ERASMUS UNIVERSITY ROTTERDAM
Erasmus School of Economics

Master Thesis Financial Economics

The Effects of Liquidity Risk on Bank Performance During a Financial Crisis

Name Student: Hassan Mohamed Hassan Ali Amer
Student ID number: 494460

Supervisor: Ruben de Bliek
Second Assessor:

Date Final Version: December 1st 2023

Abstract

This paper investigates how liquidity risk affects bank performance during a financial crisis. Using quarterly bank data from the U.S ranging from 1996 to 2013, we find that liquidity risk decreased bank survival rates, ROA, Net-interest margin, and increased loan-loss-provisions expense during the subprime crisis of 2007-09. Furthermore, this effect was more serious for banks with lower capital ratios and higher credit risk. We compare these results to bank performance during two market crisis and find that liquidity risk may actually increase bank performance measures such as ROA. Finally, by empirically differentiating between credit risk and liquidity risk we are able to conclude that the leading cause of weak bank performance during the subprime crisis of 2007-09 was in fact liquidity risk and not insolvency.

Table of Contents

1.Introduction

Liquidity risk is an essential source of risk for banks. Liquidity is the availability of cash or cash equivalents, therefore liquidity risk is the potential loss that can come from the lack of cash or liquid assets. This can be due to a banks inability to obtain funding at reasonable returns in order to cover unforeseen short-term obligations. Liquidity risk can also be seen as the potential for banks to suffer economic loss in the pursuit to obtain cash which is required to meet these obligations (Banks, 2014). Although maintaining an appropriate liquidity buffer is essential for bank functionality, it also poses profit risk. Cash that is not invested in securities or interest-bearing assets poses an opportunity cost for banks. Therefore, from the profit maximising point of view, banks may intend to meet regulatory requirements and invest the rest into interest bearing assets (Diamond and Dybvig, 1983). In recent times, we have seen the importance of banks maintaining enough liquidity. In early 2023, Credit Suisse, which is considered as one of thirty globally systematically important banks collapsed. In order to recover from this collapse, the Swiss National Bank had to inject up to $54 billion of liquidity into Credit Suisse. In addition, Credit Suisse had to sell their shares to UBS for $3 billion to further increase their liquidity and avoid bankruptcy. However, it is important to note that liquidity risk is not an appropriate measure for a bank's overall health (Banks, 2014). A bank may be generating sufficient returns while being highly illiquid. In times of financial stability and low liquidity pressure, this illiquidity will likely not have an effect on the performance of the bank. However, due to short term liabilities such as deposits being used to fund long term assets, it can be costly for banks to make adjustments to meet short term obligations when the aggregate demand for liquidity is high (Diamond and Rajan, 2011). The problem arises in these times of high liquidity demand, liquidity shocks can put pressure on banks to sell assets in unfavourable market conditions to secure the necessary liquidity to meet their obligations. In this case, the liquidity risk of a bank may have serious implications on its performance or survival (Diamond and Rajan, 2011). This paper aims to further understand the relationship between liquidity risk and bank performance. In order to do this, we will be taking a look at the origins of one the largest liquidity shocks to ever plague the United States, which occurred during the subprime crisis of 2007 – 09 (GFC). We hope to determine the root cause of the liquidity shock as well as investigate whether liquidity risk during a financial crisis will have a significant impact on the performance of the banking sector.

There are a number of academic articles with varying approaches and results that cover this topic. Cornett et al. (2021), Thakor (2018), Berger and Bouwman (2013), and Chen et al. (2021) lay the groundwork for the assumptions and methodology we take in this paper. Cornett et al. (2021), and Thakor (2018) provide insights for our theoretical background by taking opposing views on the source of the liquidity shock during the subprime crisis of 2007-09. Cornett et. al (2021) provides evidence to show that the source of liquidity shock was liquidity risk while Thakor (2018) argues that it was in fact an insolvency crisis that led to the liquidity shock. We aim to address this by testing the effects of liquidity risk on bank performance while controlling for credit risk. Therefore, if we see significant results for our liquidity risk measures, this would support the view that liquidity risk is an independent factor in the change in bank performance during the subprime crisis of 2007-09. Chen et al. (2021) and Berger and Bouwman (2013) provide insights for the data and methodology of this paper. An importent aspect of Berger and Bouwman (2013) is the distinction the paper makes between the two different types of financial crisis, banking crisis and market crisis. In this paper, we will also make the same distinction to assess how the relationship between liquidity risk and bank performance changes between the two scenarios. Chen et al. (2021) provides insights on appropriate bank performance measures and also discusses which bank liabilities are the main sources for bank liquidity risk.

This paper contributes to the literature in four ways. Firstly, our paper aims to add by directly testing the effects of liquidity risk on bank performance during a financial crisis. This will give insight as to how changes in liquidity demand and market conditions effect our performance indicators. Second, since there is no consensus on how measure bank liquidity risk, we will construct our own based on the assessment of previous literature. Third, we test the effects of bank size on our results. Finally, we also add to existing literature on bank capital and risk management by measuring the effects of liquidity risk on bank performance for banks with lower credit risk and higher capital ratios.

Empirically speaking, we will conduct our analysis by gathering quarterly data on bank balance sheet, and income statement information for U.S banks. These banks will be observed over a period of eighteen years which includes multiple market crisis, our main banking crisis the subprime crisis of 2007-09, and normal times of low liquidity pressures. We develop two different regression models to assess our results and they will be tested using logit and OLS regressions. We make several predictions for our results. Firstly, banks with higher liquidity risk will experience worse bank performance during the subprime crisis of 2007-09. We expect that these results will not hold for the market crisis results since there is much less liquidity demand on the banking system when the financial markets are under pressure relative to a banking crisis. Our second prediction is that large banks will be more immune to the effects of liquidity risk due to their experience in risk management and their ability to raise funds when necessary. Finally, we predict that the adverse effect of liquidity risk will be more severe for banks with lower pre-crisis capital ratios and higher pre-crisis credit risk.

2.Theoretical Background

2.1 Bank Performance

Banks perform an essential function of any economy. Over the last ten years, empirical research on bank performance has proven to be a significant area of study for financial and economic literature. This can be attributed to the consequences of the subprime crisis of 2007-09, which had a major impact on economies worldwide. Due to the consequences of the crisis, there was a serious transformation in banking regulation, and market structures. These transformations not only impacted the core functions of banks but also changed the way bank performance was measured and assessed. Rastogi et. al (2020) provides an overview on the developments of bank literature over the years. Previously, bank performance literature focused on improvements in balance sheet indicators such as assets, liabilities, deposits and borrowings yet evidence shows that increases in balance sheet indicators can also be paired with decreasing trends in profit and non-performing assets. This raised a lot of questions regarding what the core factors are that impact bank performance. Based on this, Rastogi et al. (2020) comes to the conclusion that bank performance in recent years especially since the subprime crisis of 2007-09 revolves around two important performance measures, profitability and efficiency. It is no secret that an organization cannot survive without being profitable and banks are no exception, due to this necessity profit is an essential indicator on the performance of a bank. Efficiency is also a key indicator of performance because it bridges the gap between profitability and risk. Banks may be profitable but inefficient in utilizing their capital, which could ultimately decrease their risk-adjusted return. In this paper, we aim to test a variety of performance measures which are indicators for both profitability and efficiency, based on this we hope to have a deeper understanding on how liquidity risk affects performance during a financial crisis and whether the nature of the crisis has a role in the results. The remainder of the theoretical background will dive deeper into the root causes of the financial crisis, how this caused a liquidity shock , and finally we draw our hypothesis from this discussion.

2.2 The Global Financial Crisis & Subsequent Liquidity Shock

During the lead up to the subprime crisis of 2007-09 (GFC), interest rates were at an all-time low, this lead to a sharp increase in mortgage lending which was also complimented by the expansion of the housing market. Subsequently, the securitization of bundled mortgage loans began. Large pools of mortgages were sold from banks to wall street banks which were then packaged and sold to investors as low risk securities known as mortgage backed securities (MBS). At the time these securities were perceived to be as very safe investments with reliable returns. However, due to the popularity of these securities, many of the mortgages issued were made to borrowers with poor credit history known as subprime borrowers at very low rates. Furthermore, these loans were given out without the necessary steps to confirm that the borrower had the income to cover the payments. Consequently, a lot of these MBS were comprised of much riskier mortgages than what was realised by investors and these MBS were still given very high credit ratings by rating agencies. In addition, unregulated over the counter derivatives such as CDS swaps were issued as insurance in the event of MBS defaults, and were sold for tens of billions by companies such as AIG. The SEC had also relaxed capital requirements for five of the largest investment banks on Wall Street which allowed them to leverage their initial investments even more (Manoj, 2023). The eventual collapse was imminent when the FED started raising interest rates and the homeowners market eventually reached a saturation point. Housing prices dropped and many homeowners found themselves with overly expensive homes with mortgages they are unable to afford. With mortgage defaults rates rising quickly, many financial institutions took heavy losses.

With some of the most reliable and safe securities becoming almost worthless, the flight to liquidity began. This occurred on both the supply and demand side. Demand for precautionary liquidity immediately set in the market due to the fear of the unknown and the recent turbulence in the market. From the supply side, healthy banks were no longer confident in their counterparties' ability to meet their obligations, so banks that would normally lend, found themselves hoarding liquidity. It is the combination of these two aspects that ultimately led to such a strong liquidity shock in the market during that time (Logan, 2011). These liquidity shocks can initiate chain reactions in the financial system and completely freeze lending markets, which ultimately would expose the liquidity risk that banks carried. Eventually this lead to government intervention and large liquidity injections (Antoniades, 2016).

2.3 Origin of the Liquidity Shock: Credit Risk vs. Liquidity Risk

Whether the liquidity shock originated from liquidity risk is still up for debate. Existing research has varied opinions based on their respective findings. In the following section we aim to breakdown the relationship between the liquidity shock and bank performance during the crisis and assess whether the origin of the shock was due to insolvency or liquidity problems. While some research claims that liquidity risk has a direct negative impact on bank performance measures such as stock price, credit production, and interest income, other research points to credit risk as being the core driver of bank performance and that liquidity risk is simply amplifying the results.

2.3.1 Sources of Liquidity Risk & the Effects on Credit Production

Banks hold cash in addition to other liquid assets as part of their overall strategy to manage liquidity risk. Due to government guarantees and the FDIC's provision of depositors insurance, deposits can actually help protect banks from liquidity risk. According to Cornett et al. (2011) "In modern banks, liquidity risk stems more from exposure to undrawn loan commitments, the withdrawal of funds from wholesale deposits, and the loss of other sources of short-term financing than from the loss of demand deposits." (p.297). This is supported by the results of Diamond and Dybvig (1983) which shows a significant decrease in wholesale deposit growth while core deposits, that are insured by the FDIC remained steady and reliable. Some evidence actually shows that there that there may be an inflow of deposits during times of low market liquidity (Gratev and Strahan, 2003). Therefore, it is important to differentiate between the liability structure of different financial institutions as not all debt carries the same level of liquidity risk.

