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Marcia Milon Cornett
Bentley University

Jamie John McNutt
Southern Illinois University

Philip E. Strahan
Boston College and NBER

Hassan Tehranian
Boston College

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LIQUIDITY RISK MANAGEMENT AND CREDIT SUPPLY IN THE FINANCIAL CRISIS

Marcia Millon Cornett
Bentley University

Jamie John McNutt
Southern Illinois University, Carbondale

Philip E. Strahan
Boston College and NBER

Hassan Tehranian
Boston College

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Abstract

Liquidity dried up during the financial crisis of 2007-2009. Banks that relied more heavily on core deposit and equity capital financing – stable sources of financing – continued to lend relative to other banks. Banks that held more illiquid assets on their balance sheets, in contrast, increased asset liquidity and reduced lending. Off-balance-sheet liquidity risk materialized on the balance sheet and constrained new credit origination as increased take down demand displaced lending capacity. We conclude that efforts to manage the liquidity crisis by banks led to a decline in credit supply.

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LIQUIDITY RISK MANAGEMENT AND CREDIT SUPPLY IN THE FINANCIAL CRISIS

I. INTRODUCTION

During the financial crisis of 2007-2009, the Federal Reserve attempted to stabilize the financial system and foster expansion of loan supply by injecting liquidity into the banking system. This strategy did not lead to expanded credit growth, and thus failed to stimulate the real economy, because banks hoarded cash. The Fed ran into a classic Keynesian liquidity trap, making the traditional tools of monetary policy ineffective. The Fed and Treasury responded with alternative approaches, including direct capital injections into banks, fiscal stimulus (such as the 'cash for clunkers' program), and direct purchase of commercial paper, asset-backed securities, and mortgage-backed securities (quantitative easing).

In this paper, we study how banks managed the liquidity shock that occurred during the financial crisis of 2007-2009 by adjusting their holdings of cash and other liquid assets, and how these efforts to weather the storm affected loan availability. Because the Federal Reserve sets the *aggregate* supply of liquidity in the banking system, focusing only on time-series variation in liquidity merely illustrates choices made by the Fed (that is, the aggregate supply of liquidity). Our strategy instead focuses on within-bank variation in holdings of cash and other liquid assets, which allows us to understand why some banks chose to build up liquidity faster than others during the crisis. This approach helps us understand why the Fed's efforts to stimulate the economy with traditional tools of monetary policy were ineffective.

Our empirical model starts with the premise that banks hold cash and other liquid assets as part of their overall strategy to manage liquidity risk. In modern banks, liquidity risk stems largely from exposure to undrawn loan commitments, the withdrawal of funds from wholesale deposits, and the loss of other sources of short-term financing, rather than from the loss of

demand deposits as in classic models of banking (e.g., Diamond and Dybvig, 1983). Liquidity risk from loan commitments, for example, was evident in aggregate data when the commercial paper markets froze following the September 2008 failure of Lehman Brothers. Issuers responded by taking down funds from commercial paper backup lines issued by banks. Such liquidity risk – 'runs' in wholesale credit markets – was evident throughout the financial crisis. We show that banks more exposed this liquidity risk increased their holding of liquid assets, which in turn reduced their capacity to make new loans.

On the asset side of balance sheets, we find that banks holding assets with low market liquidity expanded their cash buffers during the crisis. Specifically, banks that held more loans, mortgage-backed securities, and asset-backed securities tended to increase holdings of liquid assets and decrease investments in loans and new commitments to lend. Because of concern about the liquidity of loans and securitized assets, these banks rationally protected themselves by hoarding liquidity, to the detriment of their customers and markets. Turning to the right-hand side of the balance sheet, banks with stable sources of financing were less constrained by the crisis and thus were able to continue to lend. Banks using more core deposits (all transactions deposits plus other insured deposits) and more equity capital to finance their assets saw significant increases in lending, relative to banks that relied more on wholesale sources of debt financing. The results hold when we control for aggregate time effects, bank fixed effects, measures of loan demand, as well as the effects of financial structure during 'normal' market conditions. Moreover, the results are consistent across both large and small bank samples, although the economic impact is generally larger for the large-bank sample.

We also test how banks managed shocks to loan demand stemming from pre-existing unused loan commitments (held off the balance sheet). Unused commitments expose banks to

liquidity risk, which became manifest when take-down demand increased following the collapse of Lehman Brothers. We find that banks with higher levels of unused commitments increased their holdings of liquid assets (i.e., their precautionary demand for liquidity increased) and also cut back on new credit origination (measured by summing on-balance-sheet loans with off-balance-sheet loan commitments). Loan commitment draw downs thus displaced new credit origination during the crisis.

Our paper complements the recent empirical analysis of Ivashina and Scharfstein (2010), who use *Dealscan* data to show that new bank lending growth fell *less* at banks funded with deposits and *more* at banks exposed to unused credit lines. We extend their analysis in three ways. First, we show that liquidity-risk exposure is not only *negatively* correlated with loan growth in the crisis, but it is also *positively* correlated with the growth in liquid assets. These parallel results support the interpretation that efforts to build up balance-sheet liquidity displaced funding to support new lending. Second, we have a much larger and richer dataset (Call Reports v. LPC *Dealscan*), which allows us to explore more dimensions of liquidity risk exposure. For example, we show that the market liquidity of bank assets negatively affected their accumulation of liquid assets and positively affected their loan growth. Also, we show that it is core deposits, rather than total deposits, that provided stable funding to banks. Finally, we are able to rule out loan-demand explanations for our results by exploiting geographical exposure and loan-account data available from Call Reports.

In the remainder of the paper, we first provide a simple chronology of the financial crisis. This narrative helps justify our identification strategy based on time variation of the TED spread as a measure of liquidity strains on the banking system. After laying out the drivers of bank

liquidity risk to motivate our empirical model, we describe the data and results in Section III. We end with a short conclusion in Section IV.

II. THE FINANCIAL CRISIS OF 2007-2009

The Financial Crisis of 2007-2009 is the biggest shock to the U.S. and worldwide financial system since the 1930s and offers a unique challenge to both financial institutions' and regulators' understanding of liquidity production and liquidity-risk management. In broad terms, banks and other financial institutions experienced runs from customers, counterparties, and short-term creditors. Figure 1 illustrates the time series of new loan originations to large businesses from Loan Pricing Corporation's *Dealscan* database from 2000 to the end of 2008 (see Ivashina and Scharfstein (2010) for an analysis of syndicated loan originations). During the 2001-2002 recession, both lines of credit and term loans declined as would be expected during a mild recession. But, this earlier decline pales relative to the steep drop in new lending beginning in the middle of 2007.

The roots of the crisis lie in the overvaluation in housing prices and the subsequent crash in those prices beginning early in 2007. The popping of this real estate bubble created large losses to lenders. Kindleberger and Aliber (2005) describe past episodes of asset pricing bubbles, going back several hundred years. They find such bubbles tend to be preceded by loose monetary policy and an over-expansion of credit. The crisis of 2007-2009 supports this understanding of the historical record. Mian and Sufi (2008) show that markets where credit expanded most experienced both the greatest appreciation of housing prices and the worst subsequent crashes. Demyanyk and Van Hemert (2009) provide evidence that underwriting standards eased within each lending cohort from 2000 through 2006, coinciding with the run-up in prices.

Most analysts have blamed the move from the traditional 'buy and hold' to the new 'originate-to-distribute' model of bank lending for the credit expansion, and a few recent studies have offered rigorous evidence consistent with this notion. For example, Keys et al. (2008) show that securitized mortgages had greater ex-post default rates than otherwise similar mortgages retained by lenders. Purnanandam (2009) shows that banks with large pipelines of mortgages that were intended to be sold faced losses when liquidity dried up in the mortgage-backed securities market (i.e., they faced relatively high chargeoff rates on mortgages that would have otherwise been distributed). Loutskina and Strahan (2009) argue that because banks moved en masse toward a diversified lending model, a model facilitated by securitization, banks' investments in private information generation about local credit markets declined, thus setting the stage for over-expansion of credit.

While concern about sub-prime mortgages began somewhat earlier, the crisis really took hold in the summer of 2007. In June and July, two Bear Stearns hedge funds required assistance, and Countrywide, one of the largest sub-prime mortgage originators, announced unexpectedly large losses. In August 2007, the asset-backed securities market dried up when several issuers failed to provide liquidity to support funding of securitized assets financed with short-term commercial paper (Brunnermeier, 2009). Banks had been moving pools of loans off-balance-sheet and into so-called structured investment vehicles (SIVs) financed with short-term commercial paper. This market peaked in 2007 with about $1.2 trillion outstanding, and then declined by about 50 percent in just six months. The funding liquidity risk of these structures, which replaced the old on-balance-sheet model of asset transformation, *did not* leave the banking system because issuers provided liquidity backstops to insure against refinancing risk in the asset-backed commercial paper. The market's faith in these backstop facilities wavered when an

SIV issued by IKB, a small German bank, was unable to refinance its commercial paper, and IKB could not meet its obligation to re-finance the SIV through its line of credit. The asset-backed securitization market collapsed, leading to balance sheet stress for large issuers such as HSBC and Citigroup, who had to take large pools of these assets back onto their balance sheets.

