Liquidity Hoarding and the Financial Crisis: An Empirical Evaluation

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Abstract

I test and find supporting evidence for the precautionary motive hypothesis of liquidity hoarding for U.S. commercial banks during the recent financial crisis. I find that banks held more liquid assets in anticipation of future expected losses from securities write-downs. Exposure to securities losses in their investment portfolios, and expected loan losses (measured by loan loss reserves) represent a more accurate measure of banks' risks than conventional off-balance sheet risk measures such as the proportion of unused loan commitments to bank lending capacity. I also find important differences in liquidity hoarding across bank size. Although banking institutions of all sizes increased their holdings of liquid assets during the crisis, the reasons behind such behavior differ depending on their size. Large unused commitments are a key determinant of increased liquid buffers only for large banks. For small and medium-sized banks the relevant source of liquidity risk is their exposure to securities losses. Finally, I find that for liquidity-hoarding banks, about one-fourth of the lending contraction is due to the precautionary motive.

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1. Introduction

At the onset of the financial crisis in the summer of 2007, short-term funding markets experienced a severe disruption: securitization markets—in particular the market for asset-backed commercial paper—collapsed and interbank markets froze (Strahan, 2008; Brunnermeier, 2009). Although conditions improved in early 2008 relative to late 2007 due to an aggressive policy response and a massive liquidity injection into the banking sector, funding markets experienced significant distress again during the fall of 2008 after Lehman Brothers and AIG failed, and Fannie Mae and Freddie Mac were placed under conservatorship. As Gorton (2009) and Lucas and Stokey (2011) argue, the financial crisis resembled a banking panic that took the form of a run of financial firms on other financial firms. Such panic centered on the repurchase agreement (repo) market, which suffered a run when lenders withdrew their funds by declining to roll over their loan agreements, and by raising their repo haircuts. Concerned about the size and location of the exposure to subprime-related assets, banks stopped lending to other banks, and decided to hoard liquid buffers in response to several factors: widespread concerns about the solvency of their counterparties in interbank operations, increased risks in their asset portfolios, and potential liquidity risk arising from draw-downs of committed lines of credit.

This paper studies the main determinants of bank liquidity hoarding and its effects on bank lending during the recent financial crisis. I propose a measure of liquidity risk—unrealized losses on securities holdings—that accounts for the severe exposure of banks to potential capital losses at the peak of the run in the repo market, and describes the precautionary motive for hoarding liquid assets. Unrealized losses in securities holdings represent the write-downs of securities (a large portion of which are used as collateral in repo transactions) that result from mark-to-market accounting of investment portfolios. In other words, they reflect the exposure to future capital losses for banks if they had to sell those assets at fire sale prices. This source of liquidity risk has not been explored at length in the literature, due perhaps to the lack of reliable data on repo market transactions and the few balance sheet items related to credit exposure covered by collateral in those transactions.

Liquidity management decisions are not uniform across banks, as they depend on the nature of the risks being faced. I document how liquidity hoarding manifested itself at the onset and during the peak of the crisis by examining the behavior of various assets commonly included in the definition of liquid assets. Depending on the type of funding pressures they faced, I find

that banks sold assets worth selling, such as treasuries and government securities, because the return on those assets was almost zero. Banks accumulated cash and excess reserves at the central bank because of the interest earned on reserve balances. Banks also accumulated securities such as mortgage-backed securities (MBS) issued or guaranteed by Fannie Mae and Freddie Mac. These securities had a positive return due to an implicit government guarantee, and provided valuation gains that partly compensated for the losses generated by subprime mortgage-related securities.

My empirical findings suggest that banks held more liquid assets in response to increased risks in their asset portfolios. In addition to unrealized securities losses, I find that a measure of expected loan losses—such as loan loss reserves—is also a key driver of liquidity hoarding. Intuitively, during the financial crisis, and most likely due to mounting worries about the economic outlook, heightened uncertainty about the credit quality of borrowers may have forced banks to reallocate their assets from riskier loans to safe and liquid securities. Unlike traditional measures of credit quality, such as net charge-offs and delinquent loans, loan loss reserves have a forward-looking component that reflects banks' efforts to increase their loan provisioning in anticipation of expected losses, and therefore, provide another motivation to hoard cash in anticipation of such losses. Compared with previously suggested proxies for liquidity risk, such as the fraction of unused loan commitments to their lending capacity, unrealized securities losses and loan loss reserves better capture the risks stemming from banks' asset management and provide supporting evidence for the precautionary nature of liquidity hoarding.

My results also indicate that liquidity hoarding occurred across all banking institutions regardless of their size. However, the reasons behind such behavior differ according to bank size. I find that large unused commitments are a key determinant of increased liquid buffers only for large banks. During the financial crisis, large banks faced liquidity pressures from corporations drawing down their committed credit lines in syndicated loan markets, as documented by Ivashina and Scharstein (2010), and Rampini and Viswanathan (2010). Yet, I do not find significant evidence that off-balance sheet liquidity risk stemming from potential take-downs of committed loans explain the decision to hoard liquidity for small and medium-sized banks. This result is consistent with recent empirical evidence indicating that banks tightened their lending standards (Lown and Morgan, 2006, Berrospide and Edge, 2010) and reduced the availability of credit lines as more and more firms breached financial covenants associated with their credit

facilities (Sufi, 2009, and Huang, 2011). In those situations, the decline in unused commitments observed for small and medium-sized banks reflects more the contraction in the supply of loans rather than the liquidity risk associated with sudden take-downs. In general, my findings suggest that, for small and medium-sized banks, the relevant source of liquidity risk is their exposure to securities losses.

Bank liquidity hoarding is not a new phenomenon. For example, in the aftermath of the Great Depression, and particularly during the late 1930s, U.S. commercial banks accumulated substantial amounts of voluntary excess reserves. As Ramos (1996) points out, during and immediately after a severe liquidity crisis, banks hoard excess cash to self-insure against further drains of cash and to send markets a strong message that their solvency is not at risk and that bank runs are not justifiable.[1] The situation during the banking crisis of the 1930s clearly resembles the bank behavior during the most recent financial crisis. As suggested at that time, banks sought to build up liquidity buffers to reduce their risk exposure on the asset side of their balance sheets at times when capital and debt was very expensive.

As previous work suggests, in managing their liquidity, banks take into account the stability of their funding sources such as equity capital and deposits.[2] My findings indicate that bank capital and deposits are important for both large and small banks, though they seem to be more relevant for small banks. This result is consistent with the view that core deposits are a more important source of funding for smaller banks, given that small banks generally have a more restricted access to interbank markets and the central bank's discount window. Furthermore, I find that core deposits represented an important funding source to increase the holdings of cash, fed funds, and MBS of small banks.

Regarding the role of deposits as a stable source of funds that adds to the accumulation of liquid buffers, I find supporting evidence of a flight-to-quality effect in deposits within the banking sector. My findings suggest that non-core deposits flew out of banks and returned in the form of core deposits, first to hoarding banks and later on to non-hoarding banks. Therefore, I provide evidence of inflows of core deposits at the onset of the crisis to banks that chose to hoard

[1] During the 1930s banks were required to increase the level of reserves as a fraction of their deposits. The argument in Ramos (1996) is that banks responded by accumulating large amounts of voluntary reserves, that is, reserves beyond the policy requirement.

[2] Berger and Bouwman (2009) show that bank capital is a key determinant for liquidity creation. They also present evidence that liquidity creation varies by bank size. Consistent with these findings, my results show that capital played a significant role in the increased holdings of liquid assets during the financial crisis.

liquidity. During the first year of the crisis, banks highly exposed to securities losses sought to hoard liquid assets as a war chest against future losses. They also managed to attract core deposit flows by raising their deposit rates. As the crisis deepened during the fall of 2008, exposed banks lost confidence and saw their core deposits flow into less exposed banks (non-hoarders of liquidity). In line with earlier effects of disruptions in interbank markets, my results suggest that the same factors leading to precautionary liquidity hoarding also contributed to the sharp decline in bank lending. I find that for liquidity-hoarding banks, about one-fourth of the lending contraction is due to the precautionary motive.

The results presented here also have important policy implications. As the recent financial crisis demonstrates, liquidity hoarding affects the normal functioning of short-term funding markets. Due to increased uncertainty and the fear of prolonged restrictions to accessing interbank loans, banks that choose to hoard liquidity may cause a rise in borrowing costs that has an adverse impact on less liquid banks. Moreover, if liquidity-hoarding banks have sufficient market power to manipulate asset prices, some form of predatory behavior may arise. Acharya, Gromb, and Yorulmazer (2008) suggest that liquid banks under-provide liquidity so as to benefit from the fire sale of assets from illiquid banks in desperate need of liquid funds. Hence, liquidity hoarding may constrain the effectiveness of monetary policy aimed at restoring the stability of funding markets. Moreover, the considerable fear associated with the riskiness of banks' portfolios further limits the ability of policy actions to revamp credit growth and stimulate the real economy. Finally, the paper also highlights important differences in the distribution of liquid assets across banks depending on their size. Understanding such differences is crucial in the context of a regulatory reform and must be taken into account in the implementation of capital and liquidity requirements (such as the liquidity coverage ratio and the net stable funding ratio) in the context of the new regulatory framework for banking institutions.

The remainder of the paper is organized as follows. Section 2 briefly describes the related literature and discusses how my empirical results compare with previous findings. In Section 3, I document the policy tools used to deal with the financial crisis and the way liquidity hoarding manifested itself in the banking sector. Section 4 provides the empirical results for the determinants and the main implications of bank liquidity hoarding. Section 5 concludes.

2. Related Literature

Several theoretical papers have examined the motivation for banks to hoard liquid assets. For example, banks may decide to hoard liquidity for precautionary reasons if they believe they will be unable to obtain interbank loans when they are affected by temporary liquidity shortages (Allen and Gale, 2004). Precautionary liquidity hoarding has also been modeled as the response of banks to the fear of forced asset liquidation, as in the frameworks of Diamond and Rajan (2009), Gale and Yorulmazer (2011). In Diamond and Rajan (2009) banks hoard liquidity in anticipation of future liquidation of assets which, in the context of severe disruptions in funding markets, provide a high expected return from holding cash. In the model of Gale and Yorulmazer, banks hoard liquidity to protect themselves against future liquidity shocks (precautionary motive) or to take advantage of potential sales (strategic motive). Acharya and Skeie (2011) develop a model in which banks hoard liquidity in anticipation of insolvency of their counterparties in interbank markets (rollover risk).

Another strand of the literature derives liquidity hoarding as a result of Knightian uncertainty—when due to increased uncertainty banks make decisions based on worst-case scenarios (Caballero and Krishnamurthy, 2008)—and contagion in financial networks. For example, Caballero and Simsek (2009) propose a framework in which banks operate in complex network structures. In those market structures, the information that banks normally collect to assess the financial conditions of their trading partners becomes insufficient. To learn more about their counterparty risks, they have to collect information on the health of the trading partners of the trading partners of the trading partners, and so on. During times of financial distress, this process becomes extremely costly. Moreover, the confusion and uncertainty that follows a liquidity shock can trigger massive flight-to-quality episodes, and force illiquid banks to withdraw from loan commitments and illiquid positions. As the flight-to-quality unfolds, the financial crisis spreads.

In a similar vein, Zawadowki (2011) uses the idea of financial contagion in network structures to show that uncertainty in short-term funding markets among interconnected institutions can lead to excessive liquidity hoarding. The author shows that, after a liquidity shock, uncertainty about not being able to roll over interbank loans leads to inefficient liquidation of assets, which causes no default in equilibrium but a significant drop in lending. The novelty in his analysis is that uncertainty is capable of spreading and magnifying the impact

of liquidity shocks through an interbank network. This network works as an interwoven structure in which each bank finances several other banks, so that uncertainty about funding in one bank spreads to more and more banks in the consecutive layers of intermediation.

