
2013Q2	6,620	6
2013Q3	6,577	1
2013Q4	6,509	6
2014Q1	6,435	4
2014Q2	6,356	3
2014Q3	6,290	3
2014Q4	6,202	4
All		475

Table 5.4: Liquidity risk and bank failure for all banks

Table 5.4 reports the logit regression results to test the impact of the Basel III liquidity measure (NSFR) and liquidity creation (CATNOFAT and CATFAT) on the probability of bank failure for all banks. The dependent variable, $Fail_{t+1}$, is an indicator variable taking the value of 1 if the bank fails at time t+1 given that it has not failed by time t and zero otherwise. Bank characteristics are used as control variables in the financial performance equation and the liquidity equation. Quarterly data of US commercial banks over the period from 2001: Q1 to 2014: Q4 has been used. P-values are presented in parentheses. *, **, and *** represent statistical significance at the 10%, 5% and 1% levels, respectively.

	1	2	3
	$Fail_{t+1}$	$Fail_{t+1}$	$Fail_{t+1}$
$NSFR_t$	-3.2885***		
	(0.0000)		
$-CATNOFAT_t$		-2.1724***	
		(0.0002)	
$-CATFAT_t$			-1.9665***
			(0.0003)
$Equity_t$	-113.5771***	-107.8488***	-108.2196***
	(0.0000)	(0.0000)	(0.0000)
LLP_t	-48.0774***	-33.6894**	-33.8384**
	(0.0033)	(0.0393)	(0.0383)
ROA_t	-91.1774***	-90.7751***	-90.5401***
	(0.0000)	(0.0000)	(0.0000)
NIM_t	-255.1666***	-244.8227***	-244.6689***
	(0.0000)	(0.0000)	(0.0000)
NPA_t	29.8217***	31.4353***	31.6239***
	(0.0000)	(0.0000)	(0.0000)
$Asset_t$	-0.2439***	-0.2358***	-0.2445***
	(0.0000)	(0.0001)	(0.0000)
$Intangible_t$	47.8275***	47.9252***	48.2920***
	(0.0000)	(0.0000)	(0.0000)
REL_t	-0.9607**	0.1759	0.1775
	(0.0389)	(0.6959)	(0.6928)
$C\&I\ Loan_t$	2.8878**	3.1460**	3.1742**
	(0.0166)	(0.0120)	(0.0112)
$Cons\ Loan_t$	12.7842	18.8680	16.6477
	(0.3440)	(0.1685)	(0.2239)
Constant	9.0591***	4.1135***	4.2038***
	(0.0000)	(0.0000)	(0.0000)
Pseudo R-sq	0.5510	0.5461	0.5460
Observations	411,068	411,068	411,068

Table 5.5: Liquidity and bank failure for high liquidity risk banks

Table 5.5 reports the logit regression results to test the impact of the Basel III liquidity measure (NSFR) and liquidity creation (CATNOFAT and CATFAT) on the probability of bank failure for banks with high liquidity risk. LNSFR is an indicator variable taking a value of 1 for banks having NSFR less than the mean of NSFR in each quarter and zero otherwise. HCNF (HCF) is an indicator variable taking a value of 1 for banks having CATNOFAT (CATFAT) greater than the mean of CATNOFAT (CATFAT) in each quarter and zero otherwise. The dependent variable, $Fail_{t+1}$,is an indicator variable taking the value of 1 if the bank fails at time t+1 given that it has not failed by time t and zero otherwise. Bank characteristics are used as control variables in the financial performance equation and the liquidity equation. Quarterly data of US commercial banks over the period from 2001: Q1 to 2014: Q4 has been used. P-values are presented in parentheses. *, **, and *** represent statistical significance at the 10%, 5% and 1% levels, respectively.