In response to the decline in asset values and an increase in concerns about bank solvency, the interbank market began to freeze. The cost of borrowing at maturities beyond overnight rose especially sharply. In August of 2007, the TED spread (the difference between the 3-month LIBOR rate and the 3-month Treasury rate) rose from about 50 to 100 basis points and continued to rise through mid-December of that year. The TED spread is an indicator of perceived credit risk in the general economy. This is because T-bills are considered risk-free, while LIBOR reflects the credit risk of lending to commercial banks. An increase in the TED spread indicates that lenders believe the risk of default on interbank loans (i.e., counterparty risk) is increasing. We plot the time-series variation of the TED spread from the beginning of 2006 to the end of the second quarter of 2009 in Figure 2. (Figure 2 also shows (in the shaded area) the period we designate as the 'crisis period' in our robustness test below.) The Federal Reserve reacted to this illiquidity by creating the Term Auction Facility (TAF) to sell a fixed quantity of three-month (and later, longer term) credit in a competitive auction. These auctions reduced borrowing costs temporarily, with spreads falling in January and February of 2008 (McAndrews et al., 2008).

Then in March 2008, concerns about the value of Bear Stearns' large portfolio of sub-prime mortgage-backed securities led to a run by many of their counterparties, short-term creditors, and large customers (e.g., hedge funds). This again stressed the interbank lending market and TED spreads again increased to above 200 basis points (see Figure 2). The Federal

Reserve stepped in, brokered a rescue of Bear Stearns by J.P. Morgan, and guaranteed most of the losses on Bear's troubled portfolio of sub-prime assets. The Fed then launched the Term Securities Lending Facility and the Primary Dealer Credit Facility, essentially opening up its discount window to the remaining large Wall Street investment banks. With these three creative new lending facilities, the Fed began its role as lender of last resort on a massive scale, stepping in to supply liquidity that had ceased to flow in the interbank credit markets.

Conditions improved following the bailout of Bear Stearns. The cost of funds to banks fell, as did TED spreads (see Figure 2). In the summer of 2008, however, mortgage foreclosures continued to rise, leading to further downgrades of mortgage-backed securities by the credit rating agencies and the acceleration of losses to holders of those securities. In July, Congress passed stop-gap legislation, formalizing its previously implicit guarantee of debt issued by Fannie Mae and Freddie Mac. Despite the debt guarantee, the razor-thin capital ratios of these two government-sponsored enterprises (GSEs) were overwhelmed by credit losses, forcing the Treasury to take both into conservatorship by early September. Similar losses accrued to other financial institutions with exposure to mortgages and mortgage-backed securities.

These losses on mortgages and mortgage-backed securities eventually led to the failure of several financial institutions, most notably during the week of September 15, 2008, in which both AIG and Lehman Brothers failed. Indeed, the depth of the crisis dramatically expanded when financial markets were shocked by the collapse of these two institutions. While AIG was bailed out by the U.S. government, Lehman Brothers was allowed to fail. Reserve Primary Fund, a large and reputedly conservative money market fund, had holdings of $785 million in commercial paper issued by Lehman. As a result of Lehman's failure, shares in Reserve Primary

Fund 'broke the buck' (i.e., fell below $1), meaning that its investors lost principal.[1] This fund had built a reputation for safe investment. Hence its exposure to Lehman scared investors, leading to a broad run on money market mutual funds.[2] Within a few days more than $200 billion had flowed out of these funds (Krishamurthy, 2008). The U.S. Treasury stopped the run by extending government insurance to all money market mutual fund accounts on a temporary basis. Nevertheless, the panic soon spread globally, leading to the expansion of insurance on deposits and interbank funds, first in Europe and then very quickly in the United States. Public capital was also injected into all of the large banks in an attempt to allay fears about insolvency.

The demise of AIG and Lehman massively increased the demand for funding liquidity across the whole financial system. Non-financial firms also lost access to short-term funds as the commercial paper market dried up. Figure 3 shows the dollar value of commercial paper and bank business loans outstanding from June 2007 through November 2008. Money market mutual funds had typically been a main purchaser of commercial paper. But their appetite for these securities collapsed in the wake of the Lehman failure and the funds replaced commercial paper with Treasury securities. Demand for liquidity from banks by non-financials also increased at the height of the financial crisis as issuers drew funds from pre-arranged backup lines of credit and loan commitments to refinance their commercial paper as it came due, thereby feeding back into banks' demand for cash. This spike in liquidity demands on the banking system can be seen clearly in Figure 3, where the drop in outstanding commercial paper coincides exactly with a spike in business loans on bank balance sheets. As on-balance-sheet loans increased in response to draw downs of off-balance-sheet credit lines, banks responded rationally by ceasing to make

[1] This was the first incidence of a share price dip below a dollar for any money market mutual fund open to the general public.

[2] The *Wall Street Journal* reported that the head of the Reserve Primary Fund had criticized competing money market fund managers for holding assets with credit risk. "Commercial paper is anathema to the concept of the money fund." Mr. Bent told Reuters in 2001 (*Wall Street Journal*, December 8, 2008).

new loans (recall Figure 1). The increase in loans on bank balance sheets, however, turned negative in the last week of October because the Federal Reserve began to purchase commercial paper, both directly from issuers and indirectly from mutual funds and other investors. Notice that the turning point in Figure 3 for commercial paper outstanding corresponds *exactly* with the turning point in bank lending during the week ending October 29, 2008.

Funding liquidity demanded by non-financial firms increased not only because these firms needed a substitute for the absence of market liquidity, but also to meet increased *precautionary* demands for cash. Many non-financial firms drew funds from existing lines of credit simply due to fears about disturbances in the credit markets. Ivashina and Scharfstein (2009) present a table summarizing twenty instances in which large firms drew funds, not to meet direct needs for cash, but in reaction to concerns about debt market access. To take one example, American Electric Power (AEP) drew down $3 billion from an existing credit line issued by J.P. Morgan and Barclays. According to their SEC Filing, "AEP took this proactive step to increase its cash position while there are disruptions in the debt markets. The borrowing provides AEP flexibility and will act as a bridge until the capital markets improve." Given cash demands on banks from existing customers, and given the increased cost of borrowing to banks, it is no surprise that new lending by banks fell precipitously.

III. Empirical Strategy and Results

In this section, we first discuss the determinants of bank liquidity risk and then describe our empirical model, data, and results.

Liquidity Risk Management

Liquidity production is central to all theories of financial intermediation. First, asymmetric information processing allows banks to create liquidity through their asset transformation function (see Diamond and Dybvig, 1983). Second, banks provide liquidity to borrowers in the form of credit lines and to depositors by making funds available on demand. These functions leave banks vulnerable to systemic increases in demand for liquidity from borrowers, and, at the extreme, can result in runs on banks by depositors. In the traditional framework of banking, runs can be prevented, or at least mitigated, by insuring deposits and by requiring banks to issue equity and to hold cash reserves (e.g., Diamond and Dybvig, 1983; Gorton and Pennacchi, 1990). Systemic increases in demand for liquidity from borrowers, in contrast, depend on external market conditions and thus are harder for individual banks to manage internally. For example, when the supply of overall market liquidity falls, borrowers turn to banks *en masse* to draw funds from existing credit lines (Gatev and Strahan, 2006).

Diamond and Rajan (2001b) note that while banks provide liquidity to borrowers, the loans themselves are relatively illiquid assets for banks. Subsequently, when banks require liquidity, they may sell the loans (e.g., sell and securitize mortgages to create mortgage-backed securities) or use the loans as collateral (e.g., mortgages serve as collateral for mortgage-backed bonds issued by the banks).[3] Such sales, however, become more difficult when market liquidity becomes scarce. Thus, Diamond and Rajan (2001b) also note that banks can ration credit if future liquidity needs are likely to be high. Diamond and Rajan (2001a) suggest banks can be fragile because they must provide liquidity to depositors on demand and because they hold illiquid loans. Further, demands by depositors can occur at undesirable times, i.e., when loan payments are uncertain and when there are negative aggregate liquidity shocks. Additionally, Kashyap et al.

[3] See Bhattacharya and Thakor (1993) and Diamond and Rajan (2001b).

(2002) note similarities between some off-balance-sheet (i.e., contingent) assets and on-balance-sheet assets. In particular, an off-balance-sheet loan commitment becomes an on-balance-sheet loan when the borrower chooses to draw on the commitment. Berger and Bouwman (2009a) find that roughly half of the liquidity creation at commercial banks occurs through these off-balance-sheet commitments. Thus, banks stand ready to supply liquidity to both borrowers and insured 'retail' depositors and can enjoy synergies when depositors fund loan commitments. Recent evidence lends supports this notion; Gatev et al. (2009) find deposits effectively hedge liquidity risk inherent in unused loan commitments and the effect is more pronounced during periods of tight liquidity.

The role of bank equity capital also plays a part in the liquidity provision function of commercial banks. Diamond and Rajan (2000) suggest equity capital can act as a buffer to protect depositors in times of distress. However, holding excessive equity capital can reduce liquidity creation and the flow of credit. Indeed, Gorton and Winton (2000) conclude regulators should be especially aware of these effects during recessionary environments, i.e., periods where regulators may want to increase capital standards to reduce the threat of bank failures. Recent evidence suggests bank size can affect which effect dominates. Berger and Bouwman (2009a) find higher capital levels 'crowd out' depositors and decrease liquidity creation at smaller banks, but higher capital levels absorb risk and increase liquidity creation at larger banks.