From the asset side, banks that hold assets with low liquidity were forced to increase their liquidity buffers during the crisis. Banks that held more mortgage-backed securities, asset-backed securities, and loans were more likely to increase their liquid assets and decrease their investments in new loans and commitments to lend (Cornett et al., 2011). This was due to the concerns about liquidity in the market, so naturally these banks increased their liquid holdings to protect themselves, which ultimately caused liquidity hoarding in the market. On the other hand, banks with more core deposits and more equity capital were not as concerned with increasing their liquidity and continued lend relative to banks that rely on wholesale deposits and other sources debt financing. The results of Cornett et al., (2011) find that banks with more unused loan commitments increased their holdings of liquid assets as a precautionary measure and also decreased their issuance of new loans. Therefore, any new loan commitment drawdowns from existing loans would be offset by the decrease in new credit issuance. Furthermore, their results show that on-balance sheet loans and undrawn commitments decreased by about $500 billion during the fourth quarter of 2008, and estimates show had the liquidity exposure of the entire banking system been in the lower quartile, the decrease in loans would only be about $87 billion.

The evidence provided by Cornett et al. (2011) strongly supports the idea that banks that held more amounts of equity capital, and higher percentages of core deposits were better performing during the crisis, as they experienced significant increases in lending and credit production. This concludes that the due to the different liabilities and assets that banks use to comprise their balance sheet, banks with similar asset sizes and returns may react differently in times of liquidity shortages due to their liquidity risk and credit risk exposures. This differentiation will be critical to our analysis later on when looking at the different liquidity measures used to predict bank performance and whether credit risk played a role in bank performance.

2.3.2 Liquidity Injections & New Regulation

During the subprime crisis 2007-09 some institutions declared bankruptcy, and others were lucky enough the federal government came to provide liquidity injections and bailouts. The Emergency Economic Stabilization Act of 2008 saw over $700 billion spent on troubled bank assets by the federal government in order to provide sufficient capital injection in the financial system and prevent a further meltdown (Kenton, 2022). It was clear that there was a serious liquidity shortage in the market when the crisis hit. Financial institutions were allowed to take excessive risks with minimal capital requirement and liquidity to cover their exposures and obligations.

Following the subprime crisis of 2007-09, the federal government of the United States introduced new legislation known as the Dodd Frank Act which aimed to improve financial stability and reduce systematic risk through various means. This included consumer protection, increased regulation of derivatives markets, and cracking down on risky mortgage lending. Furthermore, international banking regulation was also adjusted with the Basel III framework which was introduced in 2010. This included critical liquidity provisions that aimed to reduce liquidity risk among financial institutions to ensure that banks were able to meet their short term obligations. Two of the most important liquidity provisions were the net-stable funding ratio

(NSFR) and the liquidity coverage ratio (LCR). LCR is the ratio of the stock of high-quality liquid assets to total net cash outflows over the next thirty days and NSFR is the ratio of the available amount of stable funding to the required amount of stable funding. The Basel III framework required that each of these ratios should be a minimum of 1 (Hayes, 2023).

2.3.3 Insolvency & the Role of Credit Risk

Some evidence from existing literature takes an opposing view about whether it was liquidity that led to weak bank performance during the crisis and whether it was necessary for the federal the government to inject so much liquidity in the market. An insolvency crisis occurs when investors opt against lending to banks and institutions because they believe that the credit risk of that institution is too high given their liability and capital structures. On the other hand a liquidity crisis occurs when liquidity dries up in the market so institutions that rely on short term debt to fund their operations experience difficulty meeting their obligations and are forced to engage in asset fire sales to raise funds. It's important to note that the difference between the two types of crisis is that an insolvency crisis only affects banks that that become risky investments for lenders. Liquidity crisis however affects all banks (Thakor, 2018).

Thakor (2018) provides two perspectives on the series of events that lead to the liquidity shock. The first perspective is that illiquidity led to insolvency. The series of events is that first liquidity decreased in the system, which then leads to a reduction in the demand for assets. This would cause banks to engage in fire sales, which would ultimately decrease asset prices in the market and lead to insolvency. If liquidity risk was indeed the factor that caused the ripple effect in the banking system, the appropriate policy recommendation during the crisis is that the federal government would need to increase the liquidity in the market before it leads to insolvency. The second perspective which is supported by the results of Thakor (2018) is that asset prices decline which then causes the equity value of high-leveraged banks to decrease which in turn decreases their ability to raise short-term funds. This then causes liquidity to dry up in the market because investors and other banks are not confident that these institutions with insolvency problems and high leverage will be able to meet their obligations.

The empirical evidence of Thakor (2018) supports the latter perspective and strongly supports that this was an insolvency risk crisis, not a liquidity crisis. The paper makes two assertions to help provide evidence for this perspective. Firstly, the empirical evidence shows that the majority of banks did not experience a decrease in funding during the crisis and did not engage in fire sales, which is likely to happen if there is a liquidity crisis. Secondly, the evidence shows that banks that experienced liquidity shortages during the crisis were those whose insolvency risk had increased significantly due to decreases in the market value of assets.

This is supported by Boyson et. al (2014), who argues that liquidity injections by the government can be considered necessary if the frictions in the capital market do not allow for the efficient allocation of credit. However, during the subprime crisis of 2007-09, credit allocation in the market may have declined due to other reasons. The declining asset value of banks' balance sheets was leading these banks to insolvency. In that case, even in an efficient market with no friction, other banks in the market would not be willing to provide credit to these insolvent banks. Furthermore, the provision of emergency liquidity and credit would artificially support inefficient banks that should be left to fail. In the long run, this would have been counterproductive to provide capital to these failing banks without addressing the underlying reasons for their insolvency, which may be risky investment decisions and high credit risk exposure. Moreover, it would also distort the lending market and create artificial competition for healthy banks. Based on this evidence, it is possible that the weak performance banks experienced during the crisis was actually only a symptom of their insolvency rather than their liquidity problems.

Although this paper does not aim to test whether the liquidity injections were effective in mitigating the effects of the liquidity shock, by empirically distinguishing between liquidity risk and credit risk, we will be able to determine the primary cause of weak bank performance during the crisis. If insolvency was the causal effect of this weak performance then liquidity risk will not have a significant effect on bank performance **if** credit risk is controlled for. In addition, the results will have implications on the appropriate policy recommendations that should have been made by the federal government. An insolvency crisis should have very different policy recommendations. This would include increasing capital requirements, eliminating liquidity requirements, and allowing for insolvent banks to fail as not to taint the market and give incentive for risky investments. In response to a liquidity crisis however, liquidity injections and government bailouts could be seen as an appropriate response.

2.4 Hypothesis 1: Effect of Pre-crisis Liquidity Risk on Bank Performance

During a banking crisis, the overall liquidity in the system tightens. According to the discussion in 2.3.1, this can prompt wholesale depositors to withdraw their funds, and borrows with credit lines or unused loan commitments to draw down their credit. If insured depositors have concerns about the health of the banking sector, this may also prompt them to withdraw their funds in fear of losing their deposits. Due to banks facing these withdrawal pressures, they take on greater liquidity risk and must make costly adjustments to their liability structure in order to reduce the potential negative effects of the liquidity shocks (Acharya et al., 2011; Cornett et al., 2011). Some evidence even shows that bank failure can be a result of banks not being able to meet the obligations that come from the withdrawal pressures from depositors (Diamond and Rajan, 2001; Acharya and Viswanathan, 2011). Therefore, we predict that banks that have higher liquidity risk pre-crisis will experience worse performance during the crisis.

An alternative explanation regarding why liquidity risk may affect bank performance is presented by Calomiris et al. (2015). Their model argues that holding more liquidity or cash incentivizes banks to reduce their credit risk during a financial crisis when the creditworthiness of counterparties is likely to decrease. Following this reasoning, banks with more liquidity buffers (and therefore lower liquidity risk) will have more incentive to control credit risk, so in turn will experience fewer loan losses in financial crises, and thus have better performance than their counterparts with lower liquidity buffers.

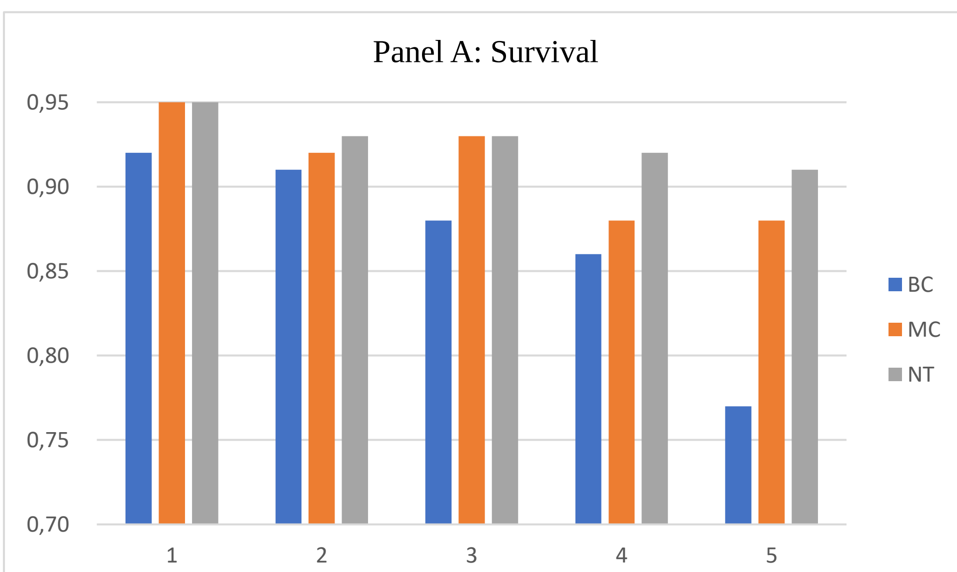
As briefly mentioned in the introduction, we make the distinction between two types of financial crisis. Whether liquidity risk will affect bank performance may depend on the nature of the financial crisis. The arguments made above are more relevant for a banking crisis than a market crisis. During a banking crisis, banks will be more concerned about their counterparties abilities to repay them and depositors will be more concerned about the safety of their funds. This logic does not necessarily hold for a market crisis. If a liquidity shock comes from stress on the financial markets, banks may be regarded as safe investments for investors' funds as an alternative to a stressed and volatile financial market. Saidenberg and Strahan (1999), and Gatev and Strahan (2006) provide results that show investors moved their funds from the financial markets to banks during a market crisis. Due to these inflows, it is unlikely that liquidity risk would worsen bank performance during a market crisis. Since it is important to distinguish between the two types of crisis, we develop separate hypothesis for each crisis:

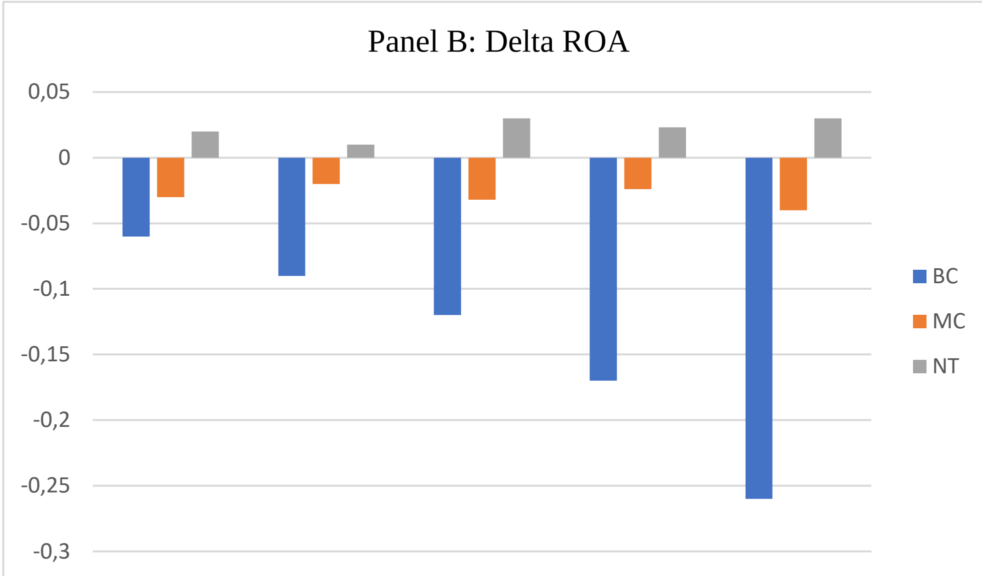
$$H1_A\text{: } \textit{Liquidity risk has a negative effect on bank performance during a banking crisis,}$$
$$\textit{this effect is bigger for banks with higher liquidity risk}$$

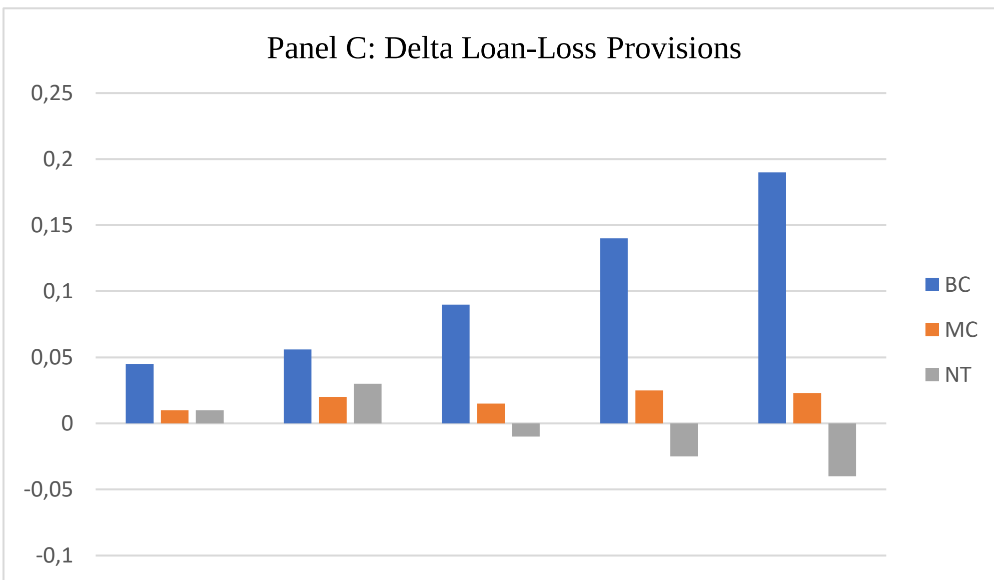
$$H1_B\text{: } \textit{Liquidity risk has a negative effect on bank performance during a market crisis,}$$
$$\textit{this effect is bigger for banks with higher liquidity risk}$$

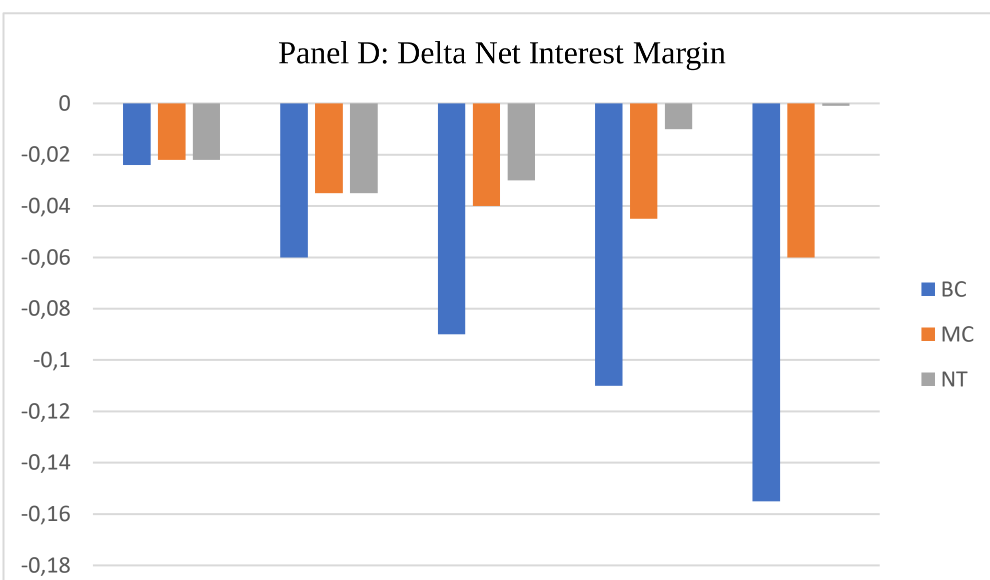
Figure (1) shows the relationship between our four bank performance measures and their respective liquidity risk. The sample was grouped into five quintiles based on their liquidity risk ratio discussed earlier. BC, MC, and NT represent banking crisis, market crisis, and normal times respectively. Panel A shows survival rates for banks, while the other panels show the percentage change in average pre-crisis to post-crisis ROA measures discussed earlier. Group 1 has the lowest liquidity risk ratio while group 5 has the highest. The results of Figure (1) are consistent with the predictions we make in the hypothesis. Across all bank performance measures, on average, during a banking crisis banks perform worse than in market and normal time crises. Furthermore, as liquidity risk index increases for banks, performance is consistently worse across all measures for all crises.

Figure (1) presents the relationship between our four performance measures and the liquidity risk index we construct. Survival is measured as a dummy variable taking on a value of 1 if the bank survives the crisis and 0 otherwise. The remaining measures are measured as the delta between the average post-crisis performance and average pre-crisis performance. The liquidity risk index represents the gap between a bank's liquidity demand and supply scaled by total assets.




Panel B: Delta ROA
0,05
0
-0,05
-0,1
-0,15
-0,2
-0,25
-0,3
BC
MC
NT


Panel C: Delta Loan-Loss Provisions
0,25
0,2
0,15
0,1
0,05
0
-0,05
-0,1
BC
MC
NT


Panel D: Delta Net Interest Margin
0
-0,02
-0,04
-0,06
-0,08
-0,1
-0,12
-0,14
-0,16
-0,18
BC
MC
NT

2.5 Hypothesis 2 & 3: The Effect of Capital Ratios & Credit Risk on Bank Performance

The second and third hypothesis aim to investigate the characteristics of banks that performed better relative to their peers. On an individual bank level, some were more resilient than others, and we predict that weak banks will suffer more during the crisis. Following Chen et. al (2021), in this paper we use bank capital ratio and credit risk to assess the financial health of a bank. These weak banks are the ones that are most likely to experience deposit withdrawals from their lenders which means they will have to service this demand during a liquidity freeze or pay higher interest rates to entice depositors to keep their funds in the bank. Therefore they will be forced to make more costly adjustments to decrease their liquidity risk (Chen et. al, 2021).

We predict that the weaker banks will suffer more during the crisis and this is supported by empirical evidence that shows that the liquidity problems were more serious for weakly capitalised banks (Taylor and Williams, 2009). Since these banks are financially weaker, the negative effects of liquidity risk will be more serious, which will result in worse performance during the crisis. It is important to note that these predictions are made under the assumption that the first hypothesis is supported. Based on the above discussion, we formulate the following hypothesis:

$$H2_A\text{: The adverse impact of liqduitiy risk on bank performance during a banking crisis is bigger for banks with lower capital ratios in the pre} - \text{crisis period}$$

$$H2_B\text{: The adverse impact of liqduitiy risk on bank performance during a market crisis is bigger for banks with lower capital ratios in the pre} - \text{crisis period}$$

$$H3_A\text{: The adverse impact of liqduitiy risk on bank performance during a banking crisis is bigger for banks with higher credit risk in the pre} - \text{crisis period}$$

$$H3_B\text{: The adverse impact of liqduitiy risk on bank performance during a banking crisis is bigger for banks with higher credit risk in the pre} - \text{crisis period}$$

3. Data

In this paper we aim to clarify the relationship between liquidity risk and bank performance during a financial crisis. First, we aim to answer the question "Does liquidity risk worsen bank performance during a financial crisis?" If the answer is yes, then we investigate whether the negative effects of the liquidity risk will differ for banks with different characteristics. In order to develop our hypothesis, we first need to define the key terms of the research question. First, what will be used as the bank performance measures? How will we define liquidity risk in our paper? Finally, what constitutes as a financial crisis?

3.1 Measuring Bank Performance

Previous literature such as Chen et. al (2021) and Imbierwicz and Rauch (2014) discuss that bank exposure to liquidity risk during the subprime crisis of 2007-09 had a direct impact on default rates and return on assets (ROA) during the crisis. Based on this evidence, we assess bank performance in our results by whether a bank survives the crisis[1] and the change in a bank's return on assets (ROA)[2]. We also aim to explore the specific way through which liquidity risk affects a bank's ROA, so we will also examine the effects of liquidity risk on two important components of bank ROA, the net interest margin[3] and loan-loss-provisions expense[4] (Chen et. al, 2021). The reason for including these two additional measures is because we expect that liquidity risk will reduce banks' interest margin because banks with higher liquidity risk need to pay higher interest expenses and accept lower interest incomes to improve their liquidity (Cornett et al., 2021). Finally, following Calomiris et al. (2015), we expect that banks with higher liquidity risk have worse incentive to control credit risk, so their loan-loss-provisions expense will be higher in financial crises.

3.2 Measuring Bank Liquidity Risk

Based on existing literature, there is no concrete consensus on how to measure a banks liquidity risk. So in this paper, we will construct our own liquidity risk measure. The liquidity risk ratio aims to measure the gap between a bank's liquidity demand and supply. The intuition is that a higher index will represent a higher liquidity risk taken on by the respective bank. The numerator

[1] Bank survival is measured as a dummy variable taking on a value of 1 if the bank survives the crisis and a value of 0 otherwise.
[2] ROA is measured as the ratio of net income to total assets.
[3] Net Interest Margin is the sum of interest expense and interest income for a specific bank divided by total assets
[4] Loan-loss provisions expense is the amount a bank sets aside for future loan losses divided by total assets

of the liquidity risk ratio will be the sum of a bank's unused loan commitments and wholesale funding as defined by Cornett et. al (2011) minus the liquidity supply which is the sum of liquid assets and loans that can be easily sold as defined by Loutskina (2011). The denominator will be the bank's total assets as a method to scale the results. As is previously discussed in section 2.3.1, the main source of a banks liquidity risk is unused loan commitments and wholesale deposits, bank runs are unlikely which is why core deposits were omitted from our liquidity risk measure (Shin, 2009, Cornett et al., 2011).