	1	2	3
	$Fail_{t+1}$	$Fail_{t+1}$	$Fail_{t+1}$
$NSFR \times LNSFR_t$	-3.1517***		
	(0.0054)		
$LNSFR_t$	3.0013**		
	(0.0198)		
$NSFR_t$	-2.0371**		
	(0.0293)		
$-CATNOFAT \times HCNF_t$		-3.2696*	
		(0.0991)	
$HCNF_t$		-0.4352**	
		(0.0210)	
$-CATNOFAT_t$		-0.5344	
		(0.7669)	
$-CATFAT \times HCF_t$			-2.9736*
			(0.0734)
HCF_t			-0.3828*
			(0.0662)
$-CATFAT_t$			-0.1592
			(0.9136)
$Controls_t$	Yes	Yes	Yes
Pseudo R-sq	0.5530	0.5469	0.5465
Observations	411,068	411,068	411,068

Table 5.6: Components of ASF and bank failure

Table 5.6 reports the logit regression results to test the impact of the components of available stable funding (ASF) on the probability of bank failure for all banks. The dependent variable, $Fail_{t+1}$,is an indicator variable taking the value of 1 if the bank fails at time t+1 given that it has not failed by time t and zero otherwise. Bank characteristics are used as control variables in the financial performance equation and the liquidity equation. Quarterly data of US commercial banks over the period from 2001: Q1 to 2014: Q4 has been used. P-values are presented in parentheses. *, **, and *** represent statistical significance at the 10%, 5% and 1% levels, respectively.

	1	2	3	4	5
	$Fail_{t+1}$	$Fail_{t+1}$	$Fail_{t+1}$	$Fail_{t+1}$	$Fail_{t+1}$
$ASF100_t$	-0.1791***				-0.4102***
	(0.0001)				(0.0000)
$ASF95_t$		0.1370***			-0.1706**
		(0.0046)			(0.0346)
$ASF90_t$			-0.4227**		-0.5279***
			(0.0235)		(0.0051)
$ASF50_t$				0.0238	-0.2331***
				(0.5940)	(0.0025)
$Controls_t$	Yes	Yes	Yes	Yes	Yes
pseudo R-sq	0.5463	0.5453	0.5451	0.5443	0.5485
Observations	411,068	411,068	411,068	411,068	411,068

Table 5.7: Components of RSF and bank failure

Table 5.7 reports the logit regression results to test the impact of the components of required stable funding (RSF) on the probability of bank failure for all banks. The dependent variable, $Fail_{t+1}$, is an indicator variable taking the value of 1 if the bank fails at time t+1 given that it has not failed by time t and zero otherwise. Bank characteristics are used as control variables in the financial performance equation and the liquidity equation. Quarterly data of US commercial banks over the period from 2001: Q1 to 2014: Q4 has been used. P-values are presented in parentheses. *, **, and *** represent statistical significance at the 10%, 5% and 1% levels, respectively.

	1	2	3	4	5	6	7
	$Fail_{t+1}$	$Fail_{t+1}$	$Fail_{t+1}$	$Fail_{t+1}$	$Fail_{t+1}$	$Fail_{t+1}$	$Fail_{t+1}$
$RSF5_t$	-0.0461						-0.0572
	(0.3888)						(0.3244)
$RSF20_t$		-0.7233***					-0.6143***
		(0.0000)					(0.0000)
$RSF50_t$			-0.0580				0.0809
			(0.6225)				(0.4885)
$RSF65_t$				-0.0768			-0.0586
				(0.2167)			(0.3730)
$RSF85_t$					-0.2388***		0.1762
					(0.0006)		(0.1390)
$RSF100_t$						0.5528***	0.5853***
						(0.0000)	(0.0000)
$Controls_t$	Yes	Yes	Yes	Yes	Yes	Yes	Yes
pseudo R-sq	0.5443	0.5504	0.5443	0.5444	0.5459	0.5512	0.5559
Observations	411,068	411,068	411,068	411,068	411,068	411,068	411,068

Table 5.8: Components of balance sheet and bank failure

Table 5.8 reports the logit regression results to test the impact of the components of assets, liabilities and equities on the probability of bank failure for all banks. The dependent variable, $Fail_{t+1}$, is an indicator variable taking the value of 1 if the bank fails at time t+1 given that it has not failed by time t and zero otherwise. Bank characteristics are used as control variables in the financial performance equation and the liquidity equation. Quarterly data of US commercial banks over the period from 2001: Q1 to 2014: Q4 has been used. P-values are presented in parentheses. *, **, and *** represent statistical significance at the 10%, 5% and 1% levels, respectively.