Banks facilitate their operations with more than retail deposits and equity capital, most notably with uninsured 'wholesale' deposits and subordinated notes and debentures. Researchers and regulators have long been interested in these alternate funding mechanisms and their role in imparting 'market discipline' on bank behavior.[4] For example, Hannan and Hanweck (1988) find

[4] See Flannery (1998) for an overview of the role of market discipline as it relates to regulatory supervision and Flannery (2001) for an overview of the notion of market discipline.

uninsured depositors require higher interest rates at riskier banks and Maechler and McDill (2006) suggest uninsured depositors may not supply liquidity to weak banks at any price. Interestingly, Avery et al. (1988) find little evidence that holders of bank issued subordinated notes and debentures effectively constrain bank risk. However, restrictive covenants have been found to be more common in debt contracts when banks are riskier (see Goyal, 2005; Ashcraft, 2008).

Size also matters. That is, the market's perception of the risk of a bank can depend on the size of the bank. Indeed, the Comptroller of the Currency's statement that some financial institutions are "too-big-to-fail" (TBTF) before Congress on September 19, 1984 was a positive wealth event for banks deemed TBTF (see O'Hara and Shaw, 1990). Further evidence is provided by Black et al. (1997) who observe a 'flight to quality' as evidenced by changes in institutional ownership of TBTF bank equity shares.

Finally, the idea of a 'liquidity trap' occurring during an economic downturn is not novel. That is, the above mentioned supply of liquidity may become unavailable exactly when users of liquidity need cash the most. Although early literature suggests a liquidity trap exacerbated the Great Depression, Brunner and Meltzer (1968) reject these findings. However, the model of Brenner and Meltzer is contingent on the assumptions that banks have the same investment opportunity set during crises and that the monetary authority can stimulate the economy by reducing interest rates—two assumptions clearly violated during the current economic crisis. Further, Stiglitz and Weiss (1981) suggest credit rationing can occur even in sound economic environments.

Empirical specification

The discussion above suggests four key drivers of liquidity risk management for banks: i) the composition of the asset portfolio (i.e., the market liquidity of assets), ii) financial structure (i.e., deposits and capital on the right-hand side of the balance sheet); iii) funding liquidity exposure stemming from loans (i.e., new loan originations via draw downs through loan commitments); and iv) bank size. While size likely does relate to liquidity management, it also proxies for many other factors; hence, we include this variable in all of our regressions but refrain from interpreting its effect. Our empirical strategy takes advantage of the fact that liquidity conditions for banks tightened dramatically during the financial crisis, and the fact that the TED spread provides an accurate and timely signal of the availability of liquidity in the interbank market (recall Figure 2).

We build a quarterly panel dataset from the beginning of 2006 through the second quarter of 2009 that includes all commercial banks as described below. This sample has observations before and during the financial crisis, at least judging by movements in TED spreads. With the panel approach we can sweep out aggregate trends, such as the Fed's expansion of the supply of overall liquidity, as well as bank fixed effects to account for unobserved heterogeneity. Moreover, we control for the 'normal' impact (correlation) of financing structure in our model and focus on the interaction of the TED spread with those variables. To be specific, we estimate the following three regressions:

$$\begin{aligned}\Delta \text{Liquid Assets}_{i,t}/\text{Assets}_{i,t-1} = {} & T^1_t + B^1_i + \beta^1 \text{Illiquid Assets/Assets}_{i,t-1} \\ & + \beta^2 \text{Illiquid Assets/Assets}_{i,t-1} * TED_t + \beta^3 \text{Core Deposits/Assets}_{i,t-1} \\ & + \beta^4 \text{Core Deposits/Assets}_{i,t-1} * TED_t + \beta^5 \text{Capital/Assets}_{i,t-1} + \beta^6 \text{Capital/Assets}_{i,t-1} * TED_t \\ & + \beta^7 \text{Commit/(Commit+Assets)}_{i,t-1} + \beta^8 \text{Commit/(Commit+Assets)}_{i,t-1} * TED_t \\ & + \beta^9 \text{Log Assets}_{i,t-1} + \beta^{10} \text{Log Assets}_{i,t-1} * TED_t + \varepsilon_{i,t} \qquad (1)\end{aligned}$$

$$\Delta Loans_{i,t}/Assets_{i,t-1} = T^2_t + B^2_i + \gamma^1 Illiquid\ Assets_{i,t-1} + \gamma^2 Illiquid\ Assets_{i,t-1} * TED_t + \gamma^3 Core\ Deposits/Assets_{i,t-1} + \gamma^4 Core\ Deposits/Assets_{i,t-1} * TED_t + \gamma^5 Capital/Assets_{i,t-1} + \gamma^6 Capital/Assets_{i,t-1} * TED_t + \gamma^7 Commit/(Commit+Assets)_{i,t-1} + \gamma^8 Commit/(Commit+Assets)_{i,t-1} * TED_t + \gamma^9 Log\ Assets_{i,t-1} + \gamma^{10} Log\ Assets_{i,t-1} * TED_t + \eta_{i,t.} \quad (2)$$

$$\Delta Credit_{i,t}/(Commit+Assets)_{i,t-1} = T^3_t + B^3_i + \lambda^1 Illiquid\ Assets/Assets_{i,t-1} + \lambda^2\ Illiquid\ Assets/Assets_{i,t-1} * TED_t + \lambda^3 Core\ Deposits/Assets_{i,t-1} + \lambda^4 Core\ Deposits/Assets_{i,t-1} * TED_t + \lambda^5 Capital/Assets_{i,t-1} + \lambda^6 Capital/Assets_{i,t-1} * TED_t + \lambda^7 Commit/(Commit+Assets)_{i,t-1} + \lambda^8 Commit/(Commit+Assets)_{i,t-1} * TED_t + \lambda^9 Log\ Assets_{i,t-1} + \lambda^{10} Log\ Assets_{i,t-1} * TED_t + \mu_{i,t.}, \quad (3)$$

where T^1, T^2, and T^3 are quarterly effects that sweep out aggregate shocks and B^1, B^2, and B^3 are bank-level fixed effects that absorb unobserved heterogeneity at the bank level. Since our panel includes only three-and-a-half years, we feel that the assumption that bank effects are fixed over time is reasonable. In constructing standard errors, we consistently cluster errors at the bank level to account for potential serial correlation at the bank level. Also, because we normalize all financing variables by total assets in the three regressions, the coefficients on these variables (i.e., Core Deposits/Assets and Capital/Assets) represent the effect of moving funding from capital (or deposits) to the omitted category (mostly wholesale sources of short-term debt). In other words, these coefficients can only be interpreted relative to the omitted category. We estimate each of these relationships separately for large (>$1 billion in assets) and small (≤ $1 billion in assets) banks. Regression variables are defined and their descriptive statistics are discussed in detail in the next section. Variables are winsorized at the 1st and 99th percentiles.

Regression (1) tests how banks adjust their holding of liquid assets; regression (2) tests how bank lending on the balance sheet adjusts; and regression (3) tests how total credit origination adjusts. Loans on the balance sheet vary both because banks expand new (net) lending and because borrowers draw funds from pre-existing commitments (off-balance-sheet items while undrawn). Hence, take downs of previous commitments, which increased during the

financial crisis after the commercial paper market dried up, may displace lending capacity in the banking system. To take account of these movements from off-balance-sheet to on-balance-sheet items, we construct a variable 'credit' for regression (3), equal to the sum of loans on the balance sheet plus undrawn loan commitments off the balance sheet. Thus, results from this regression reflect increases in bank credit from new originations of both loans and loan commitments.[5] Such an interpretation is not possible by looking only at changes in loans reported on the balance sheet. For this specification, we normalize the dependent variable by total loan commitments plus total assets rather than just total assets.

During the crisis, banks were no longer able to securitize loans, i.e., originate-and-distribute, to the extent they had prior to the crisis. Further, market liquidity for mortgage-backed securities and asset-backed securities became all but non-existent. Accordingly we expect banks that held more of these illiquid assets during the crisis period to increase their holdings of liquid assets and constrain new lending and credit creation. Thus, we expect $\beta^2 > 0$, $\gamma^2 < 0$, and $\lambda^2 < 0$. If core deposits and capital act as stable sources of financing during the crisis, then we expect banks with higher levels of both to be more willing to run down their liquidity buffers. That is, $\beta^4 < 0$ and $\beta^6 < 0$. Further, if these stable sources of funds allowed banks to continue to lend during the crisis, we expect $\gamma^4 > 0$ and $\gamma^6 > 0$ (and $\lambda^4 > 0$ and $\lambda^6 > 0$). The effect of unused loan commitments is harder to sign ex ante because banks with greater unused commitments are exposed to liquidity risk (suggesting $\beta^8 > 0$), but also experience a greater increase in loan demand in the crisis (so, $\gamma^8 > 0$ as well). However, we would expect banks with greater exposure to liquidity risk from lending via commitments to reduce total credit originations (so, $\lambda^8 < 0$).

[5] That is, loan commitment draw downs do not affect this measure of overall credit supply because unused commitments decrease by the exact same level that loans increase.

In addition to the models in regressions (1) - (3), we also report models using an indicator variable for the crisis period rather than the TED spread. We set the crisis indicator equal to 1 from 2007Q3 through 2009Q2 (see Figure 2).

Note that our strategy exploits the exogenous shock to overall liquidity as measured by the TED spread. Hence, we do not attempt to interpret the direct effects of the variables in regressions (1) - (3). Said differently, we are side stepping the problem that policymakers, the Fed in this case, chose to increase aggregate liquidity. As is well known, the Fed expanded its balance sheet from about $800 billion to a little more than $2 trillion during the fourth quarter of 2008, leading to an increase in cash in the banking system. Instead, regression (1) allows us to understand how that liquidity was distributed across the banking system, which is endogenously determined by variations in banks' liquidity demands.