As shown in what follows, by employing better proxies for liquidity risk and studying the behavior of different categories of liquid assets, my empirical results support the precautionary motive for liquidity hoarding discussed in the theoretical framework described above. Moreover, my results are also consistent with recent empirical findings by Acharya and Merrouche (2010), Heider, Hoerova, and Holthausen (2008), De Haan and Van den End (2011), and Wolman and Ennis (2011). Acharya and Merrouche, using data for large settlement banks in the U.K., showed that banks significantly increased their liquidity buffers after August 2007. This increase in liquid assets occurred when the interbank markets started to dry up and bank borrowing costs ballooned. Heider, Hoerova and Holthausen (2008) also provide evidence of liquidity hoarding in the euro interbank market. Unlike the very small spreads and infinitesimal amounts of excess reserves in normal times, they show that the unsecured euro interbank market exhibited significantly higher spreads leading to a dramatic increase in banks' excess reserves. Using a panel Vector Autoregression (p-VAR) approach, De Haan and Van den End (2011) find that in response to funding liquidity shocks, Dutch banks reduce wholesale lending, hoard liquidity in the form of liquid bonds and central bank reserves, and conduct fire sales of equity securities. Finally, Wolman and Ennis (2011) using data on U.S. commercial banks find that banks holding large excess reserves at the Federal Reserve since the fall of 2008 also increased their holdings of other liquid assets such as short-term securities. Furthermore, their findings indicate that banks holding high levels of liquidity have enough capital to expand their lending without facing binding capital requirements.

3. Liquidity Hoarding During the Financial Crisis

This section reviews the changes to monetary aggregates associated with the quick and aggressive response of the Treasury and the Federal Reserve to the financial crisis through numerous liquidity provision programs, and relates these policy actions to changes in commercial banks' assets.

3.1 Liquidity Programs and the Federal Reserve response to the crisis

In an effort to ease conditions in interbank and credit markets, the Federal Reserve provided a significant amount of liquidity to the banking sector via several new facilities.[3] Figure 1 depicts these lending facilities designed to support the liquidity of financial institutions between 2007 and 2010. Credit extended through lending facilities totaled $1600 billion in 2008 and $250 billion in 2009. Excluding liquidity swaps with other central banks and credit extended to specific institutions such as Bear Stearns and AIG through asset purchases (portfolio holdings of Maiden Lane LLC), the Federal Reserve expanded liquidity by about $600 billion over 2008,[4] with most liquidity extended in the last two quarters of 2008 when financial and economic conditions deteriorated sharply. As a result of this aggressive response to the credit crisis, the Federal Reserve's balance sheet increased from about $1 trillion in the summer of 2007 to about $2.2 trillion by the end of 2009.

As the functioning of financial markets improved, many of the liquidity programs expired or were closed in 2009. The composition of the Federal Reserve's balance sheet continued to shift in the second half of 2009 and early 2010, when the liquidity support to markets took the form of purchases of Treasuries and mortgage-backed securities. The considerable decline in the credit extended through the various liquidity programs was more than offset by the increase in securities holdings.

Combined with an approximately $220 billion capital injection through the Capital Purchase Program (TARP), a total of about $820 billion was provided to the banking industry during 2008 and 2009. Interestingly, most of the funds received by banks resulted in an increase in excess reserves of $765 billion over 2008, and $318 billion in 2009. This information suggests that banks decided to keep the injected funds in the form of reserves at the central bank.

The buildup of excess reserves held at the central bank during the implementation of the liquidity programs provides the first piece of evidence of liquidity hoarding in the United States. Moreover, this evidence is consistent with the argument that injecting more excess reserves into the banking sector does not necessarily lead to more bank lending. As Martin, McAndrews, and

[3] These new facilities include the Money Market Investor Funding Facility (MMIFF), the Asset-Backed Commercial Paper Money Market Mutual Fund Liquidity Facility (AMLF), the Commercial Paper Funding Facility (CPFF), the Primary Dealer Credit Facility (PDCF), the Term Securities Lending Facility (TSLF), and the temporary liquidity swap arrangements between the Federal Reserve and foreign central banks.

[4] This number corresponds to the flow of total borrowing of depository institutions from the Federal Reserve during 2008. Total borrowing from the Federal Reserve is equal to the term auction credit plus other loans. For comparison, as of year-end 2007, the Term auction credit and other loans equaled $40 billion and $5 billion respectively.

Skeie (2011) argue, in the context of interest paid on bank reserves and no binding reserve requirements, excess reserves may end up contracting lending. This is the case when interest rates are very low (almost zero) so that the marginal return on loans is smaller than the opportunity cost of making a loan. The adverse effect on lending is more apparent when banks face increased balance sheet costs associated with agency costs or regulatory requirements for capital or leverage ratios. Using a related argument, Hancock and Passmore (2011) contend that when the cost of capital is high and banks are capital constrained, additional excess reserves impose a tax on the banking sector because they tie up capital for a low profit (or unprofitable) use. As mentioned above, a large accumulation of excess reserves at the central bank after monetary expansions is also found using data for settlement banks in the U.K. and the unsecured euro interbank market. In light of these findings, I then examined the extent to which these liquidity and capital-infusion programs are reflected in aggregate bank balance-sheet conditions.

3.2 Commercial Banks' Balance Sheet data

Figure 2 depicts the changes in the composition of bank assets in 2008 and 2009. By far the most striking change in aggregate commercial bank balance-sheet conditions occurred in the holdings of safe and liquid assets. Holdings of cash and securities (both treasuries and agency) increased $869 billion over 2008 and 2009 ($ 375 billion and $494 billion respectively). Since most of the Federal Reserve's liquidity programs—such as the Term Auction Facility and the Asset-Backed Commercial Paper Money Market Mutual Fund Liquidity Facility (AMLF)—were specifically designed to foster the normal functioning of particular financial markets, it is not entirely surprising that the increase in securities holdings by commercial banks is explained by the liquidity provision of these specific programs. Indeed, the observed expansion of securities holdings may reflect the successful propping up of liquidity in specific short-term funding markets.

The sharp increase in the holdings of liquid assets contrasts with the evolution of bank loans during these years, especially C&I loans which declined $211 billion. In other words, the aggregate bank balance-sheet information and monetary aggregate figures seem to suggest that the majority of the funds that have been injected into banking organizations did not result in additional lending. Instead, banks chose to hoard these liquidity and capital provisions to build

up a cushion to protect against further capital losses and expected write-downs.[5] Another manifestation of the liquidity pressures banks faced during the crisis is the large reduction in trading assets and fed funds sold to non-bank institutions (decline in other assets of $449 billion).

Regarding the liability side of their balance sheets, most of the counterpart changes in liquid assets over 2008 and 2009 were also explained by a significant increase in bank deposits. Despite the slowdown in deposit growth in 2007, banks experienced significant deposit inflows from investors pulling their funds from money market mutual funds, particularly during the fall of 2008 and after the failure of Lehman Brothers and AIG. As will be seen in section 4, the deposit expansion was not uniform across banks and had a significant influence in the decision to hoard liquidity.

4. Empirical Analysis

4.1 Data and Methodology

I construct a panel dataset using quarterly balance sheet data from the Reports of Income and Condition (Call Reports) for all U.S. commercial banks between 2005 and 2010. Data are aggregated at the Bank Holding Company level to deal with common ownership of bank subsidiaries. I compute ratios and growth rates for assets, liabilities, and some off-balance sheet operations such as unused loan commitments. To deal with mergers and acquisitions, I drop bank observations with asset growth greater than 10 percent and winsorize variables at the 1st and 99th percentiles. The remaining sample consists of 106,817 bank-quarter observations for approximately 6,750 institutions.

Liquidity hoarders in this study are defined as banks for which the average ratio of total liquid assets to total assets increased by more than 3 percentage points from a period before the crisis (2005:Q1 to 2007:Q4) to the crisis period (2008:Q1 to 2009:Q2).[6] All other banks are

[5] Banks were lending a very small portion of the funds injected into the sector. Although the Federal Reserve's liquidity programs and the Treasury's TARP capital injections both share the broader objective of preserving financial stability during times of financial turmoil, the direct emphasis of the two policies on bank lending are different. In particular, the TARP's capital purchase program (CPP) was specifically intended for banks to lend the capital received. In contrast, most of the liquidity programs set up by the Federal Reserve were not *directly* aimed at reviving bank lending, although they did—by improving the functioning of specific markets—aim to *ultimately* contribute to greater credit availability for businesses and households. Thus, one might still expect these liquidity programs to reinforce the objectives of TARP and increase somewhat banks' willingness to extend loans.

[6] Although arbitrary, the 3-percentage-point cutoff identifies about one-sixth of the banks in the sample as being liquidity hoarders. I also utilize 2.5 and 3.5 percentage point cutoffs and obtain similar results.

defined as non-hoarders. This definition excludes, for example, banks which for operational purposes are highly liquid before and during the financial crisis. Total liquid assets are calculated as the sum of cash (including balances at other banks and reserves at the central bank), fed funds (including reverse repos), and investment securities (including MBS, asset-backed securities (ABS), and government securities).

Table 1 presents descriptive statistics (means) for both liquidity hoarders and non-hoarders before and during the financial crisis. Liquidity hoarders reduce their lending much more than non-hoarders during the crisis (both bank loan growth and the loan-to-asset ratio are considerably smaller for liquidity hoarders). On average, the annualized growth rate of loans for liquidity hoarders dropped 4.36 percent (from 4.7 percent before the crisis to 0.35 percent during the crisis), more than three times the decline in annual growth of their non-hoarding counterparts (1.4 percent). Furthermore, liquidity hoarders seem to be slightly larger and better capitalized than their non-hoarding counterparts, both before and during the crisis period. Differences in almost all variables across groups before the crisis and during the crisis are statistically significant at the 1 percent level.

Figure 3 presents the evolution of the ratio of total liquid assets to total assets for the average commercial bank in the U.S. between 2005 and 2010, as well as the share of some of its components: cash and fed funds, government securities (including Treasuries), and agency MBS (MBS issued or guaranteed by GSEs, which investors perceive as having an implicit government guarantee). The striking insight from Figure 3 is the remarkable gap in the behavior of liquid assets across asset categories between liquidity-hoarding banks and their non-hoarding counterparts. Such disparity confirms that the disposition to hold liquid assets is not uniform across banks or across asset categories, and highlights the advantage of exploiting bank-level variation to study the nature of liquidity hoarding. The difference in the liquid assets ratio across the two groups of banks widens considerably (from 10 to 12 percentage points) between 2008:Q3 and 2009:Q1, precisely the period when the financial crisis intensified.

In October 2008, after the failure of Lehman Brothers, the conservatorship of Fannie Mae and Freddie Mac, and the AIG bailout, a measure of counterparty risk in interbank markets such as the TED spread (difference in yield between LIBOR and a Treasury Bill of similar maturity) moved up to a record level of 430 basis points. Among the liquid asset categories on the balance sheet, banks started hoarding cash (including fed funds) and agency MBS during the crisis. The

holding of government securities, however, declined after the third quarter of 2007, especially for non-hoarding banks. This decline suggests that banks were selling treasuries and other government securities to cope with increased funding pressures. Since asset categories are moving in opposite directions, each must be examined in tandem to understand the nature of liquidity hoarding.

Figure 4 depicts measures of bank risks which provide incentives for liquidity hoarding: securities losses, loan loss reserves, and unused commitments. During the months leading up to the financial crisis, securities losses and loan loss reserves increased significantly, suggesting that they play a key role in driving the holdings of liquid assets. More striking is the considerable gap between liquidity hoarders and their non-hoarding counterparts in loan reserves, which likely stems from differences in expected loan losses. Securities losses were also significant during the months leading to the financial crisis, though they started to decline, most notably for liquidity hoarders, after 2008:Q4.[7] The capital injections and other government measures implemented in response to the financial crisis may provide an explanation for this behavior. There is also a distinctive behavior in the ratio of unused loan commitments between liquidity hoarders and non-hoarders before 2008. Interestingly, liquidity-hoarding banks were facing smaller liquidity risk emanating from draw-downs of committed credit lines compared with their non-hoarding counterparts. After 2008, the drawdown of unused commitments seems to be common for both types of banks.

4.2 Measures of Liquidity Risk

To investigate the causes of liquidity hoarding, I use a regression framework similar to that in Cornett, McNutt, Strahan, and Tehranian (2010). The regression analysis considers the share of liquid assets in total assets as the dependent variable.[8] Potential explanatory variables include the log of total assets (a proxy for bank size), the ratio of tangible common equity capital to tangible assets (TCE),[9] the share of (core) deposits in total assets (a proxy for the role of stable

[7] A positive sign indicates a loss.