	1	2	3
	$Fail_{t+1}$	$Fail_{t+1}$	$Fail_{t+1}$
$CashSecFed_t$	53.5031***		11.8539***
	(0.0000)		(0.0000)
$NonREL_t$	49.9169***		13.9574***
	(0.0000)		(0.0000)
REL_t	56.9770***		14.4273***
	(0.0000)		(0.0000)
$OtherAsset_t$	83.9779***		27.3426***
	(0.0000)		(0.0000)
$Equity_t$		-200.8843***	-181.6044***
		(0.0000)	(0.0000)
$InSavTrnDep_t$		-2.1492***	-1.9945**
		(0.0041)	(0.0130)
$UinSavTrnDep_t$		-11.8357***	-9.8032***
		(0.0000)	(0.0000)
$TDG1yr_t$		0.9723	0.1493
		(0.2825)	(0.8751)
$TDL1yr_t$		7.5030***	6.1455***
		(0.0000)	(0.0001)
$OtherLiab_t$		-3.4075***	-1.9129**
		(0.0000)	(0.0216)
Constant	-64.0095***	9.0082***	-7.1355***
	(0.0000)	(0.0000)	(0.0023)
Pseudo R-sq	0.2059	0.4762	0.5018
N	412,244	412,244	412,244

Table 5.9: Liquidity risk and CDS spreads

Table 5.9 reports 3SLS simultaneous regression results to test the impact of the Basel III liquidity measure (NSFR) and liquidity creation (CATNOFAT and CATFAT) on the CDS spreads for all banks. P-values are presented in parentheses. *, **, and *** represent statistical significance at the 10%, 5% and 1% levels, respectively.

	1	2	3
	CDS equation		
	CDS_{t+1}	CDS_{t+1}	CDS_{t+1}
$NSFR_t$	-0.0345**		
	(0.0111)		
$-CATNOFAT_t$		-0.0879***	
		(0.0007)	
$-CATFAT_t$			-0.0213
			(0.1831)
$Leverage_t$	-0.0476	-0.0531	-0.0374
	(0.5363)	(0.4888)	(0.6313)
$Z\text{-score}_t$	-0.0070*	-0.0079**	-0.0063*
	(0.0582)	(0.0335)	(0.0904)
LLP_t	-0.4043	-0.8575	-0.0856
	(0.7826)	(0.5585)	(0.9553)
ROA_t	0.9895	1.2908	0.9022
	(0.4177)	(0.2854)	(0.4746)
$Asset_t$	-0.0224***	-0.0223***	-0.0204***
	(0.0000)	(0.0000)	(0.0000)
REL_t	-0.0341	-0.0640**	-0.0285
	(0.1279)	(0.0159)	(0.2183)
$CostFund_t$	-1.8995	-0.6762	-1.6786
	(0.1473)	(0.6208)	(0.2023)
$CONC_t$	0.2757***	0.2603***	0.2437***
	(0.0002)	(0.0003)	(0.0008)
GDP_t	-0.0000	-0.0001	-0.0001
	(0.9985)	(0.9707)	(0.9425)
$Inflation_t$	-0.0007	-0.0011	-0.0006
	(0.8117)	(0.6836)	(0.8412)
Constant	0.3832***	0.3601***	0.3132***
	(0.0000)	(0.0000)	(0.0002)
	Liquidity equation		
	$NSFR_{t+1}$	$-CATNOFAT_{t+1}$	$-CATFAT_{t+1}$
CDS_t	-0.2056	-0.1367*	-0.1635
	(0.1022)	(0.0843)	(0.1150)
$Asset_t$	-0.0438***	-0.0061	-0.0401***
	(0.0000)	(0.1190)	(0.0000)
$MktPow_t$	-1.8466***	0.0739	3.4298***
	(0.0000)	(0.6122)	(0.0000)
GDP_t	-0.0008	-0.0015	-0.0036
	(0.8160)	(0.4654)	(0.1876)
Fed_t	-0.0310***	-0.0014	0.0023
	(0.0000)	(0.6289)	(0.5248)
Constant	1.7805***	0.0186	0.4227***
	(0.0000)	(0.7635)	(0.0000)
R-sq	0.0806	0.0835	0.0782
Observations	1,023	1,023	1,023