3.3 Nature of the Crisis: Market vs. Banking Crisis

As part of our approach, we differentiate between the two different types of financial crisis: market crisis, and banking crisis. This approach has been taken in previous literature such as Berger and Bouwman (2013) and Chen et. al (2021). During a banking crisis, banks face more severe financial distress, insolvency, and lose confidence from depositors and investors. As a result, the liquidity shocks are more likely to have a negative effect on the health of these commercial banks. During a market crisis, commercial banks still suffer but do not experience as extreme financial distress because confidence remains in the lending market and liquidity is more readily available. According to the results of Berger and Bouwman (2013) a market crisis does not pose much of a threat to the survival of banks. This is due to banks having access to the interbank lending market that is likely to stay open during the crisis, therefore there is availability of capital regardless of the liquidity risk. The purpose of including market crisis results is to provide alternative for the banking crisis. Since lending markets are not under as much stress during a market crisis, the expectation is to see larger adverse effects on bank performance during the banking crisis relative to the market crisis. As a final point we also create two fake crisis to represent normal times in the financial markets and banking system

The time frame of our sample ranges from 1996 until 2013, in which there are two market crisis, one banking crisis, and two normal time crisis. The exact specification of the different crisis can be found below in Table 1. We define the only banking crisis as the subprime crisis of 2007-09. The first market crisis is the Russian debt crisis and the subsequent Long Term Capital Management Bailout (LTCM), the second market crisis is the stock bubble burst following the 9/11 attacks. We also include two normal time crisis in which there was no significant pressure on financial markets or the banking sector (Berger and Bouwman 2013). We define the pre-crisis period as four quarters preceding the event of the crisis.

Table 1
The definition of pre-crisis and crisis periods during the sample period

Name of crisis	Pre-crisis period	Crisis period
Market Crisis I	1997Q3-1998Q2	1998Q3-1998Q4
Market Crisis II	1999Q2-2000Q1	2000Q2-2002Q3
Normal Time I	2003Q3-2004Q2	2004Q3-2006Q2
Banking Crisis I	2006Q3-2007Q2	2007Q3-2009Q4
Normal Time II	2011Q1-2011Q4	2012Q1-2013Q4

3.4 Dataset Overview

Our dataset consists of 6,252 unique U.S commercial banks observed from 1996Q1 until 2013Q4. This data was obtained from the Bank Regulatory database through the Wharton Research Data Services (WRDS). Based on the methodology of Berger and Bouwman (2013) a bank-quarter observation was included in the sample if "the bank has commercial real estate or commercial and industrial loans outstanding; has deposits and has gross total assets exceeding $25 million" (Berger and Bouwman, 2013, p.155). Gross total assets is equal to the sum of total assets and the allowance for loan and lease losses. As previously mentioned in 3.3, we include an eighteen year time frame to account for one banking crisis (the subprime crisis of 2007-2009), two market crisis (the Russian debt crisis and LTCM bailout of 1998; the stock bubble burst following the 9/11 attacks) and two normal time crisis to provide the counterfactual for our hypothesis. Our data is quarterly panel data because we have several commercial banks being observed multiple times over the same time period.

3.5 Model Overview

As discussed in Chapter 2.4, our first hypothesis aims to test whether banks with higher liquidity risk pre-crisis will experience worse performance during the crisis. We use two different dependent variables, the first being bank survival probability and the second being ROA. Furthermore we also explore the channels through which net interest margin and loan-loss-provisions expense influences ROA. The pre-crisis period is defined as the four quarters preceding the crisis period. We use the following regression equations to model Hypothesis 1:

$$\Delta ROA_{i,t} = \beta_0 + \beta_1 LiquidityRisk_{i,pre-t} * BC + \beta_2 LiquidityRisk_{i,pre-t} * MC + \beta_3 LiquidityRisk_{i,pre-t} * NT + \beta_4 Y_{i,pre-t} + \tau_t + \varepsilon_{i,t} \quad (1)$$

$$Survival_{i,t} = \beta_0 + \beta_1 LiquidityRisk_{i,pre-t} * BC + \beta_2 LiquidityRisk_{i,pre-t} * MC + \beta_3 LiquidityRisk_{i,pre-t} * NT + \beta_4 Y_{i,pre-t} + \tau_t + \varepsilon_{i,t} \quad (2)$$

For equation (2) $Survival_{i,t}$ is a dummy variable that takes on a value of 1 if a bank i's is observed in the pre-crisis period and survives the crisis. A bank is defined as surviving the crisis if it is still in the sample one quarter after the crisis ends. To ensure whether the bank indeed failed rather than it being omitted from the dataset for unknown reasons, we verified whether these banks were included in the FDIC's list of bank failures. t represents the five crisis we include in the sample. Therefore, a bank can be observed up to 5 times in the sample, one time for each crisis observation.

For equation (1) $\Delta ROA_{i,t}$ represents bank i's quarterly average ROA in crisis t minus its quarterly average ROA in the pre-crisis period. As previously discussed, BC, MC, and NT are the dummy variables that represent the banking crisis, market crisis, and normal time crises respectively.

All independent variables are measured as the quarterly average of the pre-crisis period. $LiquidityRisk_{i,pre-t}$ is either the liquidity risk index we construct or one of its specific components. $LiquidityRisk_{i,pre-t}$ includes three main components which can be broken down in the following:

1. $Commitments$: The ratio of unused loan commitments to total assets
2. $Wholesale$: the ratio of wholesale deposits to total assets
3. $LiquidAssets$: the ratio of cash and other liquid assets to total assets

$$LiquidityRisk_{i,pre-t} = (Commitments_{i,pre-t} + Wholesale - LiquidityAssets_{i,pre-t}) / Assets_{i,pre-t}$$

We include a variety of control variables in $Y_{i,pre-t}$ that apply to both equations. The control variables can be broken down into control variables for financial metrics and control variables for credit risk metrics. We include the same control variables as Chen et al. (2021). The definition of the control variables can be seen in Table 2. Finally τ_t is the fixed effect of crisis t and $\varepsilon_{i,t}$ is the random error for bank i in crisis t.

Table 2	
Variable	Definition
Financial Variables	
Capital	Ratio of Tier-1 Capital to Basel I RWA
LnAssets	Natural logarithm of total assets
TradingAssets	Ratio of trading assets to total assets
Credit Variables	
CreditRisk	Basel I RWA divided by total assets
ComRealEstate	Commercial real estate loans divided by total assets
NPL	Ratio of non-performing loans to total loans

For equations (1) and (2) our coefficients of interest are β_1 and β_2 . These are the coefficients that represent the relationship between the liquidity risk index interaction with the banking and market crisis and the respective dependent variables. Hypothesis 1 states that banks with higher liquidity risk pre-crisis experience worse performance during the crisis. Therefore in order to support our hypothesis we expect to see significantly negative results on the initial regressions if the independent variable used is the full liquidity risk index. We also use equations (1) and (2) to examine whether the individual components of the liquidity risk index have an effect on the dependent variable ROA and bank survival. In addition, to have a better understanding of the channels through which the liquidity risk affects the bank ROA, we also test the effect of the liquidity risk on two components of bank ROA during the crisis, loan-loss provisions expense and net interest margin. We define net interest margin as the difference between interest income and interest expenses divided by total assets, and loan-loss-provisions expense is the amount set aside by banks for future loan losses scaled by total assets. Therefore, similar to our definition of ΔROA, we define $\Delta Margin$, and $\Delta Provisions$ as the change in the quarterly average between the pre-crisis and crisis period. Furthermore, we measure these variables in percentage points for convenience. Table 3 provides a summary of how the expected sign of the various liquidity risk variables should be for each dependent variable if the results were to support our hypothesis.

Table 3

Liquidity Risk Variables	**Dependent Variables**			
	ROA			**Survival**
	ROA	Loan Loss provisions	Net Interest Margin	Survival
Liquidity Risk Index	-	+	-	-
Commitments	-	+	-	-
Wholesale	-	+	-	-
Liquid Assets	+	-	+	+

As previously discussed, if we find that the results of our initial regressions support hypothesis 1, we make further predictions that the adverse effects of liquidity risk for banks with lower capital ratios and higher credit risk would be more severe relative to their peers. We develop the following equations to test the predictions of hypothesis 2 and 3:

$$\begin{aligned}\Delta ROA_{i,t} \quad &= \beta_0 + \beta_1 LiquidityRisk_{i,pre-t} * BC + \beta_2 LiquidityRisk_{i,pre-t} * MC \\ &+ \beta_3 LiquidityRisk_{i,pre-t} * NT + \beta_4 LiquidityRisk_{i,pre-t} * BC * Interact \\ &+ \beta_5 LiquidityRisk_{i,pre-t} * MC * Interact + \beta_6 LiquidityRisk_{i,pre-t} * NT \\ &* Interact + \beta_7 Y_{i,pre-t} + \tau_t + \varepsilon_{i,t} \end{aligned} \tag{3}$$

$$\begin{aligned}Survival_{i,t} &= \beta_0 + \beta_1 LiquidityRisk_{i,pre-t} * BC + \beta_2 LiquidityRisk_{i,pre-t} * MC \\ &+ \beta_3 LiquidityRisk_{i,pre-t} * NT + \beta_4 LiquidityRisk_{i,pre-t} * BC * Interact \\ &+ \beta_5 LiquidityRisk_{i,pre-t} * MC * Interact + \beta_6 LiquidityRisk_{i,pre-t} * NT \\ &* Interact + \beta_7 Y_{i,pre-t} + \tau_t + \varepsilon_{i,t} \end{aligned} \tag{4}$$

For equations 3 and 4, $Interact$ is a variable that represents either $CreditRisk$ or $Capital$ which are our measures for credit risk and capital ratios in regards to our second and third hypothesis. Therefore, our coefficients of interest from equations 3 and 4 are β_4, β_5, and β_6 which show the interaction effect between liquidity risk in the respective crisis and credit risk or capital ratios. Please see Table 2 for the definitions of these variables. In regards to hypothesis 2 which predicts that the adverse effects of liquidity risk are more severe for banks with lower capital ratios during a banking or market crisis, then we expect to see a significantly positive impact when $Interact$ is equal to $Capital$. In regards to hypothesis 3, which predicts that the adverse effects of liquidity risk are more sever for banks with higher credit risk during a financial or market crisis, the expectation is to see a significantly negative impact when $Interact$ is equal to $CreditRisk$. As previously explained for the initial regressions on Equation (1), we will also test the effects on $\Delta Margin$ and $\Delta Provisions$ for these models as well.

For equations (2) and (4) our dependent variable, $Survival_{i,t}$ is a dummy with a binary outcome, therefore we use a logit regression for these equations. For equations (1) and (3) our dependent variable will be continuous variables $\Delta ROA, \Delta Margin,$ and $\Delta Provisions$, so we will use a standard OLS regression with robust standard errors. Table 4 presents the descriptive statistics for the entire dataset for all essential variables used in the regressions.