[8] The authors use changes normalized by total assets rather than ratios relative to total assets. To be consistent with the charts in figure 1, I report estimates using ratios of liquid assets to total assets. In unreported regressions that use changes instead of ratios, I find qualitatively similar results.

[9] The TCE ratio is a narrow measure of capital that received considerable attention from market participants during the crisis. I preferred this measure to a simple leverage measure—such as the equity-to-assets ratio—because, from an accounting perspective, my proposed measure of liquidity risk (unrealized securities losses) reduces total bank equity capital. Thus, including both equity capital and securities losses as explanatory variables for increased liquid

sources of funding), and the share of unused commitments to lending capacity—unused commitments plus loans—(a proxy for off-balance sheet funding liquidity stemming from loans).

I hypothesize that the precautionary motive to hoard liquidity is better approximated by a liquidity risk measure that captures a bank's exposure to expected losses in their securities portfolio (security write-downs) in anticipation of future liquidation of assets (Diamond and Rajan, 2009). I also propose a measure of credit risk given by the share of loan loss reserves in total loans to control for the possibility that further deterioration in credit quality forces banks to reallocate their assets from risky loans to safe and liquid securities. My proposed risk measures are therefore: the ratio of securities losses (net unrealized gains/losses on available-for-sale securities) to total assets, and the ratio of loan reserves (allowance for loan losses) to total loans. I add these two measures as key explanatory variables in the regression equation of liquid assets.

I use both gross and net (of taxes) measures of unrealized gains (losses) in available-for-sale securities. Net unrealized gains (losses) are obtained directly from the regulatory capital schedule (RC-R) of Call Reports (RCFD-8434), whereas gross unrealized gains (losses) are computed as the difference between the amortized cost and the fair value of available-for-sale securities as reported the in securities schedule (RC-B) of Call Reports. The amortized cost of securities is their book value (acquisition cost) adjusted for the discount or premium paid at purchase. The difference between amortized cost and fair value is the change in market value (write-up or write-down) of the securities still being held on banks' investment portfolios.

My proposed measure of liquidity risk is naturally linked to the fear and uncertainty surrounding the disruptions in short-term funding markets for banks: the repo (collateralized funding) and the interbank markets (uncollateralized funding). In particular, the repo market provided a key source of funds to dealer and commercial banks actively engaged in trading structured products in the months prior to the panic of 2007.

Large institutional investors withdraw their funds from the collective pool of cash by declining to roll over their loan agreements. In normal times, this can be done without causing significant effects on interest rates. However, with deepening concerns about the credit quality of counterparties and the fact that the magnitude of the exposure to subprime-related assets was unknown, investors withdrew their funds e*n masse*. This withdrawal created a huge shortage of

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assets would be redundant. Using tangible common equity capital allows me to still control for the effect of bank capital on liquidity hoarding.

collateral, which forced institutions to sell securities to meet the increased demand for liquidity. As the repo and interbank markets shrunk, the increased sale of securities drove their prices further down. Such deterioration in the value of securities (most of which were being used as collateral in repo transactions) was a natural source of liquidity risk leading to the precautionary hoarding of cash.

Figure 5 depicts the ratio of (unrealized) securities losses to total assets both by type of security (upper panel) and by bank size (lower panel), for the average bank in the sample between 2005 and 2010. Unrealized losses were significant (0.2 percent) across almost all categories of securities before the crisis (with the exception of non-agency MBS). After falling over the second half of 2007, unrealized losses peaked up again during 2008.[10] More striking from the figure is the sharp increase in the losses of non-agency MBS and ABS. Although, they represent a small fraction in banks' securities portfolios, unrealized losses of non-agency MBS and ABS were especially significant for large banks throughout 2008.

As financial strains intensified in the fall of 2008, large banks were more severely hit by securities losses than other bank-size groups. The largest 10 banks held about 45 percent of the available-for-sale securities in investment accounts and accounted for two-thirds of the securities losses during 2008.[11] As the lower panel of Figure 5 shows, securities losses increased from 0.03 percent at the end of 2007 to 0.67 percent by year-end 2008. More importantly, the figure shows that securities losses were a widespread problem for all banks, and that medium and small banks were not immune.

As Acharya and Merrouche (2010) argue, the drying up of short-term liquidity markets caused a significant increase in borrowing rates for all banks, regardless of counterparty risk. The spike in funding costs suggests an interest rate contagion channel through the interbank markets, which is well described by rate spreads such as the TED spread (3-month LIBOR rate minus 3-month Treasury rate) or the LIBOR-OIS spread (LIBOR rate over the corresponding overnight index swap rate). As in Cornett, McNutt, Strahan, and Tehranian (2010), I include interaction terms of the TED spread with the key explanatory variables as the main focus of the analysis.

[10] Part of the decline towards the end of 2007 may be explained by some reclassification of certain types of securities out of investment accounts and into trading accounts. This shift occurred after some banks, mainly large institutions, adopted new rules on fair value accounting (e.g. FAS 159 on fair value option). Banks that elected the fair value option had incentives to reclassify their securities, as unrealized losses on those securities were not reported in current earnings.

[11] See Profits and Balance Sheet Developments at U.S. Commercial Banks in 2008, Federal Reserve Bulletin 2009.

4.3 Econometric Results

In contrast to Cornett, McNutt, Strahan, and Tehranian and as suggested by Figure 3, I investigate the main determinants of liquidity hoarding for different asset categories.[12] My regression estimates are shown in columns 2 through 4 of table 2. My main findings are: (1) as documented in prior work, stable sources of funding such as deposits and capital are key determinants of liquidity hoarding across all liquidity measures. During times of financial distress (when the TED spread widens) higher capital and more deposits contribute to liquidity hoarding; (2) Although table 1 suggests that liquidity hoarders appear to be slightly larger than non-hoarders, the regression results do not support the hypothesis that larger banks hoard more liquid assets. On the contrary the results indicate that the holdings of liquid assets decrease with bank size;[13] (3) There is not a significant role for off-balance sheet liquidity risk stemming from the possibility of increased take-down demand for committed loans.

The third point may be surprising given that Cornett, McNutt, Strahan, and Tehranian find that large unused commitments are a key source of (off-balance sheet) liquidity risk for commercial banks. Table 2 provides the explanation for this discrepancy. Column 1 in table 2 is included as a reference because it replicates the findings of Cornett, McNutt, Strahan, and Tehranian (2010), who examined an overall measure of liquid assets to total assets. As can be seen, unused commitments appear to be a significant determinant of increased holdings of the overall liquid asset ratio.[14]

When looking at each individual component of the overall liquid asset ratio such as cash and fed funds, government securities, and agency MBS (columns 2 through 4, respectively) my

[12] My definition of liquid assets includes mortgage-backed securities. Cornett, McNutt, Strahan, and Tehranian considered that all MBS and ABS became illiquid during the crisis, and therefore dropped them from their definition of liquid assets. Their rationale was that these securities would be held due to their inability to be sold or used as collateral in rolling over short-term funding after the collapse of the market for securitized assets. However, most of these securitized assets are comprised of agency MBS. With and implicit government guarantee, it is not entirely clear that the majority of these securities should be excluded and considered illiquid as their market value was not really impaired during the collapse of the funding and securitization markets. In fact, most of the securities losses in banks' balance sheets result from the write downs of ABS and non-agency MBS. As shown in figure 1, agency MBS represents a large fraction of the liquid assets that banks were hoarding.

[13] This result is somewhat in line with Ashcraft, McAndrews, and Skeie (2010), who find that small banks hold larger amounts of cash and excess reserves with the Federal Reserve than larger banks.

[14] Cornett, McNutt, Strahan and Tehranian suggest a positive expected sign for loan commitments (as results in column 1 of table 1 show), but acknowledge the difficulty in establishing ex-ante the sign of this variable. As they argue, banks with greater unused commitments may be exposed to liquidity risk, but also experience greater increase in loan demand during the crisis.

results suggest a different story. Column 2 shows that unused commitments are not significant to explain a common form of liquidity hoarding: bank excess reserves in the form of cash, fed funds, and securities purchased under agreements to resell (reverse repos). Moreover, columns 3 and 4 indicate that having unused commitments seem to increase the holdings of government securities and to reduce the holdings of agency MBS. These two last results seem counterfactual if one takes the interpretation that large unused commitments are a source of off-balance sheet liquidity risk. As Figure 3 shows, rather than hoarding government securities during the financial crisis, most banks were selling them; and rather than reducing their holdings of agency MBS, most banks decided to continue holding them. In contrast, my proposed measures of risk: securities losses and loan reserves (and more importantly, their interaction with the TED spread) consistently explain the behavior of each category of liquid assets. Both variables significantly explain the increase in cash plus fed funds and the holdings of agency MBS. They also appear to be significant explanatory variables for the decline in government securities, in agreement with the behavior depicted in Figure 3.

4.4 Liquidity Hoarding and Bank Size

As mentioned above, banks size seems to play a less significant role for liquidity hoarding. To further investigate the role of size, I conducted a regression analysis on each liquid asset category for large banks (assets above $1 billion) and small banks (assets below $1 billion).[15] Results are shown in Table 3. As before, the interactions between the TED spread and the variables that explain each liquid asset category are of particular interest. Stable sources of funds such as capital and deposits are important for both large and small banks, though they seem to be more relevant for small banks. The interaction term of the TED spread and the TCE ratio significantly explains the increased holdings of MBS, as well as cash and fed funds, for small banks. However, only MBS holdings are significantly explained for large banks.

The negative and significant coefficient on the interaction term of the TED spread and core deposits suggests that, during times of financial distress, core deposits substitute for cash and fed funds for large banks. However, this coefficient is positive and significant for small banks, indicating that restricted access to the central bank's discount window and interbank

[15] Regressions were also run across different bank-size splits using both dollar thresholds and distribution quartiles. These produced similar results.

markets may cause small banks to depend more on core deposits. Moreover, this finding is in line with the view that core deposits are generally a more important source of funding for smaller banks than for larger ones. Hence, core deposits represent an important funding source to increase the holdings of cash, fed funds, and MBS of small banks. Small banks also seem to have used core deposits as a substitute for government securities.

Table 3 also reveals that, unused commitments are a key determinant of increased liquid buffers only for large banks.[16] Its interaction with the TED spread is positive and significant for large banks. This finding is consistent with Ivashina and Scharstein (2010), who find evidence that drawdowns of committed revolving facilities from large corporations in syndicated markets (dominated by large banks) helped these firms cope with their need for liquidity, but crowded out new lending to other firms and exposed banks to funding risk. However, for small banks, this interaction term enters the regression with a negative sign for securities holdings and for cash and fed funds. The interaction is positively correlated with the holdings of government securities (at times when banks were selling them) and negatively correlated with the holdings of agency MBS (at times when banks were accumulating them). In contrast, the interaction between securities losses and the TED spread significantly explains the behavior of each asset category for small banks, but only securities holdings for large banks (though the evidence on government securities is weak).[17] Another key insight from Table 3 is that loan reserves only worked as a key driver of liquidity hording for small banks.

These results show that liquidity hoarding occurred across all banking institutions regardless of their size. Both large and small banks were highly exposed to securities losses and had the desire to hoard their cash reserves in anticipation of further write-downs. Moreover, funding risk from unused commitments was not a driving force of liquidity hoarding for small banks.

[16] The number of large banks (total assets above $1 billion) in the sample ranges between 528 before the financial crisis to 595 after the crisis. The majority of banks are small (total assets below $1 billion) and their number ranges between 6320 before the crisis to 6050 after the crisis.

[17] Another source of liquidity risk that could be captured by the proxy for liquidity risk, especially for large banks, is the liquidity backstops and other forms of liquidity support to their conduits or Structured Investment Vehicles (SIVs) used in loan securitizations. When the market for asset-back commercial paper dried up, collateral values of even the safest (AAA-rated) tranches of securitized products dropped abruptly, forcing banks to either bring the underlying assets back to their balance sheets or to provide the committed support to their conduits. Their need for liquidity then rose dramatically (Allen and Carletti, 2008; Brunnermeier, 2009).