Data

We build our panel dataset from the quarterly Federal Financial Institutions Examination Council (FFIEC) *Reports of Income and Condition* (Call Reports), which all regulated commercial banks file with their primary regulator.[6] Because some banks are owned by a common holding company, we aggregate the bank-level data for banks with common ownership since these ownership ties may foster liquidity sharing across subsidiaries (see Houston et al., 1997). Specifically, we sum Call Report data at the highest holding company level for multi-bank holding companies.

Call Reports contain detailed on and off-balance-sheet information for all banks. Specific to our study, we collect information on bank assets, deposits, capital, and off-balance sheet, undrawn loan commitments. Following Federal Deposit Insurance Corporation (FDIC) and

[6] Call Report data are publicly available at the website of the Federal Reserve Bank of Chicago.

Federal Reserve guidelines, we segregate banks into two size groups based on beginning of quarter book value of assets: i) large banks have assets of greater than $1 billion and ii) small banks have assets less than or equal to $1 billion. Banks with asset growth greater than ten percent during a quarter are dropped during that quarter to mitigate the effect of large mergers on changes in liquid assets, loans, and credit supply. Table 1 lists the distribution of the sample banks by quarter.

From Call Report data we build the dependent variables for our three regression models: change in liquid assets during the quarter divided by beginning of quarter total assets (ΔLiquid $Assets_{i,t}/Assets_{i,t-1}$), where liquid assets includes cash plus non-asset-backed securities; change in loans during the quarter divided by beginning of period assets ($\Delta Loans_{i,t}/Assets_{i,t-1}$); and change in the sum of loans plus undrawn commitments divided by the sum of total assets plus undrawn commitments at the beginning of the quarter ($\Delta Credit_{i,t}/(Commit+Assets)_{i,t-1}$). We drop mortgage-backed (MBS) and asset-backed securities (ABS) from our definition of liquid assets and instead include them in our measure of illiquid assets (see below) because of the well-known collapse of market liquidity for securitized assets during the crisis.[7]

Explanatory variables in the regressions include the fraction of the firm's investment portfolio of assets that are illiquid at the beginning of the period (Illiquid $Assets/Assets_{i,t-1}$);[8] the fraction of the firm's balance sheet financed with core deposits at the beginning of the period (Core $Deposits/Assets_{i,t-1}$);[9] the fraction of the balance sheet (risk-weighted assets) financed by Tier 1 capital at the beginning of the period (common stockholders' equity plus qualifying

[7] Specifically, Liquid Assets = noninterest-bearing cash balances + interest-bearing cash balances + non-MBS and non-ABS held-to-maturity (HTM) securities + non-MBS and non-ABS available-for-sale (AFS) securities + Fed funds sold + securities purchased under agreements to resell.

[8] Specifically, Illiquid Assets = loans and leases net of unearned income and allowances + MBS and ABS HTM securities + MBS and ABS AFS securities.

[9] Core deposits are defined as the sum of deposits under $100,000 plus all transactions deposits.

perpetual preferred stock) (Capital/Assets$_{i,t-1}$); the ratio of unused commitments to commitments plus assets at the beginning of the period (Commit/(Commit+Assets)$_{i,t-1}$); and, the log of total assets at the beginning of the period (Log Assets$_{i,t-1}$). Each of these variables is included in the regressions independently and is interacted with the TED spread, equal to the quarterly average of the daily spread between the three-month LIBOR rate (obtained from the Bulgarian National Bank website) and the 3-month U.S. Treasury rate (from the Federal Reserve Economic Data (FRED) website of the Federal Reserve Bank of St. Louis). Thus, the unique relations between the independent variables and the liquid asset and credit supply measures as the TED spread changes (and, notably, during the financial crisis) are given by the coefficients on the various ratios interacted with the TED spread (e.g., β^2, β^4, β^6, β^8, and β^{10} in regression (1)).

Table 2 reports summary statistics on the variables used in the regressions. We report statistics on the liquid asset and credit supply measures (the dependent variables in our regressions) for large and small banks during non-crisis quarters, 2006Q1 through 2007Q2 (Panels A and B), large and small banks during crisis quarters, 2007Q3 through 2009Q2 (Panels C and D), and large and small banks for the fourth quarter of 2008 (Panels E and F). Not surprisingly, the mean and median changes in loans and total credit are both lower in the crisis quarters relative to the non-crisis quarters. For large banks the mean (median) percentage change in loans to assets is 1.39 (1.33) during the non-crisis period and 0.85 (0.83) during the crisis period; the mean (median) percentage change in credit supply to assets plus commitments is 1.60 (1.46) during the non-crisis period and 0.50 (0.54) during the crisis period. For small banks the mean (median) percentage change in loans to assets is 1.32 (1.06) during the non-crisis period and 1.04 (0.76) during the crisis period; the mean (median) percentage change in credit supply to

assets plus commitments is 1.41 (1.06) during the non-crisis period and 0.96 (0.65) during the crisis period.

The differences are generally even more pronounced if just the fourth quarter of 2008 (during the height of the financial crisis) values are compared with those of the non-crisis period. While mean and median liquid assets fall on average during both non-crisis and crisis quarters, stores of liquidity increase during the fourth quarter of 2008 when the Fed engineered the massive expansion of overall liquidity supply. For large banks the mean (median) percentage change in liquid assets to assets is -0.18 (-0.09) during the non-crisis period and -0.24 (-0.21) during the crisis period, yet is 0.54 (0.15) in 2008Q4 (the peak crisis quarter). For small banks the mean (median) percentage change in liquidity to assets is -0.34 (-0.21) in the crisis period, but 0.16 (0.16) in 2008Q4.

Panels G and H of Table 2 list summary statistics for large and small banks, respectively, on the independent variables used in the regression analysis. Comparing characteristics, Table 2 shows that small banks tend to rely more on core deposits and capital to finance their balance sheets than large banks. Core deposits to assets and capital to assets at small banks are, on average, 66.44 percent and 18.56 percent, respectively, and at large banks are 58.75 percent and 11.69 percent, respectively. Further, large banks have more illiquid assets per dollar of total assets than small banks (77.80 percent versus 70.27 percent) and also hold a greater fraction of unused commitments compared to small banks (16.79 percent versus 9.18 percent).

Regression Results

Table 3 reports our models for regressions (1) - (3). Panel A reports the regressions for large banks (over $1 billion in beginning-of-quarter assets), and Panel B reports the regressions for small banks. A consistent pattern emerges: during the crisis liquidity-risk exposure led to

greater increases in liquid assets, mirrored by a greater decreases in credit origination. The interaction between the TED spread and each exposure measure enters the regressions in every case with opposite sign (compare columns 1 and 3 in Table 3). For example, *Illiquid Assets/Assets*TED* enters the liquid-asset growth equation positively (2.423, Column 1) and the credit growth equation negatively (-1.340, Column 3). The same holds for *Core Deposits/Assets*TED*, *Capital/Assets*TED*, and *Commit/(Commit+Assets)*TED*. The pattern holds for both large and small banks (Panels A and B). Taken together, this is strong evidence that banks built up liquidity buffers to offset the increased risk in the crisis and, as a result, had to cut back on credit production. Liquidity risk management thus helps explain changes in credit supply across banks. The results for loan growth (column 2) are consistent with those for total credit production (column 3) across three of the four liquidity variables, the exception being unused commitments. For this variable, we observe a positive effect of *Commit/(Commit+Assets)*TED*, reflecting the increased take-down demand during the crisis in the loan growth equation as funds moved from off-balance sheet accounts to on-balance sheet accounts. This occurs despite a relatively larger drop in total credit production for banks more exposed to pre-existing commitments.

Table 4 summarizes the economic impact of our four measures of liquidity exposure, based on the regression coefficients displayed in Table 3. As noted earlier, we are interested in understanding the *differential* response to the crisis across banks, so we focus solely on the interaction terms. During the fourth quarter of 2008 – the height of the crisis – the TED spread jumped about 200 basis points above its normal level. To understand the differential responses to this jump, we compare banks at the 90th percentile of each dimension of the liquidity-risk distribution with banks at the median. For example, among large banks the 200 basis point

increase in TED would lead to liquid asset growth about 0.42 percent of assets more for banks with above-median illiquid asset holdings, relative to banks with median illiquid-asset holdings (Table 4, Panel A: first row of column 1). Looking at Column 3 of Table 4, overall credit growth would be lower for highly exposed banks by about 0.24 percent relative to total assets plus commitments, again relative to the median bank. If we compare two banks, one at the 90th percentile of all four liquidity exposure variables with another at the median for all four, the results suggests a relative decline in new credit of about 1.7%. This difference is very substantial when compared with the average loan growth of just 1.46% per quarter for large banks (see Table 2).

In Table 5, we replace the TED spread with an indicator variable equal to 1 during the quarters in which TED was elevated, i.e., 2007Q3 through 2009Q2 (see Figure 2). This approach has the advantage of better robustness because the indicator is by construction free of outliers. However, this indicator has a drawback in that it misses the activity during the key fourth quarter of 2008 when markets dried up spectacularly following the Lehman bankruptcy and AIG bailout. The results are quite consistent in terms of sign patterns with those in Table 3; magnitudes appear different because the quarterly average of the daily TED spread varies from 37 basis points (in 2006Q1) to 250 basis points (in 2008Q4), while the indicator varies between 0 and 1.