Appendix-Chapter 5

Appendix 5.A: Construction of variables

Variable	Construction	Data Source
Fail	Fail $_{t+1}$ is an indicator variable taking the value of 1 if the bank fails at time t+1 given that it has not failed by time t and zero otherwise.	Federal Deposit Insurance Corporation
CDS	5-Year CDS spreads	Markit
LCR	Liquidity coverage ratio	Federal Reserve Bank
NSFR	Net stable funding ratio	Federal Reserve Bank
CATNOFAT	[0.5*Illiquid assets+0.5*Liquid liabilities-0.5*Liquid assets-0.5*Illiquid liabilities-0.5*Equity]/Total assets	Federal Reserve Bank
CATFAT	[0.5*Illiquid assets+0.5*Liquid liabilities+0.5*Illiquid guarantees-0.5*Liquid assets-0.5*Illiquid liabilities-0.5*Equity-0.5*Liquid guarantees-0.5*Liquid derivatives]/Total assets	Federal Reserve Bank
ASF100	Standardized ratio of (Sum of Liabilities having weight of 100% in available stable funding)/Total assets	Federal Reserve Bank
ASF95	Standardized ratio of (Sum of Liabilities having weight of 95% in available stable funding)/Total assets	Federal Reserve Bank
ASF90	Standardized ratio of (Sum of Liabilities having weight of 90% in available stable funding)/Total assets	Federal Reserve Bank
ASF50	Standardized ratio of (Sum of Liabilities having weight of 50% in available stable funding)/Total assets	Federal Reserve Bank
RSF100	Standardized ratio of (Sum of Assets having weight of 100% in required stable funding)/Total assets	Federal Reserve Bank
RSF85	Standardized ratio of (Sum of Assets having weight of 85% in required stable funding)/Total assets	Federal Reserve Bank
RSF65	Standardized ratio of (Sum of Assets having weight of 65% in required stable funding)/Total assets	Federal Reserve Bank
RSF50	Standardized ratio of (Sum of Assets having weight of 50% in required stable funding)/Total assets	Federal Reserve Bank
RSF20	Standardized ratio of (Sum of Assets having weight of 20% in required stable funding)/Total assets	Federal Reserve Bank
RSF5	Standardized ratio of (Sum of Assets having weight of 5% in required stable funding)/Total assets	Federal Reserve Bank
CashSecFed	[Cash and Balances+Securities+Federal Funds Sold and Securities Purchased Under Agreements to Resell]/Total Assets	Federal Reserve Bank
NonREL	Non Real estate loans/Total assets	Federal Reserve Bank
REL	Real estate loans/Total assets	Federal Reserve Bank
OtherAsset	Other Assets/ Total Assets	Federal Reserve Bank
Equity	Total equity/Total asets	Federal Reserve Bank
InSavTrnDep	Insured Savings and Transaction Deposits/ Total Assets	Federal Reserve Bank
UinSavTrnDep	Uninsured Savings and Transaction Deposits/ Total Assets	Federal Reserve Bank

TDG1yr	Time deposits with remaining maturity greater than one year	Federal Reserve Bank
TDL1yr	Time deposits with remaining maturity less than one year	Federal Reserve Bank
OtherLiab	Other Liabilities/ Total Assets	Federal Reserve Bank
LLP	Loan loss provisions / Total assets	Federal Reserve Bank
ROA	Net income / Total assets	Federal Reserve Bank
NIM	NIM=(Interest income-Interest expense)/Total assets	Federal Reserve Bank
NPA	Non-performing assets/Total assets	Federal Reserve Bank
Asset	Natural logarithm of total assets	Federal Reserve Bank
Intangible	(Goodwill +Other intangible assets)/ Total assets	Federal Reserve Bank
C&I Loan	Commercial and industrial loans/Total assets	Federal Reserve Bank
Cons Loan	Consumer loans/Total assets	Federal Reserve Bank
Leverage	Total liabilities / Total assets	Federal Reserve Bank
Z-score	Log [{Return on assets+(Equity/Asset)}/Standard deviation of return on assets]. Standard deviation of return on assets is calculated using 1 year rolling window.	Federal Reserve Bank
CostFund	Total interest expense / Total liabilities	Federal Reserve Bank
CONC	Total sssets of the five largest banks in quarter *t* / Total assets of banking system in quarter *t*	Federal Reserve Bank
MktPow	Total assets of bank *i*in quarter *t* / Total assets of banking system in quarter *t*	Federal Reserve Bank
GDP	Annual Growth Rate of Real GDP	Datastream
Inflation	Annual Inflation Rate	Datastream
Fed	Federal Funds Rate	Datastream
LNSFR	Indicator variable taking a value of 1 for banks having NSFR less than the mean of NSFR in each quarter and zero otherwise.	Federal Reserve Bank
HCNF	Indicator variable taking a value of 1 for banks having CATNOFAT greater than the mean of CATNOFAT in each quarter and zero otherwise.	Federal Reserve Bank
HCF	Indicator variable taking a value of 1 for banks having CATFAT greater than the mean of CATFAT in each quarter and zero otherwise.	Federal Reserve Bank