A potential explanation for the negative coefficient associated with unused commitment lines is that a reduction in unused credit lines may not necessarily reflect the liquidity risk associated with the sudden use of committed lines. Rather than indicating increased drawdowns of funds from corporations demanding more liquidity, the decline in committed lines may reflect banks' reductions or cancellations of existing credit lines. This interpretation is consistent with documented evidence that during the crisis banks tightened their lending standards, and became more reluctant to renew commitment lines, especially to smaller firms (Sufi, 2009, Huang, 2010).

Bank credit lines are usually tied to financial covenants (for example, restrictions on leverage, earnings, and collateral), which may automatically turn into binding borrowing constraints when breached. As recent evidence shows, banks restrict firm access to their committed lines in response to covenant violations. As expected, these covenant violations become more common during economic downturns. In such context, the decline in unused commitments observed in bank-level data may reflect the contraction in the supply of loans rather than the liquidity risk associated with an increase in firms' loan demand.

It is also worth noting that, in the regression analysis, I compute gross securities losses for different asset categories (government securities, agency MBS, non-agency MBS, and ABS). To deal with potential endogeneity concerns, I include lagged values of gross losses in securities (other than the ones used as dependent variables) in the regression equation of each liquid asset category. For example, securities losses in ABS and MBS holdings are used as explanatory variables in the government securities regression.[18] Therefore, I interpret the explanatory power of securities losses as having a natural causal effect on liquidity hoarding because they are exogenous to all the measures of liquid assets considered here.

4.5 Deposit Growth and Liquidity Hoarding

This section considers the role of deposits as stable funding sources for banks that decided to hoard liquid buffers in light of their exposure to credit and securities losses during the 2007-2009 financial crisis. Previous work has raised concerns on the extent to which banks

[18] Although the valuation losses occurred across all securities, they were significantly larger for ABS and non-agency MBS, in particular for large banks after mid-year 2007. Since I exclude these two classes of securities as liquid assets being hoarded, I use both their holdings and their valuation losses as an alternative measure of exposure that explains banks' desire to hoard liquid buffers. Results that use these two exposure measures as explanatory variables are qualitatively similar, especially for large banks.

facing heightened liquidity risk are able to meet the increased borrowing demand from corporations shut out of the commercial paper market. As argued by Diamond and Rajan (2001) and empirically documented by Gatev and Strahan (2006) and Gatev, Schuermann, and Strahan (2009), commercial banks can cope with higher loan demand in the form of drawdowns of unused corporate credit lines as long as they are perceived as less risky and receive deposit inflows from institutional investors pulling their funds from securities markets (e.g. the commercial paper market).

Figure 6 depicts deposit flows of U.S. commercial banks between 2005 and 2010, and reveals a distinctive behavior of core and non-core deposits during two sub-periods of the financial crisis. [19] The growth rate of core deposits increased during the crisis, whereas the growth of non-core deposits contracted significantly (by almost fifty percent). Such behavior suggests a flight-to-quality effect in deposit flows. The upper panel of the figure shows that deposit growth, mainly non-core deposits, decreased remarkably over the second half of 2007. The sharp contraction in non-core deposits began immediately after the interbank markets—especially, the asset-backed commercial paper (ABCP) market—dried up. Furthermore, this sharp contraction continued through the first half of 2008, despite the significant decline in short-term interest rates that followed the reduction of the target federal funds rate from 5-1/4 percent in September 2007 to 2 percent by the spring of 2008. Deposit growth recovered months later, more notably during the fall of 2008. Intensifying turbulence in financial markets—in particular after the failure of Lehman Brothers and AIG—caused significant outflows from money market mutual funds and contributed to the strong expansion of bank deposits. Favored by the raise in the deposit insurance limit from $100,000 to $250,000 and the implementation of the Temporary Liquidity Guarantee Program (TLGP) in October 2008, transaction deposits grew considerably (about one-fifth) in 2008.

The lower panel of Figure 6 shows the growth rate of core and non-core deposits by liquidity-hoarding banks and their non-hoarding counterparts. Before the crisis, the growth rates of both core and non-core deposits were lower for liquidity hoarders (red line). This situation reverses during the first year of the financial crisis for core deposits. Deposits increased significantly as liquidity fled other markets and is mainly explained by flows to liquidity-

[19] Core deposits include transaction deposits, savings deposits, and small time deposits (less than $100,000). Non-core deposits include large time deposits ($100,000 or more) and foreign deposits.

hoarding banks. Non-hoarding banks seemed to attract core deposits at a slower pace. However, as the crisis deepened during the fall of 2008, liquidity hoarders saw a sharp contraction in their core deposits, whereas non-hoarding banks continued to receive such deposits. One interpretation for such different behavior between liquidity hoarders and non-hoarders, which I explore below, is that banks highly exposed to credit and securities losses managed to attract deposits at the beginning of the crisis (during the first year) by raising their deposit rates. At the height of the crisis, however, these banks lost confidence and were perceived by depositors as more risky institutions as some of their losses started to materialize. Less exposed banks (non-hoarders of liquidity) faced lower risks and managed to continue receiving core deposits. In contrast to the surge in core deposits, non-core deposits decreased sharply for both hoarders and non-hoarders at about the same pace.

Taken together, these findings suggest a flight-to-quality effect from non-core to core deposits. Non-core deposits flew out of both types of banks at similar rates, and returned in the form of core deposits to liquidity hoarders at first, and to non-hoarders at the peak of the crisis. More importantly, this flight-to-quality seems to have occurred within the banking sector, and, therefore, complements the flight-to-quality effect documented by Gatev and Strahan (2006).

4.5.1 Deposit rates and Liquidity Hoarding

To examine whether banks exposed to liquidity risk made efforts to attract deposit flows by raising their rates, I ran regressions on the determinants of bank deposit rates. Deposit rates are calculated from Call Reports using the interest expenses on different types of deposits (e.g. total, core, and non-core).

A similar analysis is conducted by Acharya and Mora (2011). They also find that banks hit by a funding squeeze attempted to attract deposits by raising their deposit rates. I follow a similar approach; consistent with deposit flows in Figure 6, I control for the two distinctive sub-periods during the crisis. I use the dummy variable *crisis1* to identify the first crisis year, from 2007:Q3 to 2008:Q2, and the dummy variable *crisis2* to identify the second crisis year, from 2008:Q3 to 2009:Q2. I also use interactions of the determinants of deposit rates with these two dummy variables. To depart from their analysis, I consider my proposed measures of risk

consistent with the precautionary motive of liquidity hoarding. [20] In particular, I am interested in testing the hypothesis that banks raised their deposit rates in response to large expected losses in their securities holdings.

Table 5 presents the regression results for the relationship between deposit rates and liquidity risk measures. The first three columns refer to interest rates on all deposits, core deposits, and non-core deposits, respectively. Columns 4 and 5 present the coefficient estimates for large and small banks. A salient result across all the specifications, in line with my finding on the determinants of liquidity hoarding, is that the two interaction terms between the ratio of unused commitments and the crisis dummies are significant and enter the regression with a negative sign. This negative coefficient suggest that banks facing off-balance sheet liquidity risk—due to potential sudden drawdowns of committed credit lines—paid lower deposit rates during the entire crisis period. In other words, large unused commitments did not represent a significant source of liquidity risk during the crisis for the majority of banks so as to create incentives to attract deposits and hoard liquidity. My estimates suggest that a 10 percentage-point increase in the unused commitment ratio would lead banks to reduce deposit rates by 3 basis points.

The positive coefficient on the interaction of my preferred measure of liquidity risk with *crisis1* in columns 1 and 2, suggests that banks exposed to securities losses sought to attract deposits, mainly core deposits, by raising their rates during the first year of the crisis. This result is in line with the core deposit flows in Figure 6and indicates that a 30 percentage-point increase in securities losses is associated with 0.6 basis point increase in deposit rates. The negative coefficient on the interaction of securities losses with *crisis2,* also consistent with deposit outflows in Figure 6, suggests that larger expected losses during the second half of 2008 forced banks to lower their rates, and contributed to the reduction in deposits. Interestingly, and to add support to my previous findings, the last two columns indicate that expected securities losses forced large banks to reduce their deposit rates even during the first year of the crisis. Small

[20] In addition to the liquidity risk measures in Cornett, McNutt, Strahan, and Tehranian (2010) (unused commitment ratio, capital ratios, and size (large bank indicator)), Acharya and Mora (2011) include a liquidity ratio, a wholesale funding ratio, and a measure of credit quality given by the non-performing loan ratio, all interacted with the two crisis dummies. My specification also controls for bank dependence on wholesale funding, and includes a different measure of credit quality: loan loss reserves. Unlike non-performing loans, I argue that loan loss reserves contain a forward-looking component intended to capture the precautionary motive. Furthermore, I do not include the liquidity ratio as an explanatory variable for deposit rates. Instead, I consider its main determinants, among which securities losses is the main variable of interest.

banks, however, managed to offer higher deposit rates. As already discussed, securities losses were so much bigger for large banks that the loss exposure could have prevented them from offering higher deposit rates.

The coefficient on loan loss reserves is negative in all specifications, suggesting that loan losses would normally deter banks from raising deposit rates. However, the interaction between loan reserves and the crisis dummies are always positive. This result indicates that, as banks expected to increase provisioning for future credit losses during the financial crisis, they offered higher rates. A 50 percentage-point increase in the ratio of loan losses leads to a 1 basis point increase in bank deposit rates.

The other explanatory variables for deposit rates in Table 6 enter the regression with the expected sign. Columns 1 through 5 show that bigger banks were able to raise deposit rates, though this happened only during the first year of the crisis. Similarly, banks with higher capital ratios offered higher rates on core deposits, especially during the first year of the crisis. The coefficient on the TCE ratio in column 1 suggests that a 10 percentage-point increase in this ratio leads to a 2.8 basis point increase in the core deposit rate. Results by bank size (columns 4 and 5) indicate that the capital ratio is significant only for small banks (and, although not shown, also for medium-sized banks). In general, the TCE ratio is larger for small banks (11 percent on average) than for large banks (8.6 percent on average). Having a higher level of capitalization, smaller banks could have been in a more comfortable position to offer higher rates than larger ones. Finally, banks that depend more on wholesale funds are normally able to offer higher rates, as suggested by the positive coefficient on the wholesale funding ratio. However, during the crisis, reliance on wholesale funding led to lower deposit rates. This result indicates that banks that managed to increase their wholesale funding during the crisis (for example, fed funds or large time deposits) lowered their deposit rates as they faced less funding pressures.

To summarize, during the recent financial turmoil many banking institutions had enormous difficulties accessing short-term debt markets. In those circumstances, it is also likely that within the banking sector—where institutions are more harshly competing for liquid funds—banks perceived as a safe haven for deposits (with large holdings of liquid assets) benefited more than less liquid banks and were able to attract inflows in the form of core deposits by raising their rates. My findings suggest that core deposits added liquidity to banks that wanted to hoard their liquid funds.

4.6 Determinants of the Decision to Hoard Liquid Assets

Since I can identify the quarter when a bank switches from not hoarding to hoarding liquidity, I investigated the determinants of the decision to hoard liquid assets. This was done using a Cox-Proportional Hazard model, which better captures the dynamics in the decision to start hoarding liquidity.[21] In this framework, the dependent variable is a binary variable intended to measure the probability that a bank decides to start hoarding liquid assets at time *t*, conditional on the fact that it did not hoard liquidity as of *t-1*.

Figure 7 shows the number of liquidity-hoarding banks in each quarter of the sample. The number of liquidity hoarders grows steadily from about 200 in 2007:Q3 to about 1200 at the end of the crisis period in 2009:Q2. Notice that the number of liquidity hoarders increases significantly in 2008:Q1 (when almost 330 banks decided to start hoarding liquidity) and in 2009:Q1 (when about 170 additional banks switched to hoard liquid assets). The rise in the number of banks switching to hoarding liquidity during those two dates suggests some clustering that could be the result of common factors affecting the decision to hoard liquidity such as interconnectedness (e.g., contagion within interbank markets, consistent with the notion of network structures).

The bank's decision to start hoarding liquid assets is modeled as a function of its own characteristics, such as size, capitalization, and availability of deposits. These variables are measured at the beginning of each period (previous quarter). I also include quarter fixed effects to capture time-varying characteristics affecting all banks equally. As before, the main variables of interest are the measures of risk: unused commitments, loan loss reserves as a proxy for future losses in bank loan portfolios, and exposure to losses in securities portfolios.