One of our most consistent findings is that core deposits (transactions deposits + other insured funds) helped banks sustain lending. In fact, in unreported tests we have added wholesale deposits (uninsured, non-transactions deposits) as an additional explanatory variable but find that these do not correlate positively with credit production. While depositors can withdraw transaction deposits on demand, they rarely do. Thus, banks use these deposits to fund loans and commitments; they act as a substitute for liquid assets. By contrast, wholesale funds

are more volatile, flowing into banks when rates on alternative investments are low, or when economic risk is high, and flowing out of banks when rates on alternative investments are high, or economic risk is low.

Diamond and Dybvig's model of asset transformation ties bank fragility to demandable deposits. In contrast to this classic scenario, during the financial crisis funds were *leaving* the securities markets and flowing *into* the banking system (the opposite of a run), and most of the funds flowed into bank *transactions deposit accounts*. Further, the Federal Deposit Insurance Corporation extended its insurance blanket to cover all transactions deposits in October 2008, thereby eliminating depositors' incentives to pull funding from any transaction accounts. The effects of these market pullbacks and policy steps can be seen clearly in the aggregate flows of deposits, graphed in Figure 4 (which shows weekly changes in core and wholesale deposits at commercial banks from September 10, 2008 through January 10, 2009).[10] Wholesale deposits fell in aggregate by almost $200 billion in the last quarter of 2008, while core deposits grew by about $500 billion in aggregate. Given these flows, it should come as little surprise that banks more reliant on core deposit financing faced fewer liquidity problems relative to banks that relied more heavily on wholesale sources of debt financing.

Robustness tests

We have interpreted relationships between liquidity exposure and loan growth as supply-induced correlations driven by banks' efforts to manage liquidity risk. To make such an interpretation, we must argue that our results are not reflecting variation in *loan demand*. We consider demand explanations unlikely because they could only drive our interaction effects if two conditions hold: 1) demand must be correlated with the measures of liquidity risk; and 2)

[10] Source: Federal Reserve's H8 weekly data on bank assets and liabilities.

demand must change differentially as the economy moves from boom (low TED spread) to bust (high TED spread). While we think these conditions are not likely to hold simultaneously, we nevertheless have estimated two additional models designed to rule out demand-side explanations for our findings. In the first approach, we control for differences in loan shares across banks, and in the second we control for differences in geographical markets.

To be specific, we estimate the following robustness tests:

$$\begin{aligned}\Delta Credit_{i,t}/(Commit+Assets)_{i,t-1} = {} & T^3_t + B^3_i + \lambda^1 Illiquid\ Assets/Assets_{i,t-1} \\ & + \lambda^2\ Illiquid\ Assets/Assets_{i,t-1} * TED_t + \lambda^3 Core\ Deposits/Assets_{i,t-1} \\ & + \lambda^4 Core\ Deposits/Assets_{i,t-1} * TED_t + \lambda^5 Capital/Assets_{i,t-1} + \lambda^6 Capital/Assets_{i,t-1} * TED_t \\ & + \lambda^7 Commit/(Commit+Assets)_{i,t-1} + \lambda^8 Commit/(Commit+Assets)_{i,t-1} * TED_t \\ & + \lambda^9 Log\ Assets_{i,t-1} + \lambda^{10} Log\ Assets_{i,t-1} * TED_t \\ & + \lambda^{11} C\&I\ Loans/Loans_{i,t-1} + \lambda^{12} C\&I\ Loans/Loans_{i,t-1} * TED_t \\ & + \lambda^{13} Real\ Estate\ Loans/Loans_{i,t-1} + \lambda^{14} Real\ Estate\ Loans/Loans_{i,t-1} * TED_t + \mu_{i,t.}, \quad (4)\end{aligned}$$

and

$$\begin{aligned}\Delta Credit_{i,t}/(Commit+Assets)_{i,t-1} = {} & T^3_t + B^3_i + \lambda^1 Illiquid\ Assets/Assets_{i,t-1} \\ & + \lambda^2\ Illiquid\ Assets/Assets_{i,t-1} * TED_t + \lambda^3 Core\ Deposits/Assets_{i,t-1} \\ & + \lambda^4 Core\ Deposits/Assets_{i,t-1} * TED_t + \lambda^5 Capital/Assets_{i,t-1} + \lambda^6 Capital/Assets_{i,t-1} * TED_t \\ & + \lambda^7 Commit/(Commit+Assets)_{i,t-1} + \lambda^8 Commit/(Commit+Assets)_{i,t-1} * TED_t \\ & + \lambda^9 Log\ Assets_{i,t-1} + \lambda^{10} Log\ Assets_{i,t-1} * TED_t \\ & + State\ Effect_i * TED_t + \mu_{i,t.}. \quad (5)\end{aligned}$$

Equation (4) removes demand effects by controlling for a bank's relative emphasis on business lending (C&I loans) and real estate lending, allowing each of these effects to enter directly and also to vary as the economy moves into the crisis (i.e., we include the interaction with the TED spread). By including the interaction with TED, this specification accounts for the possibility that borrowers react differently to the advent of the crisis.

Equation (5) sweeps out potential demand variation related to geographical specification by adding a state effect interacted with the TED spread .[11] Most business lending, particularly lending to small business, relies on monitoring facilitated by close geographic proximity between the lender and the borrower. For example, Berger, Miller, Petersen, Rajan & Stein (2004) report a median distance between small borrowers and their bank of just three miles. Average distance does increase, however, with bank size; large banks are more likely to lend using information technology such as credit scoring as a substitute for personal connections with borrowers. Moreover, we use the state of the bank's head office to define the fixed effect. This strategy will work very well for small banks whose markets are limited to just one state but will be less effective for the small number of large institutions with branches in many states. Thus, we expect that equation (5) will for control for demand better for our sample of banks under $1 billion in assets.

The results of these robustness tests are reported in Table 6. Since the emphasis here is on loan demand variation, we only report the models of total credit production. The first column of Table 6 reproduces the baseline models from Table 3, column 3. These results show that our results of interest are stable even when we introduce two distinct approaches to sweep out demand. In every case the interaction between TED and the liquidity variables maintain similar sign and magnitude. We lose little statistical significance. There is *no evidence* that coefficients are systematically moving toward or away from zero (e.g. no evidence of attenuation bias, nor evidence that we are overstating the effects of liquidity exposure); in some cases coefficients increase slightly in magnitude, while in others they decline slightly. In no cases, however, do the effects change much relative to sampling error.

[11] Note that in this strategy the direct effect of geography has already been accounted for with the bank fixed effect.

IV. CONCLUSIONS

Liquidity at banks dried up during the financial crisis of 2007-2009, both because interbank markets froze and because markets for asset-backed and mortgage-backed securities collapsed. Illiquidity peaked in the fourth quarter of 2008 after the failure of Lehman and the AIG bailout. The government attempted to stabilize the financial system with traditional tools of monetary policy, expanding their balance sheet by more than $1 trillion over a few weeks, and later with new approaches such as equity injections and extensions of liability guarantees. In this paper, we show how this expansion of liquidity was distributed across the banking system. We find that banks with more illiquid asset portfolios, i.e., those banks that held more loans and securitized assets, increased their holdings of liquid assets and decreased lending. We also find that banks financed with core deposits and capital, i.e., stable sources of financing, continued to lend relative other banks. Off-balance-sheet liquidity risk, in the form of undrawn loan commitments, materialized as borrowers drew on pre-existing commitments in large quantities. These take-downs displaced lending capacity and constrained new credit origination. Our results emphasize that sources of liquidity risk at commercial banks have evolved. Runs from demand depositors no longer expose banks to the risk of funding outflows, perhaps due to implicit and explicit government safety nets. Instead, liquidity demands from borrowers and exposure to and the use of wholesale debt financing are the new key sources of liquidity risk in the modern bank.

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TABLE 1

NUMBER OF COMMERCIAL BANKS EXAMINED BETWEEN 2006Q1 AND 2009Q2

This table lists the distribution of the sample banks by quarter. We segregate banks into two size groups based on beginning of quarter book value of assets. Large banks are those banks with beginning of quarter assets greater than $1 billion and small banks are those banks with beginning of quarter assets less than $1 billion. Bank asset size is collected from Federal Financial Institutions Examination Council (FFIEC) *Call Reports of Condition and Income* found on the website of the Federal Reserve Bank of Chicago, www.chicagofed.org.

Year	Quarter	Large	Small	Total
2006	1	430	5,784	6,214
	2	432	5,789	6,221
	3	442	5,731	6,173
	4	434	5,563	5,997
2007	1	455	5,664	6,119
	2	453	5,670	6,123
	3	457	5,639	6,096
	4	462	5,539	6,001
2008	1	459	5,460	5,919
	2	483	5,583	6,066
	3	485	5,575	6,060
	4	468	5,440	5,908
2009	1	491	5,506	5,997
	2	511	5,638	6,149

TABLE 2
SUMMARY STATISTICS FOR COMMERCIAL BANK CHARACTERISTICS AND SELECT CASH FLOW STATEMENT ITEMS OVER THE PERIOD 2006Q1 THROUGH 2009Q2

This table reports summary statistics for changes in liquid assets, loans, and credit supply at commercial banks and bank characteristics. Growth variables standardized by beginning of period total assets or beginning of period assets plus unused commitments. Bank characteristics are beginning of period values. The data are observed quarterly for a panel of all U.S. commercial banks over the period 2006Q1 through 2009Q2. Crisis quarters include 2007Q3-2009Q2. Bank data, aggregated at the high holding company as appropriate, are from the *Call Reports of Condition and Income* accessed via the Federal Reserve Bank of Chicago website, www.chicagofed.org.