Table 4 presents the descriptive statistics for all essential variables. Survival is a dummy variable. The three remaining dependent variables are measured as the delta between their post-crisis and pre-crisis average. All remaining variables are measured as their pre-crisis average. Since there are 6,252 unique banks, each bank can be observed up to five times, once for each crisis.

Table 4 **Summary Statistics for all the crisis periods**

Variables	Mean	S.D	Min.	Max.	Observations
Dependent Variables					
Survival	0.96	0.31	0	1	12,851
ΔROA(%)	-5.16	2.39	-84.2	82.9	12,851
$\Delta Margin$(%)	-1.38	3.53	-119	175	12,851
$\Delta Provisions$(%)	1.44	3.25	-465	2425	12,851
Liquidity Variables					12,851
$Commitments$	0.01	0.01	-0.001	0.17	12,851
$Wholesale$	0.85	0.84	0.01	0.96	12,851
$LiquidAssets$	0.05	0.05	0.001	0.95	12,851
$LiquidityRisk$	0.79	0.09	-0.89	1.01	12,851
Financial Variables					
$Capital$	0.17	0.14	0.05	9.33	12,788
$LnAssets$	11.6	1.27	6.96	20.5	12,851
$TradingAssets$	0.01	0.01	0	0.49	12,851
Credit Risk Variables					
$CreditRisk$	1.01	0.26	0.02	107.5	12,788
$ComRealEstate$	0.17	0.12	0	0.88	12,842
NPL	0.01	0.05	0	1.82	12,789

4.Main Results

4..1 Liquidity Risk Measures

In this section, we will first examine whether the three liquidity variables that are used to construct our liquidity risk index affect bank performance during the financial crisis. As previously discussed in the methodology, the three liquidity risk measures are $Commitments, Wholesale$, and $LiquidAssets$. Table 5 and Table 6 present the initial regression results for the effect of the liquidity risk components on bank ΔROA and $Survival$ during a financial crisis. The regression model follows Equation (1) and (2) respectively. The results for Table 5 show that all liquidity risk measures have a significant effect on the ROA during a financial crisis at a 1% level. Models 1 and 2 show that unused loan commitments and wholesale deposits which were the predicted sources of liquidity risk have a negative effect on a bank's ROA during a banking crisis, while liquid assets which is expected to reduce liquidity risk has a positive effect on ROA. The same cannot be said for the market crisis and normal time crisis, which shows a significant positive effect for unused loan commitments and wholesale deposits, and a significant negative effect for liquid assets on the bank ROA. This may suggest that an increase in unused loan commitments/wholesale deposits, or a decrease in liquid assets may reduce a bank's ROA during a market crisis. As previously discussed in the introduction, holding more liquidity poses a profit risk and opportunity cost for banks. In the case of market crisis, banks are regarded as safe places for investment because the overall health of the financial system is not at risk. (Gatev and Strahan 2006). Therefore, increases in loan commitments and wholesale deposits represent an increase in illiquid investments with higher expected returns. Since there is no liquidity pressure during the market crisis, the liquidity risk of these commitments is not evident in the results. The increase in wholesale deposits and loan commitments allows the bank to increase their interest income, while maintaining their illiquidity during the market crisis.

The results from Table 6, which look at bank survival as the dependent variable, is very similar to the results of bank ROA when looking at the banking crisis results. All coefficients for the interaction between the banking crisis and the respective liquidity variable have a significant effect at the 1% level with the same signs discussed above for Table 5. In regards to the market crisis interaction with the liquidity measures, we see a significantly negative effect for unused loan commitments while wholesale deposits and liquid assets are insignificant. These results may be insignificant due to the fact that bank defaults during a market crisis are highly unlikely even if the bank was suffering from liquidity problems. Moreover, the results suggest that liquidity plays a bigger role for banks during banking crisis rather than market crisis, which is supported by the results from Table 5.

In regards to the control variables, the results show that banks with higher capital ratios are more likely to survive, and experience an improvement in their ROA. Banks with more real estate loans relative to their total loans outstanding were less likely to survive and experienced decreases in their ROA. Banks that carried more credit risk saw decreases in their ROA although they were more likely to survive. This relationship between survival rates and taking on credit risk may be a reflection of core bank operations of managing credit risk.

The Effects of Individual Bank Liquidity Components on ΔROA. *Table 5 reports the coefficients and standard deviations of an OLS regression with dependent variable ΔROA. This is a representation of Equation (1). Significance is denoted by *, **, *** with the significance level being 10%, 5%, and 1% respectively.*

Table 5	Dependent Variable: ΔROA		
	Model 1	Model 2	Model 3
Variables	Commitments	Wholesale	LiquidAssets
LiquidityRiskxBC	-13.01***	-0.417***	0.265***
	(11.27)	(0.861)	(1.11)
LiquidityRiskxMC	2.14***	0.263**	-0.578***
	(3.95)	(0.744)	(0.802)
LiquidityRiskxNT	9.27***	0.376***	-0.070***
	(6.83)	(0.824)	(0.576)
CreditRisk	-0.147***	-0.142***	-0.146***
	(0.246)	(0.251)	(0.248)
ComRealEstate	-0.718***	-0.840***	-0.748***
	(0.237)	(0.307)	(0.244)
NPL	0.269***	0.422***	0.433***
	(0.453)	(0.652)	(0.643)
Capital	0.245***	0.256***	0.244***
	(0.277)	(0.259)	(0.221)
LnAssets	-0.031***	-0.026***	-0.026***
	(0.027)	(0.029)	(0.025)
TradingAssets	-0.737	-0.432	-0.601
	(2.34)	(2.25)	(2.32)
Crisis Fixed Effects	Yes	Yes	Yes
Observations	12,787	12,787	12,787
Adjusted R-Squared	0.190	0.177	0.186

The Effects of Individual Bank Liquidity Components on $\boldsymbol{Survival}$. *Table 6 reports the coefficients and standard deviations of a Logit regression with dependent variable* $Survival$. *This is a representation of Equation (2). Significance is denoted by *, **, *** with the significance level being 10%, 5%, and 1% respectively.*

Table 6	Dependent Variable: Survival		
	Model 2	Model 3	Model 4
Variables	Commitments	Wholesale	LiquidAssets
LiquidityRiskxBC	-1.95***	-0.09***	0.115***
	(1.84)	(0.02)	(0.04)
LiquidityRiskxMC	-0.178***	0.001	0.012*
	(0.214)	(0.02)	(0.036)
LiquidityRiskxNT	-0.056**	0.005	0.082
	(0.816)	(0.02)	(0.045)
CreditRisk	0.125***	0.04***	0.03***
	(0.034)	(0.001)	(0.001)
ComRealEstate	-0.146***	-0.017***	-0.013***
	(0.016)	(0.017)	(0.016)
NPL	-0.013	0.016	0.018
	(0.028)	(0.028)	(0.028)
Capital	0.012***	0.01***	0.01***
	(0.007)	(0.007)	(0.007)
LnAssets	0.001	0.001	0.001
	(0.01)	(0.01)	(0.01)
TradingAssets	-0.02	0.027	0.02***
	(0.217)	(0.22)	(0.21)
Crisis Fixed Effects	Yes	Yes	Yes
Observations	12,787	12,787	12,787
Pseudo-R-Squared	0.068	0.066	0.066

4.2 Hypothesis 1

Based on the results of Table 5 and 6, we find that all three of our liquidity risk measures had a significant impact on bank ROA and survival probability during the banking crisis. This gives us confidence in our liquidity risk index, which is used to test the first hypothesis. Table 7 shows the results of the effects of our constructed liquidity risk index during a financial crisis on bank ROA which follows Equation (1). Model 1 is a standard regression without control variables and Model 2 includes the various credit and financial controls discussed previously. For both models the coefficients of $LiquidityRiskxBC$,and $LiquidityRiskxMC$ are significant at the 1% level. The results of Model 2 show coefficients for the $LiquidityRiskxBC$,and $LiquidityRiskxMC$ are -0.449 and 0.286 respectively with a 1% significance. This may suggest that the effects of liquidity risk on bank ROA differs in the subprime crisis and market crisis for our sample. During the subprime crisis, an increase in pre-crisis liquidity risk leads to a decrease in bank ROA, while it increased ROA during the market crisis.

We measure the marginal effects of a one standard deviation increase on our results in Table A1, which is located in the appendix. The results show that a one standard deviation increase in liquidity risk lead to a decrease in ΔROA by 4.1% during a banking crisis while holding all other variables constant. Therefore when we use ΔROA as a bank performance measure, the results support Hypothesis 1A in the case of the banking crisis. The same cannot be said about the market crisis since ROA was not significantly worse. As discussed in the theoretical background, this may be due to liquidity risk only affecting banks negatively in financial crises when the financial health of the banking sector becomes a public concern. However, when the crisis starts in the financial markets rather than the banking industry, banks with higher pre-crisis liquidity risk may be rewarded with increases in ROA for taking more risk. This is supported by the marginal effects results, which show that a one standard deviation increase lead to an increase in ΔROA by 2.6% during a market crisis while holding all other variables constant.

Table 8 shows the results for the effect of our liquidity risk measure on bank survival probability. The results for the banking crisis coefficients, $LiquidityRiskxBC$ are similar to those in table 7 which show a negative significant effect at the 1% level. The results for the market crisis coefficient, $LiquidityRiskxMC$, differ when using bank survival as a proxy for the performance measure. The coefficients show a negative significant effect at the 1% level, which suggests that liquidity risk reduced a bank's survival probability in both the subprime crisis and market crisis. Our marginal effects results from Table A1 show that a one standard deviation increase in liquidity risk lead to a decrease in bank survival probability by 11.8% and -3.5% during a banking and market crisis respectively while holding all other variable constant. An interesting coefficient to note is that of the $Capital$ variable which is positive and significant at the 1% level. This may suggest that an increase in a banks capital may help a bank survive during a crisis. This will be further explored in the results for the second hypothesis, which will include a direct interaction term between bank capital and liquidity risk.

In summary, the results from Table 7 and 8 show a strong support for hypothesis 1A when looking at both performance measures. This suggests that indeed the nature of the crisis is critical in estimating how the role of liquidity risk affects bank performance, and that during the subprime crisis, banks with higher liquidity risk experienced lower ROA and survival rates. The results from the market crisis results vary. During the market crisis, banks with higher levels of liquidity risk experienced lower survival rates and higher levels of ROA. These results suggest that banks that take on more liquidity risk during a market crisis might actually realise higher returns. Therefore, hypothesis 1B is supported when looking at survival rates but is not supported when looking at ROA as a bank performance measure. Finally, it is important to note that our results for the liquidity risk measures in Model 2 for both performance measures are significant despite controlling for credit risk, which supports our predictions that the weak bank performance was due to liquidity risk rather than insolvency.