Table 4 presents the estimation results for two specifications. In model 1, exposure to securities losses is measured by the ratio of securities losses (gains) to total assets, and in model 2 this variable is proxied by the share of non-agency securities in total assets. Both bank size and bank capital are significant and negatively correlated with the decision to start hoarding liquid assets, which suggests that smaller and less capitalized banks become liquidity hoarders sooner than large and more capitalized banks. Even after controlling for those time-varying bank-

[21] Unlike a probit model used to estimate the probability that a bank is a liquidity hoarder (the dummy variable describing hoarding banks is time-invariant), in the proportional hazard model the dependent variable varies over time as the deterioration in financial markets continues to cause more and more banks to accumulate liquid assets. In unreported probit regressions, I also find that securities losses and loan reserves have significant explanatory power for the probability of liquidity hoarding.

specific characteristics, I find strong and significant coefficients on my two proxies for liquidity risk (i.e. securities losses and the size of non-agency securities).

The share of loan loss reserves in total loans is also strongly and positively correlated with the decision to start hoarding liquidity. These estimates are consistent with my hypothesis that banks hoard liquid assets in response to future expected losses and write-downs. Moreover, as before, I do not find evidence of a significant role for off-balance sheet liquidity risk stemming from potential take-downs of committed loans in the decision to hoard liquid assets. The coefficient on unused commitments, although positive, is not statistically significant.

4.7 Effect of Liquidity Hoarding on Bank Lending

After establishing the result that banks hoard liquidity in response to increased risks in their asset portfolios, particularly during times of financial stress in short-term funding markets (when the TED spread widens), I next test the effects of liquidity hoarding on bank loan growth. I use the following regression specification for the quarterly growth rate of bank loans:

$$\Delta\%LOAN_{i,t} = \sum_{s=1}^{3} \alpha_s \cdot \Delta\%LOAN_{i,t-s} + \sum_{s=1}^{3} \gamma_s \cdot \Delta\%GDP_{t-s} + \lambda.Liquid_i + \sum_{s=1}^{3} \beta_s \cdot \Delta TED_{t-s} * Liquid_i + \sum_{s=1}^{3} \chi_s \cdot CHG_{i,t-1} + \varepsilon_{i,t}$$

In this specification, economic growth (Δ% GDP) is included to control for changes in loan demand, and the fraction of net charge-offs to total assets (CHG) is a measure of credit quality.[22] *Liquid* is a dummy variable that takes the value of 1 for banks identified as liquidity hoarders and 0 otherwise. As expected, when a bank hoards liquidity it has less funds available to lend, and therefore, the coefficient on *Liquid* should be negative ($\lambda<0$). The effect of changes in the TED spread interacted with *Liquid* is also of particular interest. If the TED spread is an accurate description of the severe stress in interbank and other short-term funding markets, and it causes more liquidity hoarding through the effects on expected losses in banks' asset portfolios, then one would expect a negative impact on lending for banks that hoard liquidity ($\beta_s<0$).

The decision to hoard liquid assets is, of course, endogenous. For example, a bank may decide to hoard liquid assets in response to a lack of lending opportunities. Thus, it is possible

[22] As in Cornet, Mc Nutt, Strahan, and Tehranian (2011), in (unreported) alternative specifications, I find that the sources of liquidity risk (including securities losses) that explain increased holdings of liquid assets also explain the contraction in the loan growth rate during the crisis. I prefer specification (1) as it estimates a loan supply relationship and controls for credit quality and loan demand factors.

that the causality runs from less lending to increased holdings of liquid assets. To address endogeneity concerns, and given that I already model the determinants of the decision to hoard liquid assets (using both a probit model and a proportional hazard model), I also run regression (1) replacing the dummy variable *Liquid* with the predicted values of the decision to hoard liquidity (from a probit model).[23] Furthermore, for robustness I also run regression (1) using continuous measures of liquidity such as the overall liquid assets ratio, and its predicted value.

The estimation results using OLS regressions are reported in Table 6. Panel A shows four different specifications: the first two columns use the dummy variable *Liquid* to identify liquidity-hoarding banks and the last two use its predicted value. Models 1 and 3 include the liquidity hoarding variable only, whereas models 2 and 4 add the interaction term between the changes in the TED spreads and the liquidity hoarding variable. All variables enter the regressions with the expected sign and are statistically significant. For example, the positive and significant coefficient on economic growth suggests that loan growth increases with higher loan demand. The negative and significant coefficient on the charge-off rate suggests that deterioration in borrower quality reduces bank loan growth. The negative coefficients on the propensity to hoard liquidity in model 1 suggest that liquidity-hoarding banks reduce their quarterly loan growth about 1.3 percent more than non-hoarding banks. More importantly, the regression results in model 2 provide evidence that, compared to non-hoarding banks, an increase in the TED spread reduces significantly the loan growth of liquidity-hoarding banks.

The coefficient on the liquidity hoarding measure is negative and significant in model 3 but insignificant in model 4. This latter result seems to be explained by the fact that most of the negative impact of a higher propensity to be a liquidity hoarder on loan growth occurs only when the TED spread widens (the coefficient of the interaction term is three times larger than in the specification that uses the *Liquid* dummy).

Panel B of Table 6 shows the regression estimates that use continuous measures of liquidity. Models 1 and 2 use the overall liquid assets ratio and models 3 and 4 use its predicted value obtained from the regression on the determinants of liquidity hoarding (Table 2, column 1).

[23] Another robustness check I consider to deal with endogeneity is a methodology proposed by Faulkender and Peterson (2011). In this case, regression (1) includes not only the predicted value for the decision to hoard liquidity but also a residual (unexplained) component of liquidity hording given by the difference between the actual dummy *Liquid* and its predicted value. By including these two components, the regression specification controls for the likelihood of being a liquidity hoarder and, conditional on the decision to hoard liquidity, the residual component identifies the effect of liquidity hoarding on loan growth. I obtained similar results using this method.

Interestingly, (lagged values of) these continuous measures of liquidity seem positively associated with the growth rate of loans, indicating than in normal circumstances more liquid banks can expand their lending more. However, the interaction term of the liquid asset ratio and the TED spread is negative and statistically significant, suggesting once again that increased holdings of liquid assets during times of financial distress reduce the growth rate of bank loans. Column 4 shows that the interaction term is negative but statistically insignificant when using the predicted value of the liquid assets ratio. One interpretation for its lack of statistical significance is that the predicted value of an overall liquidity measure may not capture the fact that some of its components moved in opposite directions during the crisis: banks were selling government securities and were simultaneously increasing their holdings of cash and agency MBS.

In short, consistent with previous work documenting the substantial real and financial effects of disruptions in interbank markets, estimates using model 2 indicate that a 10-basis-point increase in the change of the TED spread reduces the annualized growth of bank loans of liquidity hoarders by 1.22 percentage points. Taking into account that banks that hoard liquidity reduced their annualized loan growth by about 4.3 percent, this result suggests an important economic effect: more than one fourth of the reduction in bank lending during the crisis is explained by precautionary liquidity hoarding.

5. Conclusions

This paper studies the main determinants of bank liquidity hoarding during the recent financial crisis. Consistent with theoretical explanations for the precautionary motive of liquidity hoarding, the empirical results show that banks choose to build up liquid buffers in anticipation of future expected losses from securities write-downs.

Compared with previously suggested proxies for banks' liquidity risk—such as the proportion of unused loan commitments to their lending capacity—exposure to securities losses in their investment portfolio represents a more accurate measure of liquidity risk associated with the run in repo markets during the financial crisis. This measure of liquidity risk is consistent with the theory of liquidity hoarding reviewed in the paper and provides supporting evidence for the precautionary motive. I also find evidence that loan loss reserves are another key factor contributing to the increased holdings of liquid assets, especially for small banks. Although not a substitute for cash, and thus less related to liquidity risk, the forward-looking component of loan

loss reserves seems to reflect banks' asset reallocation from loans (which have become riskier due to the reduced creditworthiness of their borrowers) to safe and liquid securities.

The paper also documents an important flight-to-quality effect in deposit flows. Consistent with the view that deposits represent a stable source of funds for bank operations, I find evidence of inflows of core deposits during the financial crisis to banks that chose to hoard liquidity. Furthermore, I find supporting evidence that liquidity hoarding banks raised deposit rates to attract deposits (mainly core deposits) during the first year of the crisis. During the second year of the crisis, deposit rates dropped significantly following the reduction in short-term interest rates. Non-core deposits flew from both liquidity-hoarding and non-hoarding banks, moving into hoarding banks in the form of core deposits. Finally, the paper also finds evidence consistent with previous work documenting the substantial real and financial effects of disruptions in interbank markets. I find that for liquidity-hoarding banks, more than one-fourth of the lending contraction is due to the precautionary motive.

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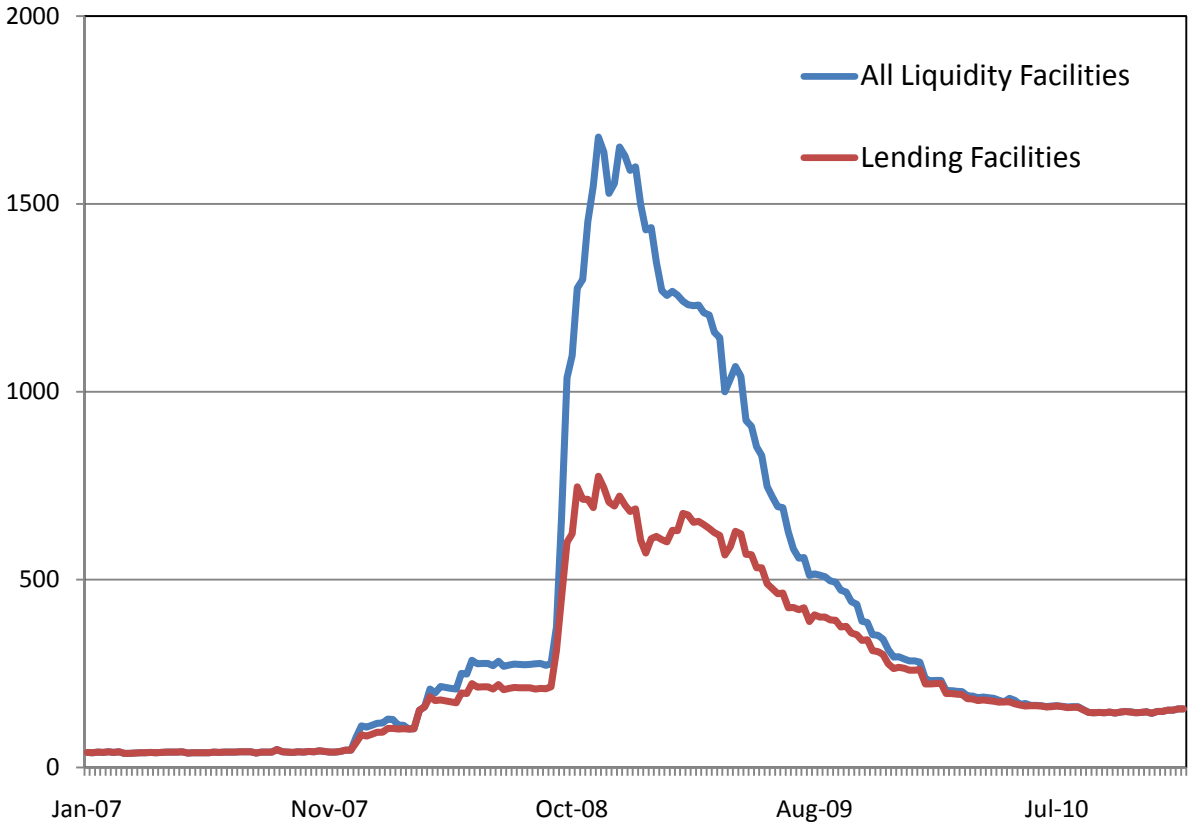
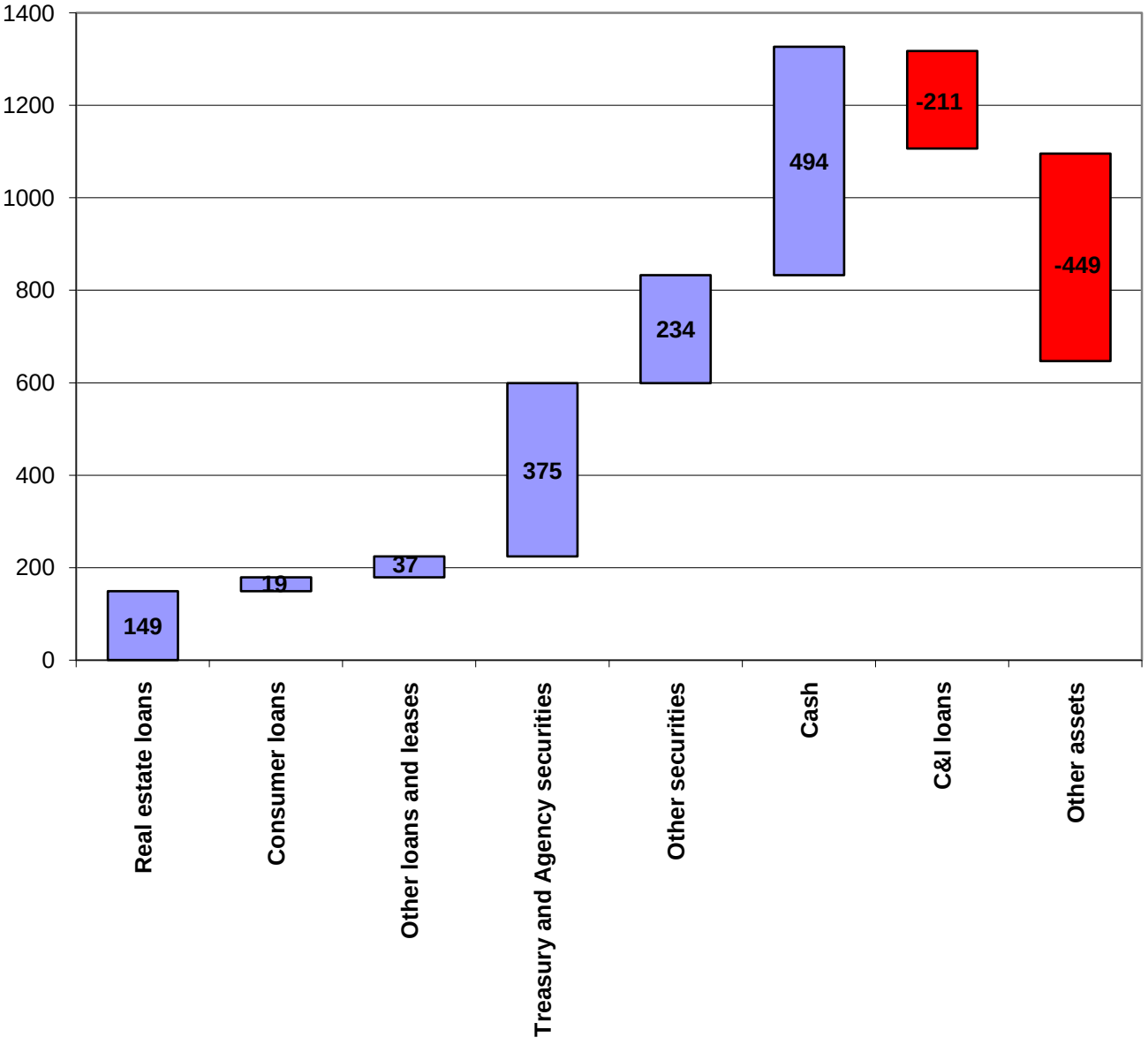
Figure1 : Credit Extended through the Federal Reserve Liquidity Facilities: 2007-2010