Appendix 5.B Summary of net stable funding ratio calculation

Available Stable Funding (Sources)	
Tier 1 Capital	100%
Tier 2 capital	
Time deposits with a remaining maturity of over one year	
Other borrowed money with a remaining maturity of over one year	
Stable retail transaction deposits	95%
Small time deposits with a remaining maturity of less than one year	
Stable Retail Savings deposit	
Less Stable retail transaction deposits	90%
Less Stable Retail Savings deposits	
Wholesale transaction deposits	50%
Wholesale Savings deposits	
Large time deposits with a remaining maturity of less than one year	
Foreign deposits	
Other borrowed money with a remaining maturity of less than one year	
Transaction deposits of US government	
Transaction deposits of states and political subdivisions in the United States	
Transaction deposits of foreign governments and official institutions	
Required Stable Funding (Uses)	
Unused commitments	5%
Letters of credit	
Securities in 0% risk weight category	
Securities in 20% risk weight category	20%
Securities in 50% risk weight category	50%
Loans in 0% risk weight category	
Trading assets in 0% risk category	
Other assets in 0% risk category	
Loans in 20% risk weight category	65%
Trading assets in 20% risk category	
Other assets in 20% risk category	
Loans in 50% risk weight category	85%
Trading assets in 50% risk category	
Other assets in 50% risk category	
Securities in 100% risk weight category and no risk weight category	100%
Loans in 100% risk weight category and no risk weight category	
Trading assets in 100% risk category and no risk weight category	
Other assets in 100% risk category and no risk weight category	

Appendix 5.C Summary of liquidity creation calculation of US commercial banks

Illiquid assets	
Commercial real estate loans (CRE)	Loans to finance commercial real estate, construction and land development activities (not secured by real estate)
Loans to finance agricultural production	Loans to finance agricultural production and other loans to farmers
Commercial and industrial loans (C&I)	Commercial and industrial loans
Other loans and lease financing receivables	
	Other loans for purchasing or carrying securities
	All other loans
	All other leases
Other real estate owned (OREO)	Other real estate owned
Investment in unconsolidated subsidiaries	Investments in unconsolidated subsidiaries and associated companies
Intangible assets	
	Goodwill
	Other intangible assets
Premises	Premises and fixed assets
Other assets	Other assets
Liquid assets	
Cash and due from other institutions	Cash and due from depository institutions
All securities (regardless of maturity)	
	Held-to-maturity securities
	Available-for-sale securities
Trading assets	Trading assets
Fed funds sold	Federal funds sold and securities purchased under agreements to resell
Liquid liabilities	
Transactions deposits	
	Noninterest-bearing balances
	Interest-bearing demand deposits, now, ATS, and other transaction accounts
Savings deposits	Money market deposit accounts and other savings accounts
Overnight federal funds purchased	Federal funds purchased in domestic offices
Trading liabilities	Trading liabilities
Illiquid liabilities	
Subordinated debt	
	Subordinated notes and debentures
	Subordinated notes payable to unconsolidated trusts issuing trust preferred securities, and trust preferred securities issued by consolidated special purpose entities
Other liabilities	Other liabilities
Equity	
Total equity	Total equity
Illiquid guarantees	
	Unused commitments
	Financial standby letters of credit and foreign office guarantees
	Performance standby letters of credit and foreign office guarantees
	Commercial and similar letters of credit
	All other off-balance sheet liabilities
Liquid guarantees notional values	Risk participations in bankers acceptances acquired by the reporting institution
Liquid derivatives gross fair values	
	Interest rate derivatives
	Foreign exchange derivatives
	Equity and commodity derivatives

6. Conclusion

6.1 Introduction

This thesis investigates the effect of banks' funding liquidity risk on their risk-taking behaviours. We discover empirical evidence that banks facing lower funding liquidity risk take more risk. In this thesis, we consider banks with lower funding liquidity risk take more risk, while banks have higher deposits to have lower funding liquidity risk because deposits prevent banks from run risk because of deposit insurance. We examine the effects of different funding liquidity risk on bank risk taking, using the quarterly data from the United States bank holding companies between 1866 and 2014, we tested the impacts of banks' funding liquidity risk on various representations for bank risk taking. Using theories as discussed by Acharya and Naqvi (2012), we considered a number of deposits relative to total assets as our proxy for banks' funding liquidity risk because deposits shield banks from run risk. We discovered that banks with excessive deposits to be less likely to have funding shortfalls in the near future, thus bank managers tend to take more risk. After considering banks with higher deposits as having lower funding liquidity risk, we are able to examine the influence of banks' capital buffers and bank size on the funding liquidity risk and bank risk relationship.