The Effects of Liquidity Risk on ΔROA. *Table 7 reports the coefficients and standard deviations of an OLS regression with dependent variable ΔROA. This is a representation of Equation (1). Significance is denoted by *, **, *** with the significance level being 10%, 5%, and 1% respectively.*

Table 7	Dependent Variable: ΔROA	
	Model 1	Model 2
Variables	LiquidityRisk	
LiquidityRiskxBC	-0.336***	-0.449***
	(0.524)	(0.692)
LiquidityRiskxMC	0.377***	0.286***
	(0.501)	(0.579)
LiquidityRiskxNT	0.305***	0.413***
	(0.526)	(0.665)
CreditRisk		-0.142***
		(0.250)
ComRealEstate		-0.855***
		(0.313)
NPL		0.335***
		(0.412)
Capital		0.261***
		(0.251)
LnAssets		0.024***
		(0.027)
TradingAssets		-0.363***
		(2.24)
Crisis Fixed Effects	Yes	Yes
Observations	12,851	12,787
Adjusted R-Squared	0.152	0.188

The Effects Liquidity Risk on Survival. *Table 8 reports the coefficients and standard deviations of a Logit regression with dependent variable Survival. This is a representation of Equation (2). Significance is denoted by *, **, *** with the significance level being 10%, 5%, and 1% respectively.*

Table 8	Dependent Variable: Survival	
	Model 1	Model 2
Variables	LiquidityRisk	
LiquidityRiskxBC	-0.021***	-0.017***
	(0.020)	(0.021)
LiquidityRiskxMC	-0.022**	-0.020***
	(0.019)	(0.019)
LiquidityRiskxNT	0.024	0.021
	(0.020)	(0.021)
CreditRisk		0.002***
		(0.001)
ComRealEstate		-0.026***
		(0.015)
NPL		0.015
		(0.042)
Capital		0.06***
		(0.007)
LnAssets		-0.001
		(0.001)
TradingAssets		0.188
		(0.448)
Crisis Fixed Effects	Yes	Yes
Observations	12,851	12,787
Pseudo-R-Squared	0.069	0.073

4.3 Hypothesis 2 & 3

The evidence provided in the results for hypothesis 1 suggests that bank liquidity risk can hurt bank performance during a financial crisis. Following this, we made further predictions in Hypothesis 2 that the adverse effects of liquidity risk were more serious for banks with lower capital ratios and in Hypothesis 3 that the adverse effects of the liquidity risk were more serious for banks with higher credit risk. These predictions follow the assumption that banks with lower capital ratios and higher credit risk are more likely to suffer during a financial crisis because they will be required to make more costly adjustments to increase liquidity buffers and reduce credit risk.

Table 9 provides the results for Hypothesis 2 and 3 when looking at ΔROA as the proxy for bank performance. Considering our market crisis results were not supported for ROA as a bank performance measure, we will focus on the banking crisis results. Table 9 table is a representation of Equation (3), and the main coefficient of interest is $LiqudityRiskxBCxInteract$, which shows the relationship between our dependent variable and the interaction term of our liquidity risk index, the banking crisis, and $Interact$. $Interact$ represents our variable for bank capital or credit risk in Model 2 and Model 3 respectively. These variables have been previously defined in Table 2. The coefficient of interest will highlight whether a lower capital ratio or higher credit risk in a bank will lead to worse performance due to liquidity risk. As previously discussed in the Hypothesis 1 results, Hypothesis 1B was not supported when using ROA as a bank performance measure, which is why we will not further investigate whether capital ratios or credit risk will have an effect on bank ROA during a market crisis. From Models 2 and 3, the coefficients of $LiqudityRiskxBCxCapital$ and $LiqudityRiskxBCxCreditRisk$ are 1.69 and -0.543, respectively, and both are significant at the 1% level. The marginal effects results from Table A1 show that a one standard deviation increase in bank capital ratio lead to an increase in ΔROA by 25.0%. A one standard deviation increase in credit risk lead to a decrease in ΔROA by 14.1% while holding liquidity risk and all other variables constant. These results suggest that during the subprime crisis, banks with the same liquidity risk that carry more capital relative to their counterparts will experience a higher ROA between the pre-crisis and crisis period. Similarly, the coefficient for the credit risk model suggests that during the subprime crisis, banks that carry the same liquidity risk but carry higher credit risk exposure will experience lower ROA between the pre-crisis and crisis period. These results support Hypothesis 2A, and 3A when using ROA as the proxy for bank performance.

Table 10 provides the results for Hypothesis 2 and 3 when using bank survival as the proxy for our performance measure. This regression is modelled using Equation (4) in the Hypothesis Development section. In section 5.2, our results supported Hypothesis 1A and 1B, when using survival as our performance measure, meaning that liquidity risk decreased bank survival in both the subprime crisis and market crisis'. Therefore our coefficients of interest are both $LiqudityRiskxBCxInteract$, and $LiqudityRiskxMCxInteract$. In model 2, which provides the results relating to bank capital and Hypothesis 2A and 2B, the coefficients of interest are both are significant at the 1% level. The marginal effects results show that a one standard deviation increase in bank capital leads to an increase in bank survival probability by 33.6% and 11.6% during a banking and market crisis respectively while holding all other variables constant. This implies than an increase in bank capital alleviated the negative impact of liquidity risk on bank survival for both the subprime and market crisis. Model 3 provides similar results, with the coefficients for the banking and market crisis being significant at the 1% and 5% levels respectively. The marginal effects are -13.8% and -1.5% respectively. These results suggest that an increase in credit risk worsened the negative impact of the liquidity risk on bank survival for both the market and banking crisis. For the results relating to bank survival as our performance measure all out hypothesis (1A,1B,2A,2B,3A,3B) are supported. However, when looking at ROA the evidence does not support the market crisis hypothesis.

The Effects of Liquidity Risk on ΔROA. *Table 9 reports the coefficients and standard deviations of an OLS regression with dependent variable* ΔROA. *Models 2 and 3 include the interaction effect between our crisis dummies, liquidity risk, and capital ratios/credit risk. This is a representation of Equation (3). Significance is denoted by *, **, *** with the significance level being 10%, 5%, and 1% respectively.*

Table 9	Dependent Variable: ΔROA		
	Model 1	Model 2	Model 3
Variables		Capital	CreditRisk
LiquidityxBC	-0.449***	-0.837***	1.86***
	(0.692)	(0.811)	(0.90)
LiquidityxMC	0.286***	-0.695	-2.06**
	(0.579)	(0.718)	(0.72)
LiquidityxNT	0.413***	0.839**	-1.88***
	(0.665)	(0.790)	(0.938)
LiquidityxBCxInteract		1.69***	-0.543***
		(1.98)	(0.463)
LiquidityxMCxInteract		1.84**	0.985**
		(1.98)	(0.300)
LiquidityxNTxInteract		-1.91	0.657***
		(1.96)	(0.496)
CreditRisk	-0.142***	-0.141***	-0.475*
	(0.250)	(0.250)	(0.378)
ComRealEstate	-0.855***	-0.879***	-0.764***
	(0.313)	(0.311)	(0.282)
NPL	0.335***	0.025**	0.023*
	(0.412)	(0.029)	(0.026)
Capital	0.261***	-1.60***	-0.280***
	(0.251)	(1.49)	(0.233)
LnAssets	0.024***	-0.026***	-0.042***
	(0.027)	(0.026)	(0.025)
TradingAssets	-0.363***	-0.338	-0.073
	(2.24)	(2.28)	(2.39)
Crisis Fixed Effects	Yes	Yes	Yes
Observations	12,787	12,787	12,787
Adjusted-R-Squared	0.152	0.193	0.195

The Effects of Liquidity Risk on $\boldsymbol{Survival}$. *Table 10 reports the coefficients and standard deviations of an Logit regression with dependent variable* $\Delta Survival$. *Models 2 and 3 include the interaction effect between our crisis dummies, liquidity risk, and capital ratios/credit risk. This is a representation of Equation (4). Significance is denoted by *, **, *** with the significance level being 10%, 5%, and 1% respectively.*

Table 10	Dependent Variable: Survival		
	Model 1	Model 2	Model 3
Variables		Capital	CreditRisk
LiquidityxBC	-0.017***	-0.045***	0.065***
	(0.021)	(0.036)	(0.026)
LiquidityxMC	-0.020***	-0.043***	0.058**
	(0.019)	(0.033)	(0.023)
LiquidityxNT	0.021	-0.043	0.064*
	(0.021)	(0.035)	(0.024)
LiquidityxBCxInteract		0.170***	-0.017***
		(0.116)	(0.019)
LiquidityxMCxInteract		0.012***	-0.011**
		(0.096)	(0.005)
LiquidityxNTxInteract		0.012	-0.013*
		(0.012)	(0.008)
CreditRisk	0.002***	0.133***	0.006***
	(0.001)	(0.087)	(0.003)
ComRealEstate	-0.026***	-0.005**	-0.004**
	(0.015)	(0.014)	(0.014)
NPL	0.015	0.029	0.043
	(0.042)	(0.018)	(0.019)
Capital	0.06***	0.012***	0.005***
	(0.007)	(0.078)	(0.010)
LnAssets	-0.001	0.001	-0.001
	(0.001)	(0.001)	(0.001)
TradingAssets	0.188	0.027	0.271
	(0.448)	(0.313)	(0.310)
Crisis Fixed Effects	Yes	Yes	Yes
Observations	12,787	12,787	12,787
Pseudo-R-Squared	0.069	0.071	0.071

5.Additional Results

In this section we conduct two additional analysis to discover the driving forces behind our results. First, we examine how liquidity risk affects two components of ROA, net interest margin and loan-loss provision expenses during a financial crisis. This will help us better understand the channel through which the liquidity risk affects ROA during the crisis. Second, we will divide our samples into two groups based on bank size to investigate whether bank size will affect the results.

5.1 ROA Channels

The bank performance measures we use throughout the paper are ΔROA and Survival. These two measures are able to reflect overall bank performance. However, in order to better understand the channels through which liquidity risk affects banks during a crisis, we choose to further investigate more detailed measures of bank performance. In the following section, we take a look at two measures that are important components of ROA, net-interest margin and loan-loss-provision expenses. Net interest margin represents a bank's cost of adjustment as a response to the liquidity shock, and loan-loss-provision expense represents whether a bank is able to maintain quality loans during the liquidity shock. As previously predicted in the Hypothesis Development section, we believe that banks with higher liquidity risk will experience higher adjustment costs and therefore will experience a more significant decrease in their net interest margin. Furthermore, banks with higher liquidity risk have a worse incentive to control for credit risk and will therefore experience a more significant increase their loan-loss-provision expenses.

5.1.1 Net-Interest Margin

We define net interest margin as the sum of interest income and interest expense scaled by total assets and our dependent variable $\Delta Margin$ represents the difference between the average crisis and pre-crisis net interest margin. Table 11 presents the results for $\Delta Margin$ as our dependent variable. Model 1 is represented by Equation (1) and Models 2 and 3 are represented by Equation (3). The coefficient from Model 1 for $LiqiduityRiskxBC$ and $LiqiduityRiskxMC$ are -0.036 and -0.023, respectively. The coefficient for the banking crisis is significant at the 1% level while the coefficient for the market crisis is not significant. In regards to Model 1, the results support Hypothesis 1A only, so we will only look at the banking crisis results in relation to Hypothesis 2 and 3. For Models 2 and 3, our main coefficient of interest, $LiquidityRiskxBCxInteract$, has values of 0.107 and -0.115 respectively. They are both significant at the 1% level. These results are in line with our predictions and show that firstly, banks with higher capital ratios experienced a less significant decrease in their net interest margin during the subprime crisis, and secondly banks with higher credit risk experienced a more significant decrease in their net interest margin.