Lending Facilities include: the Term Auction Facility (TAF), the Money Market Investor Funding Facility (MMIFF), the Asset-Backed Commercial Paper Money Market Mutual Fund Liquidity Facility (AMLF), the Commercial Paper Funding Facility (CPFF), the Primary Dealer Credit Facility (PDCF), the Term Securities Lending Facility (TSLF), and the Therm ABS Liquidity Facility (TALF).
Source: Federal Reserve Statistical release H.4.1 (Factors Affecting Reserve Balances).

Figure 2: Changes in Commercial Banks Assets in 2008 and 2009 ($ Billion)



Source: Federal Deposit Insurance Corporation (FDIC).

Figure 3: Liquidity Hoarding: US Commercial Banks: 2005 - 2010

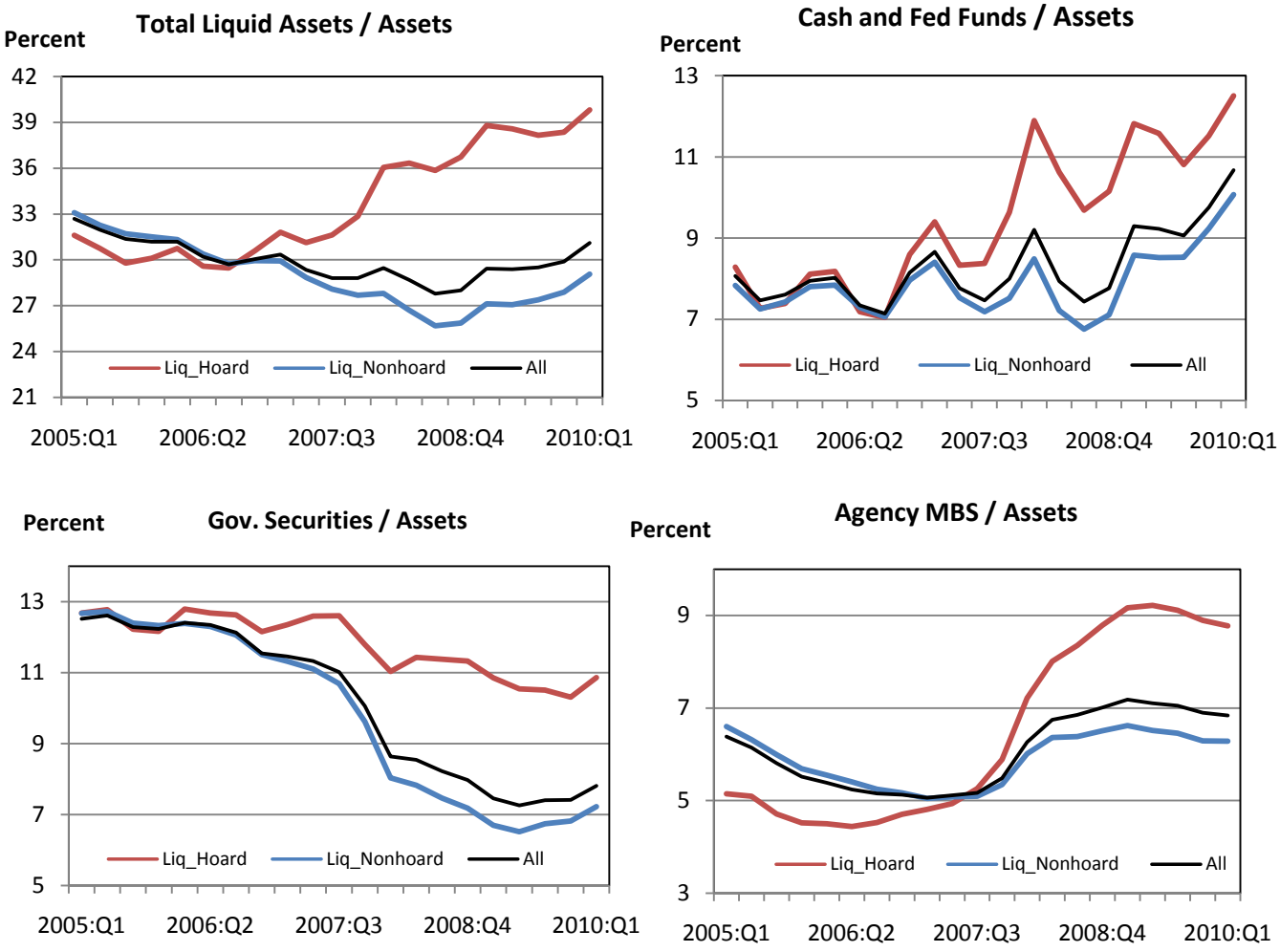


Figure 4: Incentives for Liquidity Hoarding: US Commercial Banks: 2005 - 2010

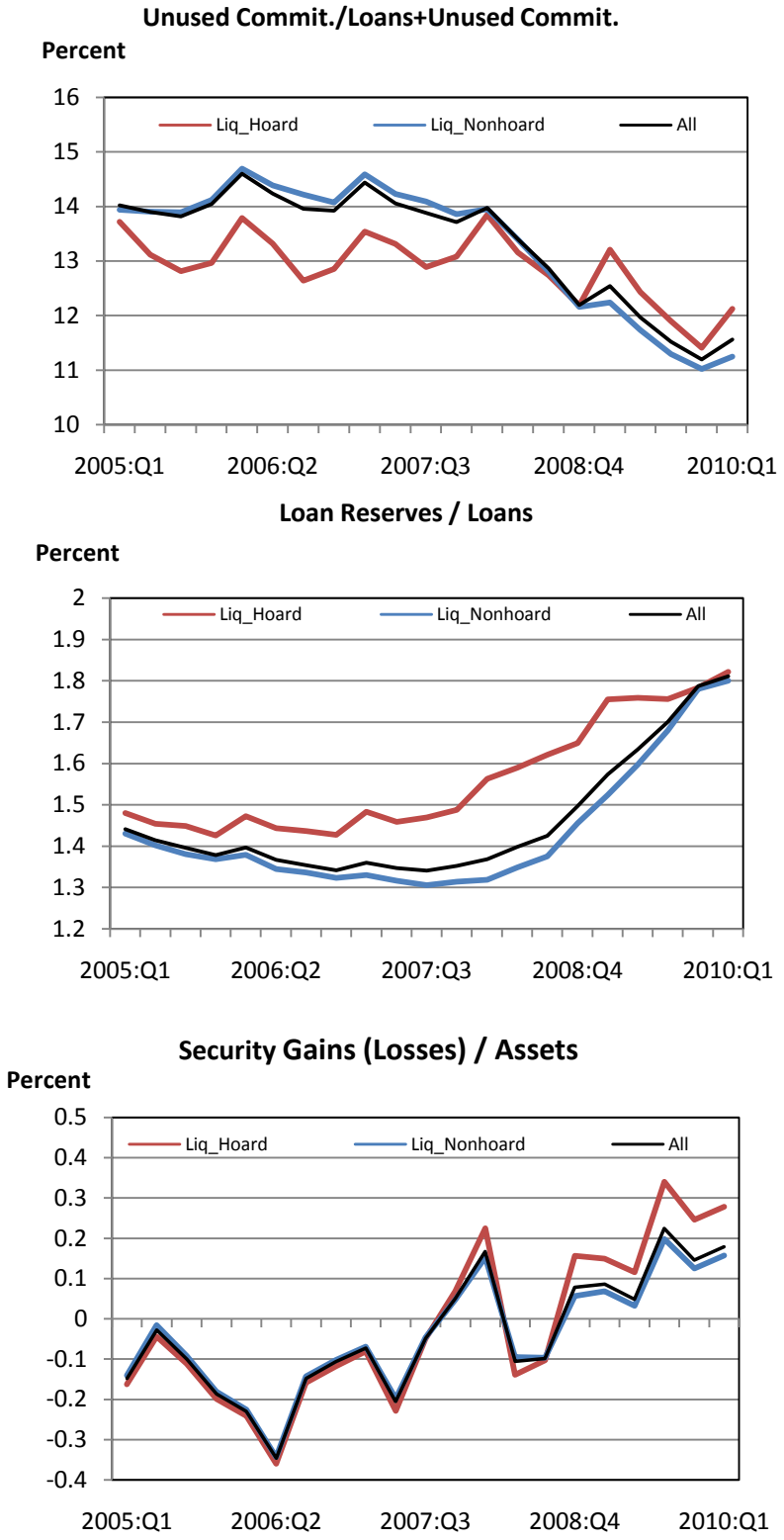
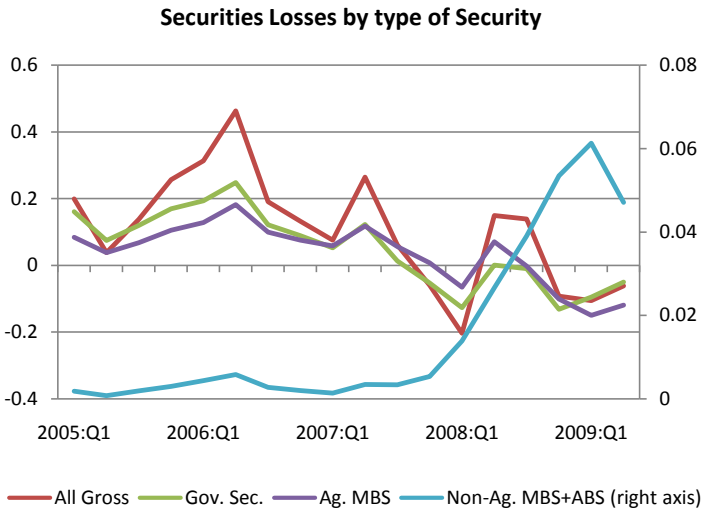
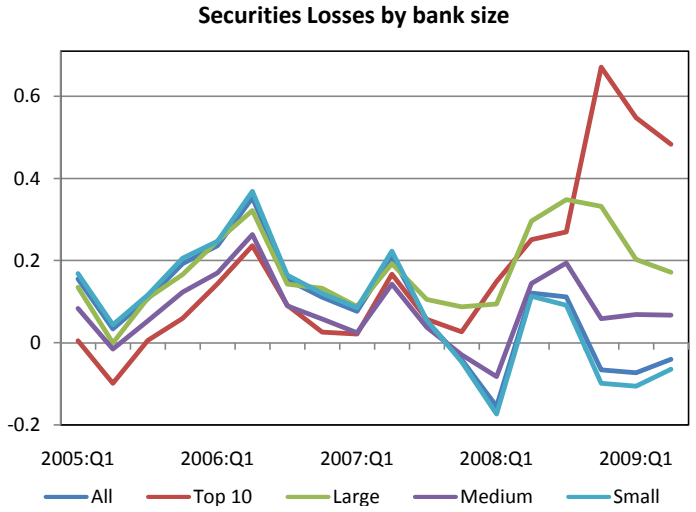