Panel A: Large banks during non-crisis quarters					
	Average	10th percentile	Median	90th percentile	Standard deviation
ΔLiquid assets / Assets (%)	-0.18	-2.69	-0.09	2.39	2.93
ΔLoans / Assets (%)	1.39	-0.72	1.33	3.99	3.04
ΔCredit supply / (Commit + Assets) (%)	1.60	-1.08	1.46	4.75	3.63
Panel B: Small banks during non-crisis quarters					
	Average	10th percentile	Median	90th percentile	Standard deviation
ΔLiquid assets / Assets (%)	-0.40	-4.63	-0.21	3.92	4.11
ΔLoans / Assets (%)	1.32	-1.73	1.06	4.79	3.33
ΔCredit supply / (Commit + Assets) (%)	1.41	-1.97	1.06	5.19	3.97
Panel C: Large banks during crisis quarters					
	Average	10th percentile	Median	90th percentile	Standard deviation
ΔLiquid assets / Assets (%)	-0.24	-3.30	-0.21	2.89	3.40
ΔLoans / Assets (%)	0.85	-1.55	0.83	3.68	3.39
ΔCredit supply / (Commit + Assets) (%)	0.50	-2.49	0.54	3.62	4.08
Panel D: Small banks during crisis quarters					
	Average	10th percentile	Median	90th percentile	Standard deviation
ΔLiquid assets / Assets (%)	-0.34	-4.91	-0.21	4.40	4.43
ΔLoans / Assets (%)	1.04	-2.11	0.76	4.56	3.39
ΔCredit supply / (Commit + Assets) (%)	0.96	-2.47	0.65	4.63	4.98

TABLE 2 – CONTINUED

Panel E: Large banks during 2008Q4					
	Average	10th percentile	Median	90th percentile	Standard deviation
ΔLiquid assets / Assets (%)	0.54	-2.37	0.15	4.08	3.09
ΔLoans / Assets (%)	0.57	-1.45	0.75	3.00	4.40
ΔCredit supply / (Commit + Assets) (%)	0.07	-2.99	0.20	3.11	5.01

Panel F: Small banks during 2008Q4					
	Average	10th percentile	Median	90th percentile	Standard deviation
ΔLiquid assets / Assets (%)	0.16	-4.03	0.16	4.69	4.41
ΔLoans / Assets (%)	0.97	-1.96	0.81	4.34	3.22
ΔCredit supply / (Commit + Assets) (%)	0.73	-2.47	0.56	4.20	3.57

Panel G: Large bank characteristics					
	Average	10th percentile	Median	90th percentile	Standard deviation
Illiquid Assets / Assets (%)	77.80	65.78	79.95	88.72	11.41
Core Deposits / Assets (%)	58.75	42.35	61.08	72.84	14.41
Capital / Assets (%)	11.69	8.90	10.39	15.12	5.54
Commit / (Commit + Assets) (%)	16.79	7.27	15.22	25.52	11.10
Book value of total assets ($MM)	19,739.53	1,113.43	2,135.22	16,630.48	116,421.91

Panel H: Small bank characteristics					
	Average	10th percentile	Median	90th percentile	Standard deviation
Illiquid Assets / Assets (%)	70.27	50.90	73.34	85.89	16.44
Core Deposits / Assets (%)	66.44	53.54	67.88	78.85	11.63
Capital / Assets (%)	18.56	9.83	13.71	26.13	104.65
Commit / (Commit + Assets) (%)	9.18	2.35	8.34	16.30	7.02
Book value of total assets ($MM)	195.39	31.63	123.22	477.83	197.35

TABLE 3

FIXED-EFFECTS REGRESSIONS OF LIQUID ASSET, LOAN, AND CREDIT SUPPLY GROWTH ON TED SPREAD, FIRM CHARACTERISTICS, AND INTERACTIONS

This table reports fixed-effects regressions of quarterly growth in liquid assets standardized by beginning of period assets. The table also reports fixed-effects regressions of growth in loans standardized by beginning of period assets and growth in credit supply (i.e., growth in loans plus growth in unused commitments) standardized by beginning of period assets plus unused commitments. The data are observed quarterly for a panel of U.S. commercial banks over the period 2006Q1 through 2009Q2. Large banks are those banks with beginning of quarter assets greater than $1 billion and small banks are those banks with beginning of quarter assets less than $1 billion. Commercial bank data, aggregated at the high holding company as appropriate, are from *Call Reports of Condition and Income* accessed via the Federal Reserve Bank of Chicago website. Banks with asset growth greater than ten percent during a quarter are dropped during that quarter to mitigate the effect of large mergers on changes in liquid assets, loans, and credit supply. Variables are winsorized at the 1st and 99th percentiles. TED spread is the quarterly average of the daily difference between the three-month London Interbank Offered Rate (LIBOR) and the three-month U.S. Treasury bill secondary market rate. LIBOR data are from the Bulgarian National Bank website and Treasury bill data are from the Federal Reserve Economic Data (FRED) website of the Federal Reserve Bank of St. Louis. Standard errors, clustered at the firm level, are reported in parentheses. ***, **, and * denote the coefficients are statistically significantly different from zero at the one percent, five percent, and ten percent levels, respectively.

Panel A: Large banks (total assets > $1 billion)			
	ΔLiquid assets$_t$ / Assets$_{t-1}$	ΔLoans$_t$ / Assets$_{t-1}$	ΔCredit$_t$ / (Commit+Assets)$_{t-1}$
Illiquid Assets / Assets$_{t-1}$	0.209***	-0.015	0.030*
	(0.023)	(0.014)	(0.017)
Illiquid Assets / Assets$_{t-1}$ * TED	2.423***	-1.145*	-1.340*
	(0.863)	(0.678)	(0.762)
Core Deposits / Assets$_{t-1}$	0.004	-0.025***	-0.044***
	(0.014)	(0.009)	(0.011)
Core Deposits / Assets$_{t-1}$ * TED	-0.837	1.231***	1.356**
	(0.663)	(0.453)	(0.555)
Capital / Assets$_{t-1}$	-0.042	0.042	0.088*
	(0.050)	(0.037)	(0.054)
Capital / Assets$_{t-1}$ * TED	-0.499	5.732**	5.984**
	(2.233)	(2.637)	(2.699)
Commit / (Commit + Assets) $_{t-1}$	0.070***	0.176***	-0.012
	(0.023)	(0.027)	(0.032)
Commit / (Commit + Assets) $_{t-1}$ * TED	0.933	2.303**	-2.753***
	(0.961)	(0.937)	(0.855)
Log Assets$_{t-1}$	-0.016***	-0.017***	-0.027***
	(0.005)	(0.005)	(0.007)
Log Assets$_{t-1}$ * TED	0.186***	0.064	0.131*
	(0.072)	(0.052)	(0.067)
Firm dummies	Yes	Yes	Yes
Quarterly time dummies	Yes	Yes	Yes
N	6,462	6,462	6,462
Adjusted R-squared	0.244	0.404	0.342

TABLE 3 – CONTINUED

Panel B: Small banks (total assets ≤ $1 billion)			
	ΔLiquid assets$_t$ / Assets$_{t-1}$	ΔLoans$_t$ / Assets$_{t-1}$	ΔCredit$_t$ / (Commit+Assets)$_{t-1}$
Illiquid Assets / Assets$_{t-1}$	0.291***	-0.067***	-0.051***
	(0.011)	(0.004)	(0.006)
Illiquid Assets / Assets$_{t-1}$ * TED	0.240	-0.546***	-0.516***
	(0.296)	(0.163)	(0.183)
Core Deposits / Assets$_{t-1}$	-0.028***	0.002	-0.002
	(0.006)	(0.005)	(0.006)
Core Deposits / Assets$_{t-1}$ * TED	-0.229	0.673***	1.553***
	(0.295)	(0.204)	(0.238)
Capital / Assets$_{t-1}$	-0.008	0.070***	0.067***
	(0.012)	(0.009)	(0.012)
Capital / Assets$_{t-1}$ * TED	-1.456***	1.135***	1.058***
	(0.500)	(0.273)	(0.325)
Commit / (Commit + Assets) $_{t-1}$	-0.167***	0.295***	-0.137***
	(0.010)	(0.009)	(0.012)
Commit / (Commit + Assets) $_{t-1}$ * TED	3.090***	1.071**	-3.034***
	(0.611)	(0.459)	(0.557)
Log Assets$_{t-1}$	-0.040***	-0.015***	-0.028***
	(0.003)	(0.004)	(0.006)
Log Assets$_{t-1}$ * TED	-0.311***	0.079***	0.021
	(0.033)	(0.022)	(0.024)
Firm dummies	Yes	Yes	Yes
Quarterly time dummies	Yes	Yes	Yes
N	78,581	78,581	78,581
Adjusted R-squared	0.270	0.380	0.299

TABLE 4
ECONOMIC IMPACT OF TED INTERACTION COEFFICIENT ESTIMATES

This table reports the estimated effect of a 200 basis point (bp) increase in TED spread on changes in liquid assets, loans, and credit supply. The presented values are calculated as the difference in the change in the left-hand-side variables, given a 200bp increase in TED spread and the coefficient estimates on the interaction terms in Table 3, between observations with right-hand-side variables measured at the 90th percentile level and at the median. ***, **, and * denote the coefficient estimates from the Table 3 regressions are statistically significantly different from zero at the one percent, five percent, and ten percent levels, respectively. The data are observed quarterly for a panel of U.S. commercial banks over the period 2006Q1 through 2009Q2.