We also calculate the liquidity creation measures guided by Berger and Bouwman (2009) of United States bank holding companies using historical call report data over the period between 1995 and 2014 to investigate the impact of liquidity creation on banks' debt funding costs, profitability and value. We calculate the relative Basel III liquidity measures metric for the United States bank holding companies using historical call report data over the period between 2001 and 2014, to investigate the impact of increases in asset liquidity and funding stability required under Basel III on banks' adjusted market-to-book value of equity. An increase in liquidity of assets and funding stability reduces liquidity risk whereas increase in liquidity creation increases liquidity risk. We compute the net stable funding ratio and liquidity creation using historical call report data over the period between 2001 and 2014 of US commercial banks to investigate the link between banks' liquidity risk and credit risk proxied by the probability of failure and CDS spreads.

6.2 Overview of the thesis

This thesis has four essays. The first essay examines the relationship that exists between funidng liquidity risk and bank risk taking. We use quarterly data from United States bank holding companies between 1986 and 2014 to reveal that banks with lower funding liquidity risk as represented by higher deposit ratios, take more risk. A decrease in banks' funding liquidity risk increases bank risk, as evidenced by higher risk-weighted assets, lower z-scores, and greater liquidity creation.

In the second essay, we calculate the quarterly liquidity creation of US bank holding companies for the period 1995–2014 using call report data. We investigate the effect of liquidity creation on banks' costs of funds, profitability and market values. Bank's cost of debt funding is proxied by the ratios of total interest expense to total liabilities and interest expenses on deposits to total deposits whereas the profitability is proxied by banks' net interest margins and return on equity and value is proxied by the adjusted market-to-book value of equity. We find evidence that banks experience lower funding costs but higher profitability and market value in response to liquidity creation.

The third essay uses historical data to calculate the Basel III liquidity measures (LCR and NSFR) for US bank holding companies from 2001 to 2014 in order to examine the relationship between these liquidity risk measures and banks' market-to-book values of equity. We apply the Basel III liquidity measures metric by looking back in time and examining how these proxies for liquidity risk have been historically related to banks' market valuation of equity. Using 3SLS simultaneous equations to capture reverse causality we present empirical evidence in this study that reductions in liquidity risk destroy the banks' adjusted market-to-book values of equity. The decrease in the banks' liquidity risk reduces banks' financial performance, which in turn reduces banks' market values.

The fourth essay investigates the link between banks' liquidity risk and credit risk. We also investigated whether the weights used to calculate NSFR are appropraite. Using logit regressions, we find that reductions in liquidity risk, proxied by high funding stability and low liquidity creation, reduce the probability of failure of US commercial banks for the period from 2001–2014. Using 3SLS simultaneous regressions, we find evidence that reductions in

liquidity risk reduce banks' credit risk proxied by CDS spreads. Our findings support the view that the Basel III liquidity measures, which aim to improve funding stability by ensuring high NSFR and low liquidity creation, reduce banks' credit risk proxied by the probability of failure and CDS spreads.

6.3 Findings and policy implications

Our findings are consistent with the theoretical prediction of Acharya and Naqvi (2012) that banks with higher deposits are less likely to face immediate funding shortfalls, and that in these banks, bank managers' aggressive risk-taking behaviours are less likely to be audited. The results show that increases in bank deposits leads to increases in risk-weighted assets and liquidity creation, consistent with the findings of Acharya and Naqvi (2012). These findings reveal that banks lend aggressively at lower rates in response to higher deposits. Our results are also in agreement with those of Keely's (1990), that deposit insurance creates a moral hazard problem for excessive risk taking by banks in response to increases in deposits. We affirm that deposit ratios increase bank risks, as evidenced by z-scores.