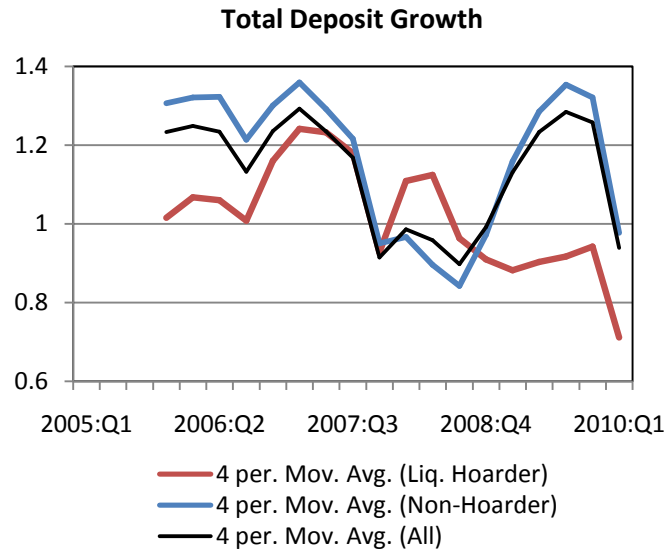
Figure 5: Commercial Banks: Securities Losses / Total Assets, 2005-2010

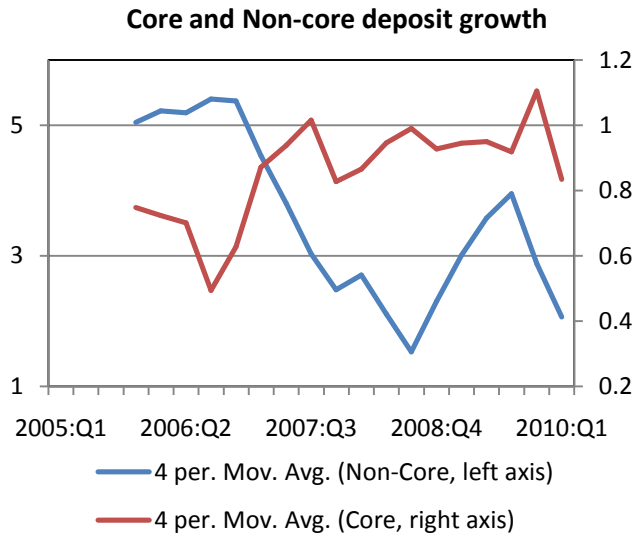


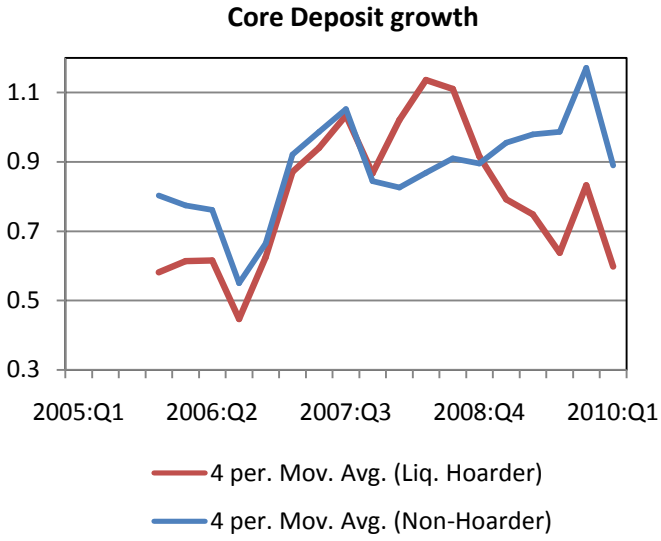


Large banks are ranked 1st to 100th largest by assets, medium banks are ranked 101st to 1000th largest by assets, and small banks are banks not among the 1000th largest by assets.

Figure 6: US Commercial Banks: Deposit Growth 2005 - 2010
(Quarterly growth rates, 4-period Moving Averages)







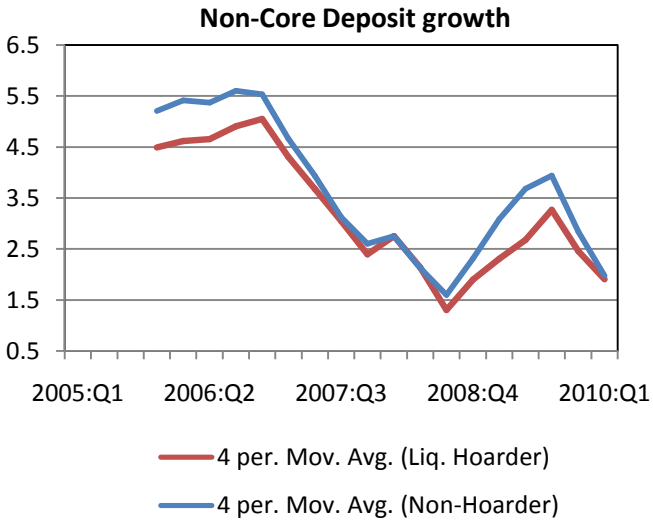


Figure 7: Number of Commercial Banks Hoarding Liquidity - 2007-2009

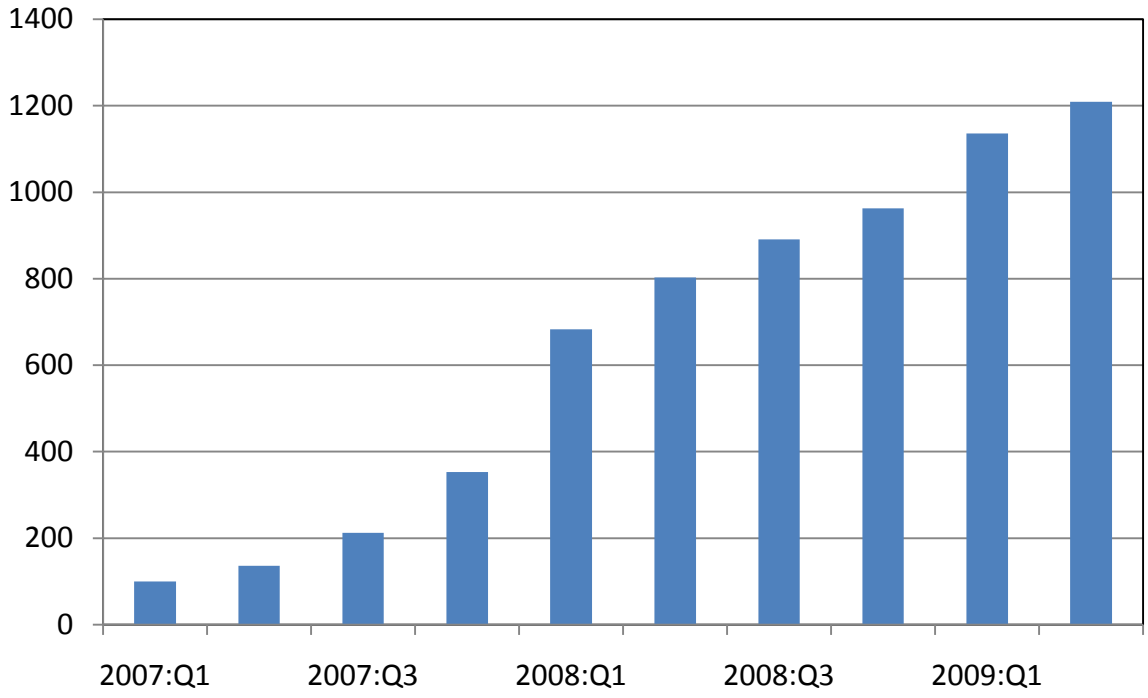


Table 1: U.S. Commercial Banks: Summary Statistics for Liquidity Hoarders and Liquidity Non-hoarders: 2005 – 2009 (Sample means)

		Before Crisis	Crisis
Liquidity	Assets ($ Million)	1463.21	1687.54
Non Hoarder	TCE	0.103	0.104
	Loan growth (% quarter)	2.209	1.856
	Liq. Assets / Assets	0.309	0.271
	Loans / Assets	0.650	68.45
	Unused Commitment ratio	0.142	0.131
	Security Gain (Loss) / Assets	0.153	0.021
	Loan Reserves / Loans	1.360	1.376
	Total Deposit growth	1.337	1.034
	Core Deposit growth	0.839	0.878
	Non-core Deposit growth	5.046	2.792
	Net charge offs / Assets	0.111	0.366
Liquidity	Assets ($ Million)	1748.57	2265.66
Hoarder	TCE	0.107	0.105
	Loan growth (quarter)	1.181	0.088
	Liq. Assets / Assets	30.44	0.352
	Loans / Assets	0.656	0.605
	Commit. / Commit. + Loans	0.131	12.90
	Security Gain (Loss) / Assets	0.170	-0.013
	Loan Reserves / Loans	1.453	1.594
	Total Deposit growth	0.962	0.779
	Core Deposit growth	0.555	0.708
	Non-core Deposit growth	4.365	2.161
	Net charge offs / Assets	0.177	0.399
All Banks	Assets ($ Million)	1525.88	1809.38
	TCE	0.104	0.104
	Loan growth (quarter)	1.983	1.484
	Liq. Assets / Assets	0.308	0.288
	Loans / Assets	0.651	0.668
	Commit. / Commit. + Loans	0.140	0.131
	Security Gain (Loss) / Assets	0.156	0.014
	Loan Reserves / Loans	1.380	1.422
	Total Deposit growth	1.255	0.981
	Core Deposit growth	0.777	0.842
	Non-core Deposit growth	4.897	2.659
	Net charge offs / Assets	0.126	0.373

Table 2: U.S. Commercial Banks: Fixed effect Regressions of Various Liquid Assets