Panel A: Large banks (total assets > $1 billion)			
	ΔLiquid assets$_t$ / Assets$_{t-1}$	ΔLoans$_t$ / Assets$_{t-1}$	Credit$_t$ / (Commit + Assets$_{t-1}$)
Illiquid Assets / Assets$_{t-1}$	0.42%***	-0.20%*	-0.24%*
Core Deposits / Assets$_{t-1}$	-0.20%	0.29%***	0.32%**
Capital / Assets$_{t-1}$	-0.05%	0.54%**	0.57%**
Commit / (Commit +Assets$_{t-1}$)	0.19%	0.47%**	-0.57%***

Panel B: Small banks (total assets < $1 billion)			
	ΔLiquid assets$_t$ / Assets$_{t-1}$	ΔLoans$_t$ / Assets$_{t-1}$	Credit$_t$ / (Commit + Assets$_{t-1}$)
Illiquid Assets / Assets$_{t-1}$	0.06%	-0.14%***	-0.13%***
Core Deposits / Assets$_{t-1}$	-0.05%	0.15%***	0.34%***
Capital / Assets$_{t-1}$	-0.36%***	0.28%***	0.26%***
Commit / (Commit +Assets$_{t-1}$)	0.49%***	0.17%**	-0.48%***

TABLE 5
FIXED-EFFECTS REGRESSIONS OF LIQUID ASSET, LOAN, AND CREDIT SUPPLY GROWTH ON CRISIS INDICATOR, FIRM CHARACTERISTICS, AND INTERACTIONS

This table reports fixed-effects regressions of quarterly growth in liquid assets standardized by beginning of period assets. The table also reports fixed-effects regressions of growth in loans standardized by beginning of period assets and growth in credit supply (i.e., growth in loans plus growth in unused commitments) standardized by beginning of period assets plus unused commitments. The data are observed quarterly for a panel of U.S. commercial banks over the period 2006Q1 through 2009Q2. Large banks are those banks with beginning of quarter assets greater than $1 billion and small banks are those banks with beginning of quarter assets less than $1 billion. Commercial bank data, aggregated at the high holding company as appropriate, are from *Call Reports of Condition and Income* accessed via the Federal Reserve Bank of Chicago website. Banks with asset growth greater than ten percent during a quarter are dropped during that quarter to mitigate the effect of large mergers on changes in liquid assets, loans, and credit supply. Variables are winsorized at the 1st and 99th percentiles. CRISIS is an indicator variable that takes the value of one for observations that occur during the period 2007Q3 through 2009Q2, and zero otherwise. Standard errors, clustered at the firm level, are reported in parentheses. ***, **, and * denote the coefficients are statistically significantly different from zero at the one percent, five percent, and ten percent levels, respectively.

Panel A: Large banks (total assets > $1 billion)			
	ΔLiquid assets$_t$ / Assets$_{t-1}$	ΔLoans$_t$ / Assets$_{t-1}$	ΔCredit$_t$ / (Commit+Assets)$_{t-1}$
Illiquid Assets / Assets$_{t-1}$	0.205***	-0.012	0.029*
	(0.022)	(0.013)	(0.017)
Illiquid / Assets$_{t-1}$ * CRISIS	0.048***	-0.021**	-0.020**
	(0.012)	(0.008)	(0.009)
Core Deposits / Assets$_{t-1}$	-0.002	-0.022***	-0.041***
	(0.012)	(0.008)	(0.011)
Core Deposits / Assets$_{t-1}$ * CRISIS	-0.002	0.020***	0.021***
	(0.008)	(0.006)	(0.007)
Capital / Assets$_{t-1}$	-0.065	0.064*	0.109**
	(0.048)	(0.035)	(0.050)
Capital / Assets$_{t-1}$ * CRISIS	0.033	0.063*	0.072**
	(0.030)	(0.032)	(0.033)
Commit / (Commit + Assets) $_{t-1}$	-0.069***	0.189***	-0.020
	(0.022)	(0.025)	(0.031)
Commit / (Commit + Assets) $_{t-1}$ * CRISIS	0.020*	0.014	-0.039***
	(0.011)	(0.012)	(0.011)
Log Assets$_{t-1}$	-0.016***	-0.017***	-0.025***
	(0.005)	(0.005)	(0.007)
Log Assets$_{t-1}$ * CRISIS	0.002**	0.002***	0.002***
	(0.001)	(0.001)	(0.001)
Firm dummies	Yes	Yes	Yes
Quarterly time dummies	Yes	Yes	Yes
N	6,462	6,462	6,462
Adjusted R-squared	0.246	0.407	0.346

TABLE 5 – CONTINUED

Panel B: Small banks (total assets < $1 billion)			
	ΔLiquid assets$_t$ / Assets$_{t-1}$	ΔLoans$_t$ / Assets$_{t-1}$	ΔCredit$_t$ / (Commit+Assets)$_{t-1}$
Illiquid Assets / Assets$_{t-1}$	0.286***	-0.068***	-0.049***
	(0.007)	(0.004)	(0.005)
Illiquid Assets / Assets$_{t-1}$ * CRISIS	0.014***	-0.009***	-0.012***
	(0.003)	(0.002)	(0.002)
Core Deposits / Assets$_{t-1}$	-0.032***	0.005	0.001
	(0.005)	(0.005)	(0.006)
Core Deposits / Assets$_{t-1}$ * CRISIS	0.003	0.007**	0.022***
	(0.004)	(0.003)	(0.003)
Capital / Assets$_{t-1}$	-0.016	0.073***	0.071***
	(0.011)	(0.009)	(0.011)
Capital / Assets$_{t-1}$ * CRISIS	-0.006	0.017***	0.021***
	(0.006)	(0.004)	(0.004)
Commit / (Commit + Assets) $_{t-1}$	-0.159***	0.300***	-0.150***
	(0.010)	(0.009)	(0.011)
Commit / (Commit + Assets) $_{t-1}$ * CRISIS	0.038***	0.004	-0.046***
	(0.007)	(0.005)	(0.007)
Log Assets$_{t-1}$	-0.041***	-0.014***	-0.025***
	(0.003)	(0.004)	(0.005)
Log Assets$_{t-1}$ * CRISIS	-0.004***	0.001***	0.000
	(0.000)	(0.000)	(0.000)
Firm dummies	Yes	Yes	Yes
Quarterly time dummies	Yes	Yes	Yes
N	78,581	78,581	78,581
Adjusted R-squared	0.270	0.381	0.302

TABLE 6

FIXED-EFFECTS REGRESSIONS OF CREDIT SUPPLY GROWTH ON TED SPREAD, FIRM CHARACTERISTICS, AND INTERACTIONS, WITH LOAN-DEMAND CONTROLS

This table reports fixed-effects regressions of quarterly growth in credit standardized by beginning of period credit. The data are observed quarterly for a panel of U.S. commercial banks over the period 2006Q1 through 2009Q2. Large banks are those banks with beginning of quarter assets greater than $1 billion and small banks are those banks with beginning of quarter assets less than $1 billion. The first column replicates results from Table 3 for comparison. Column 2 adds the share of loans in C&I, the share of loans in real estate, and their interactions with TED to sweep out potential demand effects; column 3 instead introduces state fixed effects based on the bank's headquarters and interactions between these state effects and TED. Standard errors, clustered at the firm level, are reported in parentheses. ***, **, and * denote the coefficients are statistically significantly different from zero at the one percent, five percent, and ten percent levels, respectively.

Panel A: Large banks (total assets > $1 billion)			
	Base Model (Table 3, Column 3)	With Loan Shares *TED	With State Effects * TED
Illiquid Assets / $Assets_{t-1}$	0.030*	0.027	0.027
	(0.017)	(0.017)	(0.017)
Illiquid Assets / $Assets_{t-1}$ * TED	-1.340*	-0.897	-0.899
	(0.762)	(0.781)	(0.831)
Core Deposits / $Assets_{t-1}$	-0.044***	-0.049***	-0.046***
	(0.011)	(0.012)	(0.012)
Core Deposits / $Assets_{t-1}$ * TED	1.356**	1.594***	0.967
	(0.555)	(0.567)	(0.594)
Capital / $Assets_{t-1}$	0.088*	0.091*	0.083
	(0.054)	(0.055)	(0.057)
Capital / $Assets_{t-1}$ * TED	5.984**	5.581**	6.243**
	(2.699)	(2.626)	(3.030)
Commit / (Commit + Assets) $_{t-1}$	-0.012	-0.009	-0.019
	(0.032)	(0.031)	(0.031)
Commit / (Commit + Assets) $_{t-1}$ * TED	-2.753***	-3.676***	-2.804**
	(0.855)	(0.869)	(1.148)
Log $Assets_{t-1}$	-0.027***	-0.028***	-0.026***
	(0.007)	(0.007)	(0.006)
Log $Assets_{t-1}$ * TED	0.131*	0.112*	0.094
	(0.067)	(0.067)	(0.067)
Firm dummies	Yes	Yes	Yes
Quarterly time dummies	Yes	Yes	Yes
Loan Share & Loan Shares * TED	No	Yes	No
State dummies * TED	No	No	Yes
N	6,462	6,462	6,462
Adjusted R-squared	0.342	0.345	0.348