These results suggest that during a banking crisis, banks with higher liquidity risk would likely need to make more costly adjustments to increase their liquidity. This could include reduction in their credit production, liquidation of other interest bearing assets, or borrowing in the debt markets from other banks. This same logic does not hold for the market crisis scenario, since there is no liquidity pressure on the banking system, banks with higher liquidity risk do not need make adjustments to increase their liquidity buffers. Furthermore, as previously discussed in the hypothesis development, evidence has shown that investors may even choose to transfer their funds from the financial markets to the banking system for safety. This reasoning is supported by the insignificant coefficient for the market crisis in Model 1. Overall the results for the net interest margin support Hypothesis 1A,2A, and 3A.

The Effects of Liquidity Risk on $\Delta \boldsymbol{Margin}$. *Table 11 reports the coefficients and standard deviations of an OLS regression with dependent variable* $\Delta Margin$. *Models 2 and 3 include the interaction effect between our crisis dummies, liquidity risk, and capital ratios/credit risk. This is a representation of Equation (3). Significance is denoted by *, **, *** with the significance level being 10%, 5%, and 1% respectively.*

Table 11	Dependent Variable: $\Delta Margin$		
	Model 1	Model 2	Model 3
Variables		Capital	CreditRisk
LiquidityRiskxBC	-0.036***	-0.059***	0.045***
	(0.013)	(0.016)	(0.019)
LiquidityRiskxMC	-0.023	0.038*	0.027
	(0.011)	(0.014)	(0.016)
LiquidityRiskxNT	0.034***	0.052***	-0.047***
	(0.012)	(0.015)	(0.019)
LiquidityRiskxBCxInteract		0.107***	-0.115***
		(0.058)	(0.091)
LiquidityRiskxMCxInteract		-0.065***	-0.003
		(0.055)	(0.007)
LiquidityRiskxNTxInteract		-0.077***	0.016***
		(0.056)	(0.009)
CreditRisk	-0.008***	-0.008***	-0.005*
	(0.004)	(0.004)	(0.007)
ComRealEstate	-0.001***	-0.002***	0.001***
	(0.006)	(0.005)	(0.005)
NPL	0.064***	0.064**	0.071**
	(0.090)	(0.089)	(0.082)
Capital	0.008***	0.062***	0.007***
	(0.005)	(0.089)	(0.005)
LnAssets	0.003***	0.003***	0.003***
	(0.001)	(0.001)	(0.001)
TradingAssets	-0.017	-0.017	0.015
	(0.024)	(0.023)	(0.024)
Crisis Fixed Effects	Yes	Yes	Yes
Observations	12,787	12,787	12,787
Adjusted R Squared	0.106	0.109	0.122

5.1.2 Loan-Loss Provision

Table 12 presents the results regarding loan-loss-provisions expenses. We define $\Delta Provisions$, as the percentage change in loan-loss-provisions expense between the crisis and pre-crisis period. First we assess Hypothesis 1 by analysing the coefficients of Model 1, our coefficients of interest, $LiquidityRiskxBC$ and $LiquidityRiskxMC$, are equal to 0.128 and 0.109 respectively. $LiquidityRiskxBC$ has a significantly positive effect on the dependent variable at the 1% level while $LiquidityRiskxMC$ is insignificant. These results suggest that during a banking crisis banks with higher liquidity risk will increase their loan-loss provisions expense while the same cannot be said in the case of a market crisis. Therefore, Hypothesis 1A is supported while Hypothesis 1B is not supported. Following these results we will focus solely on $LiquidityRiskxBCxInteract$ when looking at Models 2 and 3 to assess the effects of capital ratios and credit risk on the results. The coefficients for $LiquidityRiskxBCxCapital$ and $LiquidityRiskxBCxCreditRisk$ are -0.413 and 0.630 respectively, and both are significant at the 1% level. This supports our hypothesis by showing that the negative effect of liquidity risk is mitigated for banks with higher capital ratios by decreasing their loan-loss-provisions expense during the subprime crisis of 2007-09. Decreasing loan-loss-provisions expense means a bank is less concerned about loans defaulting and are able to use the extra capital to invest in other interest beating assets and thus improving ROA. Furthermore the results show that the negative effect of liquidity risk is amplified by an increased credit risk and this can be seen by banks increasing their loan-loss-provisions expense.

Overall our results for the subprime crisis of 2007-09 are in line with our Hypothesis predictions, while the same cannot be said for the market crisis. Throughout our analysis on ΔROA, $\Delta Margin$, and $\Delta Provisions$, we find interesting results regarding the effects of $LiquidityRisk$ during the normal time crisis. The coefficients for $LiquidityRiskxNT$ and $LiquidityRiskxNTxInteract$ seem to be the opposite to the coefficients of the banking crisis $LiquidityRiskxBC$ and $LiquidityRiskxBCxInteract$. During normal times, an increase in liquidity risk increases bank ROA and net interest margin, and decreases loan-loss-provisions. This indicates that taking on more liquidity risk during times when the banking system is not under liquidity pressure can actually improve bank performance. Furthermore, these effects are more prominent for banks with lower capital ratios and higher credit risk. This suggests that banks with lower capital ratios and higher credit risk can benefit more from increasing their liquidity risk during normal times. Bank's with lower capital ratios or higher credit risk naturally have an increased risk of default so they may face moral hazard problems. Therefore, they are more likely to invest in riskier securities or issue loans to borrowers with poor credit history in order to increase their interest margins. This follows the idea of "higher risk, higher returns". Based on our results this strategy seems to of benefit during normal times with these banks experiencing increased ROA, and net interest margin. Furthermore, these banks are under more pressure to meet regulatory capital requirements so they are more likely to reduce loan-loss-provisions expense in order to increase their capital or interest bearing assets. This shows that overall, banks with lower capital or higher credit risk experience increased ROA, net-interest margin and reduced loan-loss-provisions during normal times.

The Effects of Liquidity Risk on $\Delta Provisions$. *Table 12 reports the coefficients and standard deviations of an OLS regression with dependent variable $\Delta Provisions$. Models 2 and 3 include the interaction effect between our crisis dummies, liquidity risk, and capital ratios/credit risk. This is a representation of Equation (3). Significance is denoted by *, **, *** with the significance level being 10%, 5%, and 1% respectively.*

Table 12	Dependent Variable: $\Delta Provisions$		
	Model 1	Model 2	Model 3
Variables		Capital	CreditRisk
LiquidityRiskxBC	0.128***	0.591***	-0.374***
	(2.42)	(5.21)	(2.87)
LiquidityRiskxMC	0.109	0.092*	0.089*
	(2.76)	(2.83)	(3.20)
LiquidityRiskxNT	-0.204***	-0.052**	0.022***
	(2.95)	(2.47)	(3.36)
LiquidityRiskxBCxInteract		-0.413***	0.630***
		(2.75)	(3.69)
LiquidityRiskxMCxInteract		0.042	-0.284**
		(3.29)	(3.34)
LiquidityRiskxNTxInteract		0.035	-0.277***
		(2.62)	(3.25)
CreditRisk	0.039***	0.047***	0.245***
	(0.063)	(0.066)	(0.207)
ComRealEstate	0.049**	0.052***	0.051**
	(3.31)	(3.34)	(3.34)
NPL	0.064***	0.071***	0.071***
	(0.090)	(0.109)	(0.124)
Capital	-0.058***	-0.023***	-0.057***
	(0.005)	(0.009)	(0.007)
LnAssets	0.034***	0.029***	0.031***
	(0.035)	(0.032)	(0.034)
TradingAssets	-0.011	-0.010	-0.011
	(0.012)	(0.013)	(0.012)
Crisis Fixed Effects	Yes	Yes	Yes
Observations	12,411	12,411	12,411
Adjusted R Squared	0.225	0.227	0.232

5.2 Effect of Bank Size on Results

In this section, we recreate our main results by splitting our sample into large and small banks and testing this split on our two main dependent variables ΔROA, and bank survival.

Previous literature on this topic has provided evidence that banks size affects behaviour during a financial crisis. (Berger and Bouwman, 2009; Cornett et al., 2011). We define large banks as those with a quarterly average pre-crisis total assets of at least 1 billion U.S dollars, while all other banks will be classified as small banks. Since these results for the full sample have already been shown in Tables 7 and 8, we will only present the main coefficients for our results in Tables 12 and 13. Our results regarding small banks are similar to the results in the whole sample tables. On the other hand, when looking at the large banks, many of the coefficients lose their significance. Firstly, all market crisis coefficients are insignificant for large banks for both ROA and bank survival. Furthermore, when looking at bank survival as the dependent variable for large banks, $LiquidityRiskxBCxInteract$ coefficients are all insignificant. These results may be due to large banks being better at managing risk and therefore this would give larger banks an advantage in dealing with liquidity risk during a financial crisis. Therefore, liquidity risk will likely cause less problems for larger banks relative to smaller banks. Overall, our market crisis hypothesis are not supported which follows the results of the full sample. Hypothesis 1A, 2A, and 3A hold for both samples when looking at ROA as the dependent variable, and hypothesis 1A is supported when looking at bank survival for the both samples.

The Effects of Liquidity Risk on ΔROA, by bank size. *Table 12 reports the coefficients and standard deviations of an OLS regression with dependent variable ΔROA. Models 2 and 3 include the interaction effect between our crisis dummies, liquidity risk, and capital ratios/credit risk. This is a representation of Equation (3). Significance is denoted by *, **, *** with the significance level being 10%, 5%, and 1% respectively.*

Table 12	Dependent Variable: ΔROA					
	Big Banks			Small Banks		
	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
Variables		Capital	CreditRisk		Capital	CreditRisk
LiquidityRiskxBC	-0.510***	-0.689***	1.09***	-0.191***	-1.66***	2.18***
	(0.321)	(0.397)	(0.417)	(1.10)	(1.51)	(1.23)
LiquidityRiskxMC	0.064	0.066	-0.091	-0.042**	-0.041	-0.252***
	(0.031)	(0.037)	(0.042)	(0.981)	(1.37)	(1.04)
LiquidityRiskxNT	-0.055	0.019	-1.03**	0.119***	0.061***	-0.230***
	(0.033)	(0.041)	(0.425)	(1.06)	(1.45)	(1.27)
LiquidityRiskxBCxInteract		3.55**	-1.45***		6.05***	-1.33***
		(2.77)	(0.582)		(2.91)	(0.535)
LiquidityRiskxMCxInteract		0.379	0.146		0.601***	0.109***
		(0.217)	(0.526)		(2.73)	(0.294)
LiquidityRiskxNTxInteract		-0.386	0.149**		-0.067	0.690***
		(0.286)	(0.569)		(2.71)	(0.514)
Crisis Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	6,084	6,084	6,084	6,739	6,739	6,739
Adjusted R Squared	0.331	0.338	0.345	0.165	0.172	0.181