Also, the interactive variable between deposits and the high capital buffer dummy is significantly and negatively related to banks' risk-weighted assets, loan loss provisions and liquidity creation, which confirms that banks with higher capital buffers take less risk than banks with lower capital buffers in response to decreased funding liquidity risk. In the same way, the significant relationship between z-scores with the interactive term between deposits and capital buffers indicates that banks with high capital buffers take less risk. According to our findings, regarding large capital buffers, we show that well-capitalised banks tend to take fewer risks. Our results reveal that the interactive variable between deposits and the big bank dummy is negatively related to risk-weighted assets, bank stock return volatility and liquidity creation. Thus, larger banks take less risks than smaller ones when they have more deposits, which also evidenced by higher z-scores. Hence, to respond to decreases in banks' funding liquidity risk as represented by higher deposits, larger banks tend to take less risk. The main policy implication of the first essay is that regulators may consider limiting bank risk-taking (e.g., lending) so that bank managers are restricted in their ability to engage in aggressive lending as a result of excessive deposit inflows. Regulators need to increase oversight when deposit increases.

In the second essay, we find evidence that liquidity creation reduces the costs of funds, but increases profitability and market value. Also, larger banks face higher costs of debt funding, market value and profitability. But banks with the higher liquidity creation face lower costs of debt funding, profitability and market value. Furthermore, banks faced lower funding costs, market values and profitability during the global financial crisis than they do in normal times. Our results reveal that the creation of liquidity benefits banks. To summarise, banks benefited from transforming liquidity, as expected. Nonetheless, too much liquidity creation is harmful as it increases the probability of bank failure (Fungáčová, Turk and Weill (2013)), and financial crisis (Berger and Bouwman (2017)). The main policy implication of the second essay is that regulators are not supported to impose limits on liquidity creation (such as LCR and NSFR) as it is beneficial to banks, but too much liquidity creation is also dangerous. Regulators should be aware of the trade-off between the benefits and costs of liquidity creation.

The creation of liquidity is good for banks as it reduces the costs of funds but increases profitability and value creation. The NSFR model is opposite to liquidity creation. Increases in asset liquidity and funding stability reduce liquidity risk. In the third essay, we find empirical evidence to suggest that decreases in liquidity risk as a result of higher LCR and NSFR diminish banks' market values. We also find evidence that the market-to-book value of equity also affects liquidity risk. Most importantly, we reveal that large banks, and banks with high profitability, high capital buffers and liquidity, benefit from superior market valuations. We also find that reductions in liquidity risk increased banks' market values during the global financial crisis and the post-Basel III announcement period. Thus, the main policy implication of the third essay is that regulators may consider scrutinising the 100% binding constraint and individual risk weights (ASF and RSF factors) as they may not provide the most appropriate NSFR because NSFR reduces market value.

In the fourth essay, we find that increases in Basel III liquidity standards and reductions in banks' liquidity creation increase the probability of failure and credit default service spreads of United States commercial banks. Our findings show evidence that banks' liquidity risk and credit risk are positively associated. We also find that decreases in liquidity risk reduces the credit risk more in the banks with high liquidity risk. In addition, we test the impact of the components of NSFR on credit risk. The findings reveal that the elements of ASF and RSF affect the probability of failure according to their weights. For instance, higher ASF weights

reduce bank failure more, and higher RSF weights increase the failure of banks more. Thus, the weights of assets, equities and liabilities used to calculate the NSFR are correct. We also find out that assets with more risk have a higher impact on the probability of bank failure. Furthermore, increases in equity reduce the likelihood of bank failure to a significant extent. The main policy implication of the fourth essay is that the Basel III liquidity requirements enhance the financial stability of banks by reducing credit risk. The dark side of liquidity creation is that it increases bank credit risk.

In sum, our results firmly support the view that banks should steer away from short-term funding to improve the quality of their assets and to reduce their riskiness. They also show that capital buffers and being larger helps to curb banks' risk-taking behaviour in response to decreased funding liquidity risk. Banks are also less aggressive during financial crises when they are more actively being monitored and disciplined for taking risks.

6.4 Suggestions for future research

Future research on liquidity creation should focus on other economies where deposit and liability guarantee schemes are absent. This thesis provides a clear understanding of the link between funding liquidity risk, as captured by deposit ratios and bank risk-taking behaviour. This may help regulators redesign the banking regulatory framework to better discipline and control the perverse incentives which encourage bank managers to take too much risk in the future when bank deposits change. Specifically examining the effect of funding liquidity risk on bank managers' compensation packages would be a worthwhile direction for future research on this topic.

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