Dependent Variable	Liquid Assets	Cash+ Fed Funds	Gov. Securities	Agency MBS
	Assets	Assets	Assets	Assets
Log Assets t-1	-0.0015	0.0002	-0.0204***	0.0084**
	(0.002)	(0.001)	(0.001)	(0.001)
Log Assets t-1*TED	-0.1964***	-0.1644***	0.0155	-0.0026*
	(0.014)	(0.012)	(0.012)	(0.009)
TCE t-1	0.1264**	0.0785***	-0.0192	-0.0526***
	(0.030)	(0.023)	(0.0187)	(0.012)
TCE t-1* TED	-3.7569***	3.7667***	-7.2271***	2.2610**
	(0.986)	(0.841)	(0.897)	(0.567)
Core Deposits /Assets t-1	0.0612***	0.0128**	0.0557***	-0.130***
	(0.005)	(0.004)	(0.004)	(0.003)
Core Deposits/Assets t-1* TED	1.9388***	2.5402***	-2.5783***	1.1855***
	(0.229)	(0.191)	(0.186)	(0.147)
Unused Commitment ratio t-1	0.0888***	0.0028	0.0414***	0.0318***
	(0.008)	(0.007)	(0.006)	(0.004)
Unused Commitment ratio t-1* TED	0.0352***	-1.2695***	1.8650***	-1.7636***
	(0.505)	(0.403)	(0.375)	(0.253)
Security Gain(Loss)/Assets t-1	-0.0063***	-0.0091***	0.0019**	-0.0065***
	(0.001)	(0.001)	(0.001)	(0.001)
Security Gain(Loss)/Assets t-1* TED	-0.0660	0.5091***	-0.1706***	0.1572***
	(0.086)	(0.084)	(0.058)	(0.057)
Loan Reserves/Loans t-1	0.0180***	0.0061***	0.0090***	0.0016***
	(0.001)	(0.001)	(0.001)	(0.0005)
Loan Reserves/Loans t-1* TED	0.2302***	0.1767***	-0.1917***	0.1170***
	(0.070)	(0.045)	(0.041)	(0.034)
Intercept	0.2378***	0.0503***	0.3226***	-0.0447
	(0.028)	(0.018)	(0.017)	(0.015)
Within R^2	0.08	0.03	0.13	0.05
Firm Dummies	Yes	Yes	Yes	Yes
Quarterly dummies	Yes	Yes	Yes	Yes
Observations	106817	106817	106817	106817

Standard errors are in parentheses. *, **, *** indicate statistical significance at the 10, 5, and 1 percent levels.

Table 3: Fixed effect Regressions of Various Liquid Assets by Bank Size

	Large Banks (Total Assets > $1 Billion)			Small Banks (Total Assets < $1 Billion)		
Dependent Variable	Cash+ Fed Funds Assets	Gov. Securities Assets	Agency MBS Assets	Cash+ Fed Funds Assets	Gov. Securities Assets	Agency MBS Assets
Log Assets t-1	-0.0021	-0.0166***	-0.0031	0.0015	-0.0211***	0.0099***
	(0.004)	(0.003)	(0.002)	(0.002)	(0.002)	(0.001)
Log Assets t-1*TED	0.351	-0.0907***	-0.0917**	-0.2364***	0.0380***	0.0283***
	(0.042)	(0.026)	(0.028)	(0.014)	(0.014)	(0.011)
TCE t-1	-0. 3432***	-0.2710***	-0.1523***	0.0969***	-0.0052	-0.0385***
	(0.081)	(0.055)	(0.042)	(0.024)	(0.0193)	(0.013)
TCE t-1* TED	-0.1740	-0.8760	6.8130***	3.7197***	-7. 5247***	1.6321**
	(4.018)	(2.224)	(1.714)	(0.886)	(0.938)	(0.596)
Core Deposits /Assets t-1	0.0224*	-0.0045	-0.0031	0.0043	0.0634***	-0.0104***
	(0.013)	(0.010)	(0.01)	(0.004)	(0.004)	(0.003)
Core Deposits/Assets t-1* TED	-2.4112***	-0.9226*	2.0625***	3.8685***	-2.9773***	0.7095***
	(0.659)	(0.5200)	(0.471)	(0.209)	(0.224)	(0.171)
Unused Commitment ratio t-1	-0.0514***	0.0333	-0.0228	0.0131*	0.0401***	0.0352***
	(0.019)	(0.022)	(0.015)	(0.004)	(0.006)	(0.004)
Unused Commitment ratio t-1* TED	2.4893**	1.036	-0.7333	-2.8211***	2.2705***	-1.6966***
	(1.107)	(0.647)	(0.617)	(0.422)	(0.443)	(0.289)
Security Gain(Loss)/Assets t-1	-0.0025	-0.0058***	-0.0053***	-0.0091***	0.0027***	-0.0064***
	(0.004)	(0.002)	(0.002)	(0.001)	(0.001)	(0.001)
Security Gain(Loss)/Assets t-1* TED	0.5555	0.0462	0.4200***	0.4532***	-0.1725***	0.1077*
	(0.484)	(0.104)	(0.122)	(0.065)	(0.067)	(0.062)
Loan Reserves/Loans t-1	0.0103***	-0.0001	0.0019	0.0056***	0.0098***	0.0014***
	(0.002)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)
Loan Reserves/Loans t-1* TED	-0.0109	-0.0012	0.0685	0.1772***	-0.1920***	0.1362***
	(0.126)	(0.1245)	(0.085)	(0.047)	(0.044)	(0.038)
Within R^2	0.08	0.16	0.02	0.04	0.13	0.05
Firm Dummies	Yes	Yes	Yes	Yes	Yes	Yes
Quarterly dummies	Yes	Yes	Yes	Yes	Yes	Yes
Observations	8118	8118	8118	98699	98699	98699

Standard errors are in parentheses. *, **, *** indicate statistical significance at the 10, 5, and 1 percent levels.

Table 4: Cox Hazard Model: Determinants of the decision to be Liquidity Hoarder

	Model 1	Model 2
Log Assets t-1	-0.247***	-0.257***
	(0.030)	(0.030)
TCE t-1	-4.020***	-3.555***
	(0.866)	(0.883)
Core Deposits /Assets t-1	1.147***	1.102***
	(0.317)	(0.315)
Unused Commitment ratio t-1	0.343	0.375
	(0.406)	(0.402)
Loan Reserves/Loans t-1	0.171***	0.169***
	(0.021)	(0.022)
Security Gain(Loss)/Assets t-1	0.242*	
	(0.137)	
Non-Ag MBS/Assets t-1		7.083***
		(1.602)
Observations	53520	53143
Quarterly Dummies	Yes	Yes

Standard errors are in parentheses. *, **, *** indicate statistical significance at the 10, 5, and 1 percent levels.

Table 5: Deposit Interest rates and Measures of Liquidity Risk

	Total Deposits (1)	Core Deposits (2)	Non-Core Deposits (3)	Total Deposits Large Banks (4)	Total Deposits Small Banks (5)
Log Assets t-1	0.350***	0.334***	0.397***	0.167***	0.383***
	(0.009)	(0.009)	(0.013)	(0.035)	(0.009)
Log Assets t-1*Crisis1	0.009***	0.007***	0.013***	0.003***	0.010***
	(0.0004)	(0.0004)	(0.001)	(0.001)	(0.0003)
Log Assets t-1*Crisis2	-0.010***	-0.011***	-0.010***	-0.013***	-0.010***
	(0.0005)	(0.0005)	(0.001)	(0.002)	(0.0004)
TCE t-1	1.598***	1.447***	2.060***	0.873***	1.776***
	(0.056)	(0.056)	(0.078)	(0.258)	(0.057)
TCE t-1 * Crisis1	0.310***	0.279***	0.389***	-0.042	0.211***
	(0.028)	(0.028)	(0.043)	(0.146)	(0.028)
TCE t-1 * Crisis2	0.167***	0.184***	0.079	-0.1511	0.195***
	(0.032)	(0.031)	(0.048)	(0.200)	(0.033)
Wholesale Funding/Assets t-1	0.544***	0.263***	0.655***	0.142***	0.594***
	(0.013)	(0.019)	(0.019)	(0.037)	(0.013)
Wholesale Funding/Assets t-1* Crisis1	-0.169***	-0.140***	-0.339***	-0.034	-0.199***
	(0.010)	(0.016)	(0.016)	(0.033)	(0.001)
Wholesale Funding/Assets t-1* Crisis2	-0.235***	-0.149***	-0.376***	-0.095**	-0.265***
	(0.012)	(0.017)	(0.017)	(0.043)	(0.012)
Unused Commitment ratio t-1	0.294***	0.275***	0.310***	0.320***	0.298***
	(0.016)	(0.017)	(0.024)	(0.074)	(0.017)
Unused Commitment ratio t-1*Crisis1	-0.305***	-0.294***	-0.287***	-0.228***	-0.287***
	(0.013)	(0.015)	(0.020)	(0.035)	(0.014)
Unused Commitment ratio t-1*Crisis2	-0.400***	-0.359***	-0.398***	-0.374***	-0.417***
	(0.017)	(0.018)	(0.025)	(0.045)	(0.017)
Security Loss/Assets t-1	0.100***	0.090***	0.130***	0.136***	0.101***
	(0.003)	(0.003)	(0.004)	(0.015)	(0.003)
Security Loss/Assets t-1*Crisis1	0.019***	0.021***	0.008	-0.058***	0.023***
	(0.004)	(0.004)	(0.006)	(0.021)	(0.004)
Security Loss/Assets t-1*Crisis2	-0.033***	-0.029***	-0.050***	-0.095***	-0.030***
	(0.004)	(0.003)	(0.005)	(0.016)	(0.004)
Loan Reserves/Loans t-1	-0.016***	-0.015***	-0.018***	-0.074***	-0.014***
	(0.002)	(0.002)	(0.002)	(0.009)	(0.002)
Loan Reserves/Loans t-1*Crisis1	0.019***	0.017***	0.024***	0.055***	0.017***
	(0.001)	(0.001)	(0.002)	(0.008)	(0.001)
Loan Reserves/Loans t-1*Crisis2	0.026***	0.024***	0.030***	0.082***	0.023***
	(0.002)	(0.002)	(0.002)	(0.008)	(0.002)
Within R2	0.41	0.37	0.31	0.40	0.42
Firm Dummies	Yes	Yes	Yes	Yes	Yes
Quarterly dummies	Yes	Yes	Yes	Yes	Yes
Observations	106743	106647	106324	8118	98625

Standard errors are in parentheses. *, **, *** indicate statistical significance at the 10, 5, and 1 percent levels.

Table 6: Effect of liquidity hoarding on bank loan growth

Panel A: Using a dummy variable to identify liquidity hoarders

Dependent Variable	Model 1 Liquid dummy (1)	Model 2 Liquid dummy (2)	Model 3 Liquid_hat (3)	Model 4 Liquid_hat (4)
Sum of lagged loan growth	0.2475***	0.2460***	0.2734***	0.2745 ***
Sum of lagged GDP growth	0.5762***	0.4684***	0.5577***	0.4541***
Sum of lagged Net Chargeoffs/Assets	-0.7887***	-0.7833***	-0.7933***	-0.7846***
Liquid	-0.969***	-0.9765***	-0.7025***	-0.0061
Sum of lagged Δ TED * Liquid		-2.2618***		-6.827***
Sum of lagged Δ TED *(1- Liquid)		0.2321*		1.558***
R^2	0.118	0.120	0.112	0.116
Quarterly dummies	Yes	Yes	Yes	Yes
Observations	99293	99293	105408	105408

*, **, *** indicate statistical significance at the 10, 5, and 1 percent levels.

Panel B: Using a continuous variable to proxy for liquidity hoarding

Dependent Variable	Model 1 Liquid asset ratio (1)	Model 2 Liquid asset ratio (2)	Model 3 Liquid asset ratio_hat (3)	Model 4 Liquid asset ratio_hat (4)
Sum of lagged loan growth	0.2830***	0.2214***	0.2783***	0.2162 ***
Sum of lagged GDP growth	0.5429***	0.4992***	0.5227***	0.3146***
Sum of lagged Net Chargeoffs/Assets	-0.7560***	-0.8177***	-0.8254***	-0.8520***
Lagged Liquid asset	0.8466***	0.7466***	3.8473***	1.1737
Sum of lagged Δ TED * Lagged Liquid asset		-2.398***		-0.5133
R^2	0.112	0.09	0.112	0.09
Quarterly dummies	Yes	Yes	Yes	Yes
Observations	105408	85619	105408	85619

*, **, *** indicate statistical significance at the 10, 5, and 1 percent levels.