The Effects of Liquidity Risk on Survival , by bank size*. Table 13 reports the coefficients and standard deviations of an Logit regression with dependent variable Survival. Models 2 and 3 include the interaction effect between our crisis dummies, liquidity risk, and capital ratios/credit risk. This is a representation of Equation (4). Significance is denoted by *, **, *** with the significance level being 10%, 5%, and 1% respectively.*

Table 13	Dependent Variable: *Survival*					
	Big Banks			Small Banks		
	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
Variables		Capital	CreditRisk		Capital	CreditRisk
LiquidityRiskxBC	-0.276**	-0.246**	-0.288**	-0.035***	-0.109***	-0.063***
	(0.038)	(0.061)	(0.049)	(0.029)	(0.046)	(0.037)
LiquidityRiskxMC	-0.074	-0.043	-0.092	-0.024*	-0.079***	-0.045***
	(0.037)	(0.056)	(0.041)	(0.026)	(0.041)	(0.032)
LiquidityRiskxNT	-0.013	-0.031	-0.035	0.047	-0.098	-0.06
	(0.041)	(0.063)	(0.044)	(0.028)	(0.044)	(0.035)
LiquidityRiskxBCxInteract		0.138	-0.551		0.245***	-0.181***
		(0.239)	(0.044)		(0.180)	(0.015)
LiquidityRiskxMCxInteract		0.165	-0.014		0.175***	-0.056*
		(0.207)	(0.012)		(0.159)	(0.005)
LiquidityRiskxNTxInteract		-0.252	-0.216		0.209	-0.012
		(0.255)	(0.022)		(0.161)	(0.003)
Crisis Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	6,839	6,839	6,839	7,656	7,656	7,656
Pseudo-R-Squared	0.103	0.103	0.104	0.065	0.071	0.072

6.Conclusion

This paper aims to investigate whether bank liquidity risk lead to worse performance during a financial crisis. Firstly, our paper shows that liquidity risk leads to worse bank performance through lower survival rates and ROA during a financial crisis. These effects of liquidity risk on ROA are further explored in the additional results by looking at a bank's loan-loss-provisions expense and net interest margin.

Our empirical results find that liquidity risk indeed hurt bank performance during the subprime crisis of 2007-09. This was evident through decreases in bank survival, ROA, and net-interest margin and increases in loan-loss-provisions expense. Based on these results we made further predictions that the negative effects of liquidity risk on banks during the crisis were more prominent in banks with lower capital ratios and higher credit risk. The results for Hypothesis 2 and 3 supported these predictions by showing that the adverse effects were stronger for weakly capitalised and high credit risk banks. Furthermore, we broke our sample down into small and large banks and found that the results were more significant for small banks. This is evidence that large banks are more resilient during a banking crisis despite carrying large amounts of liquidity risk, which can be attributed to their ability to manage their risk better relative to smaller banks.

Our market crisis results however are not consistent with the predictions made in our hypothesis, except in the case of bank survival rates. The result showed that liquidity risk reduced a bank's survival rate during a market crises and this adverse effect became stronger when the bank had a lower capital ratio or higher credit risk. For the ROA results we find that liquidity risk lead to an increase in bank returns during the market crisis.

Overall our results strongly indicate that the effect of liquidity risk on bank performance is heavily influenced by the nature of the crisis. During a banking crises, the stability of the banking industry is questionable which is why debt markets may freeze. This will result in banks that carry high liquidity risk to be forced to make costly adjustments to increase their liquidity buffers in order to meet short term obligations such as wholesale deposit withdrawal or drawdowns of unused loan commitments. During a market crisis the health of the banking system is not put into question which is why there is no liquidity pressure. The results showed that higher liquidity risk during a market crisis lead to increases in ROA. This can be attributed to the increase of deposit inflows as a result of the volatile market, and better credit risk management.

Our paper contributes to the existing literature in several ways. Firstly, we construct a new measure of liquidity risk that aims to be a more complete proxy in comparison to the existing literature. Our second contribution is that in order to determine the leading cause of weak bank performance, we empirically distinguish between liquidity risk and credit risk in all of our models. Our results show that despite controlling for credit risk and a variety of financial variables, ROA and bank survival rates were lower for banks with higher liquidity risk during the subprime crisis of 2007-09. Furthermore, we test interaction effects between our liquidity risk and credit risk and conclude that higher credit risk can amplify the negative effects of liquidity risk on our bank performance measures during the banking crisis. Therefore, our results support our predictions that liquidity risk played an independent role in the impact on bank performance and was not only a result of credit risk and insolvency. Our final contribution relates to bank capital and risk management. Our second hypothesis aims to investigate whether banks with higher capital ratios performed better during the crisis. The results showed that banks with higher capital ratios did not experience the same adverse effects of liquidity risk relative to their counterparts with lower capital ratios.

7.Appendix

1. Marginal Effects

Table A1 calculates the marginal effect on the dependent. Row 1-3 calculates the marginal effect based on a one standard deviation increase in LiquidityRisk. Row 4-6 calculates the marginal effect based on a one standard deviation increase in Capital or CreditRisk, while holding LiquidityRisk constant.

Table A1	Dependent Variable	
	ΔROA	Survival
Variables		
LiquidityRiskxBC	-0.041***	-0.118***
	(0.097)	(0.004)
LiquidityRiskxMC	0.026***	-0.035**
	(0.041)	(0.004)
LiquidityRiskxNT	0.038***	0.002
	(0.067)	(0.004)
LiquidityRiskxBCxCapital	0.250***	0.336***
	(0.201)	(0.003)
LiquidityRiskxMCxCapital	0.271**	0.115***
	(0.040)	(0.003)
LiquidityRiskxNTxCapital	-0.282	0.015
	(0.067)	(0.001)
LiquidityRiskxBCxCreditRisk	-0.141***	-0.138***
	(0.098)	(0.005)
LiquidityRiskxMCxCreditRisk	0.256**	-0.015**
	(0.041)	(0.003)
LiquidityRiskxNTxCreditRisk	0.170***	-0.057*
	(0.067)	(0.003)

8.References

Acharya, V., & Viswanathan, S. (2011). *Leverage, Moral Hazard and Liquidity*. https://doi.org/10.3386/w15837

Acharya, V., Shin, H. S., & Yorulmazer, T. (2011). *Crisis Resolution and Bank Liquidity*. https://doi.org/10.3386/w15567

Antoniades, A. (2016). Liquidity risk and the credit crunch of 2007–2008: Evidence from micro-level data on mortgage loan applications. *Journal of Financial and Quantitative Analysis*, *51*(6), 1795–1822. https://doi.org/10.1017/s0022109016000740

Banks, E. (2014). *Liquidity risk: Managing funding and asset risk* (2nd ed.). Palgrave Macmillan.

Beltratti, A., & Stulz, R. M. (2012). The credit crisis around the globe: Why did some banks perform better? *Journal of Financial Economics*, *105*(1), 1–17. https://doi.org/10.1016/j.jfineco.2011.12.005

Berger, A. N., & Bouwman, C. H. S. (2013). How does capital affect bank performance during financial crises? *Journal of Financial Economics*, *109*(1), 146–176. https://doi.org/10.1016/j.jfineco.2013.02.008

Boyson, N., Helwege, J., & Jindra, J. (2014). Crises, liquidity shocks, and fire sales at Commercial Banks. *Financial Management*, *43*(4), 857–884. https://doi.org/10.1111/fima.12056

Calomiris, C. W., Heider, F., & Hoerova, M. (2015). A theory of bank liquidity requirements. *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.2477101

Chen, W.-D., Chen, Y., & Huang, S.-C. (2021). Liquidity risk and bank performance during financial crises. *Journal of Financial Stability*, *56*, 100906. https://doi.org/10.1016/j.jfs.2021.100906

Cornett, M. M., McNutt, J. J., Strahan, P. E., & Tehranian, H. (2011). Liquidity Risk Management and credit supply in the financial crisis. *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.1601992

Demirguc-Kunt, A., Detragiache, E., & Merrouche, O. (2013). Bank Capital: Lessons from the financial crisis. *Policy Research Working Papers*. https://doi.org/10.1596/1813-9450-5473

Diamond, D. W., & Dybvig, P. H. (1983). Bank runs, deposit insurance, and liquidity. *Journal of Political Economy*, *91*(3), 401–419. https://doi.org/10.1086/261155

Diamond, D. W., & Rajan, R. G. (2001). Liquidity risk, liquidity creation, and financial fragility: A theory of banking. *Journal of Political Economy*, *109*(2), 287–327. https://doi.org/10.1086/319552

Diamond, D. W., & Rajan, R. G. (2011). Fear of fire sales, illiquidity seeking, and credit freezes *. *The Quarterly Journal of Economics*, *126*(2), 557–591. https://doi.org/10.1093/qje/qjr012

Gatev, E. G., & Strahan, P. E. (2006). Banks' advantage in hedging liquidity risk: Theory and evidence from the Commercial Paper Market. *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.368131

Hayes, A. (2023). *Dodd-Frank Act: What it does, major components, and criticisms*. Investopedia. https://www.investopedia.com/terms/d/dodd-frank-financial-regulatory-reform-bill.asp

Imbierowicz, B., & Rauch, C. (2014). The relationship between liquidity risk and credit risk in Banks. *Journal of Banking Finance*, *40*, 242–256. https://doi.org/10.1016/j.jbankfin.2013.11.030

Kenton, W. (2022). *Emergency economic stabilization act (EESA) of 2008 definition*. Investopedia. https://www.investopedia.com/terms/e/emergency-economic-stability-act.asp#:~:text=What%20Is%20the%20Emergency%20Economic,restore%20liquidity%20in%20financial%20markets.

Logan, L. K. (2011, August 11). *Liquidity shocks: Lessons learned from the global financial crisis and the pandemic*. Liquidity Shocks: Lessons Learned from the Global Financial Crisis and the Pandemic - FEDERAL RESERVE BANK of NEW YORK. https://www.newyorkfed.org/newsevents/speeches/2021/log210811

Loutskina, E. (2011). The role of securitization in bank liquidity and funding management. *Journal of Financial Economics*, *100*(3), 663–684. https://doi.org/10.1016/j.jfineco.2011.02.005

Rastogi, S., Goel, A., & Bhimavarapu V. (2020). *Factors Impacting Bank's Performance: A Literature Review*

Saidenberg, M. R., & Strahan, P. (1999). *Are Banks Still Important for Financing Large Businesses?*

Shin, H. S. (2009). Reflections on northern rock: The Bank Run that heralded the global financial crisis. *Journal of Economic Perspectives*, *23*(1), 101–119. https://doi.org/10.1257/jep.23.1.101

Singh, M. (n.d.). *The 2007–2008 financial crisis in Review*. Investopedia. https://www.investopedia.com/articles/economics/09/financial-crisis-review.asp

Taylor, J. B., & Williams, J. C. (2009). A black swan in the money market. *American Economic Journal: Macroeconomics*, *1*(1), 58–83. https://doi.org/10.1257/mac.1.1.58

Thakor, A. V. (2018). Post-crisis regulatory reform in banking: Address insolvency risk, not illiquidity! *Journal of Financial Stability*, *37*, 107–111. https://doi.org/10.1016/j.jfs.2018.03.009