TABLE 6 – CONTINUED

Panel B: Small banks (total assets ≤ $1 billion)			
	Base Model (Table 3, Column 3)	With Loan Shares *TED	With State Effects * TED
Illiquid Assets / $Assets_{t-1}$	-0.051***	-0.058***	-0.049***
	(0.006)	(0.005)	(0.006)
Illiquid Assets / $Assets_{t-1}$ * TED	-0.516***	-0.335*	-0.514***
	(0.183)	(0.201)	(0.187)
Core Deposits / $Assets_{t-1}$	-0.002	-0.008	0.001
	(0.006)	(0.006)	(0.006)
Core Deposits / $Assets_{t-1}$ * TED	1.553***	1.394***	1.161***
	(0.238)	(0.241)	(0.241)
Capital / $Assets_{t-1}$	0.067***	0.056***	0.070***
	(0.012)	(0.010)	(0.012)
Capital / $Assets_{t-1}$ * TED	1.058***	1.075***	0.892***
	(0.325)	(0.343)	(0.330)
Commit / (Commit + Assets) $_{t-1}$	-0.137***	-0.144***	-0.139***
	(0.012)	(0.012)	(0.012)
Commit / (Commit + Assets) $_{t-1}$ * TED	-3.034***	-2.881***	-3.533***
	(0.557)	(0.553)	(0.582)
Log $Assets_{t-1}$	-0.028***	-0.038***	-0.027***
	(0.006)	(0.002)	(0.006)
Log $Assets_{t-1}$ * TED	0.021	0.030	0.058**
	(0.024)	(0.030)	(0.026)
Firm dummies	Yes	Yes	Yes
Quarterly time dummies	Yes	Yes	Yes
Loan Shares & Shares * TED	No	Yes	No
State dummies * TED	No	No	Yes
N	78,581	78,581	78,581
Adjusted R-squared	0.299	0.303	0.302

FIGURE 1
BUSINESS LOAN ORIGINATIONS COLLAPSE

This figure shows the dollar value of new term loans and credit lines issued to large businesses from 2000 (before the financial crisis) through 2008 (at the height of the financial crisis). Data used to construct the figure are obtained from the Loan Pricing Corporation's *Dealscan* data base.

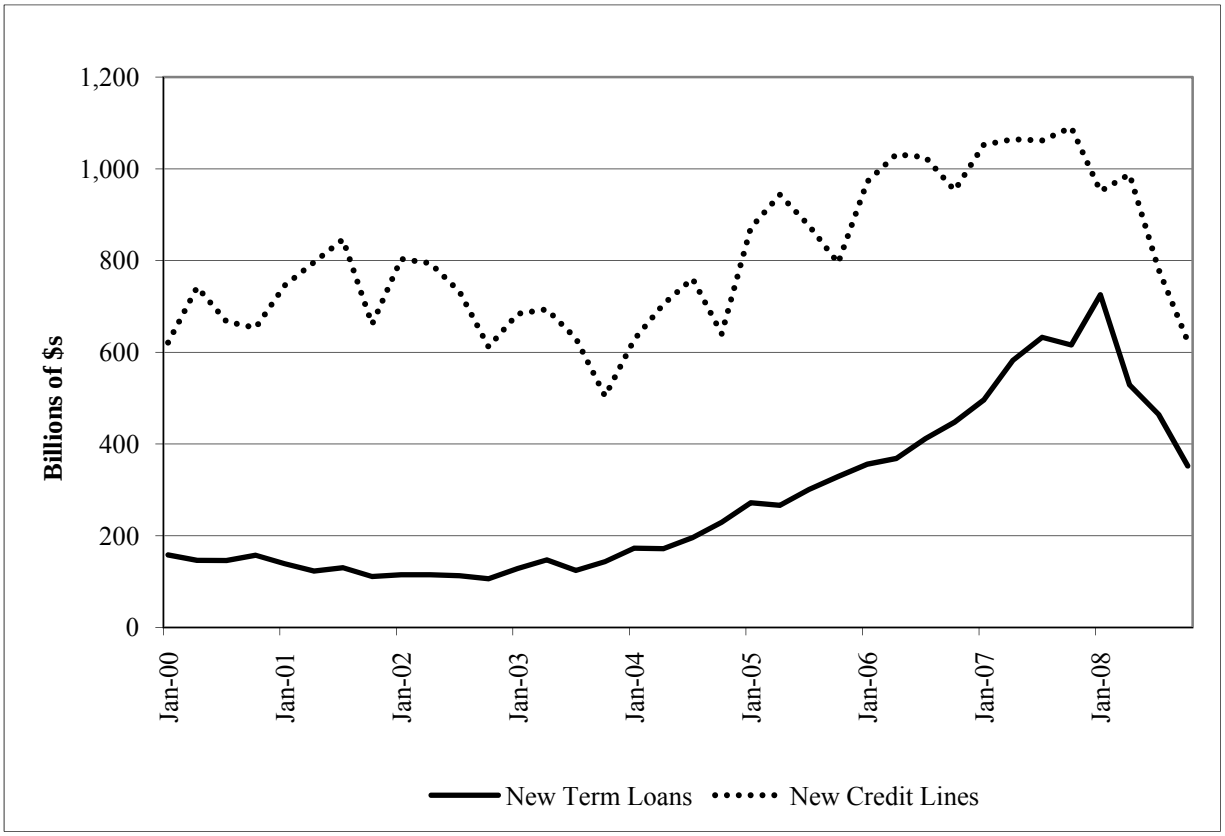


FIGURE 2
THE TED SPREAD

This figure shows movements in the TED spread from 2006 through the second quarter of 2009. The TED spread is calculated as the difference between the 3-month LIBOR rate (obtained from the Bulgarian National Bank) and the 3-month Treasury rate (from the Federal Reserve Economic Data (FRED) website of the Federal Reserve Bank of St. Louis). The shaded area includes the period we designate the "crisis period" in our empirical analysis.

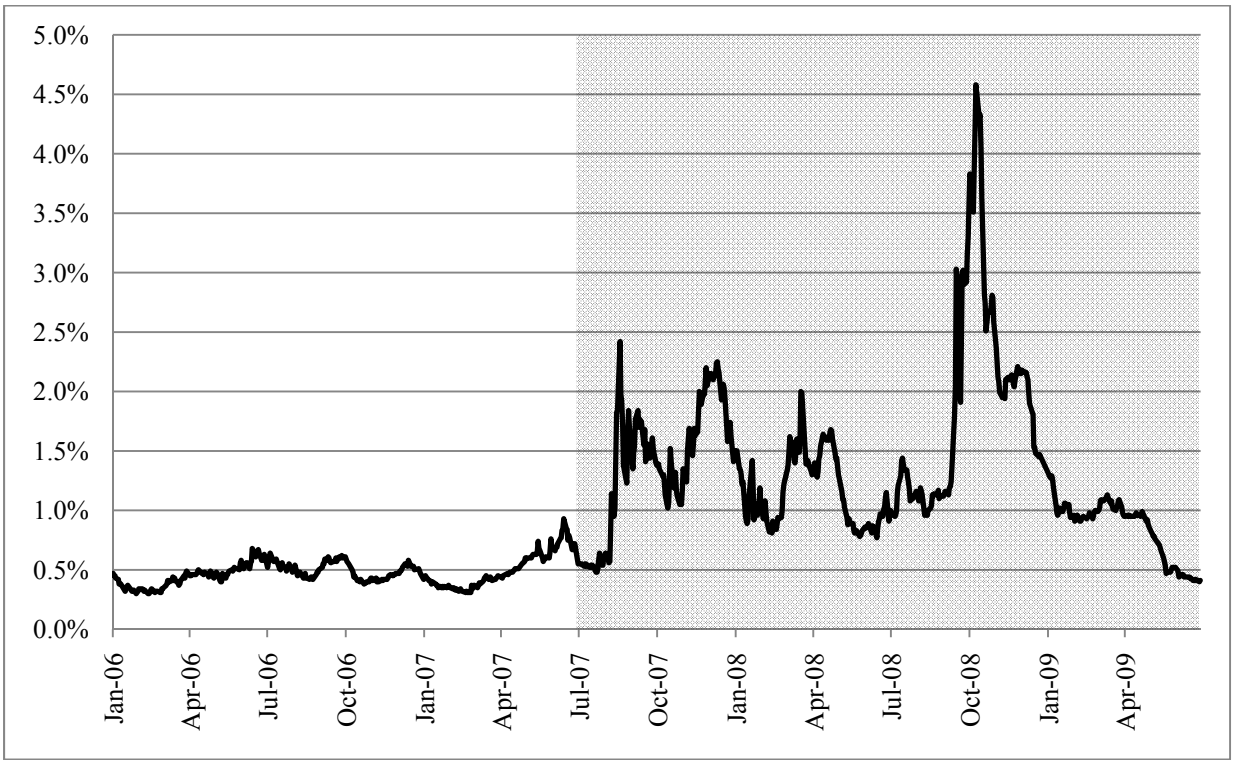


FIGURE 3
BUSINESS LENDING RISES AS COMMERCIAL PAPER MOVES BACK ON THE BALANCE SHEET

This figure shows the growth of commercial paper and bank business loans outstanding from June 2007 through November 2008. Data are obtained from the website of the Board of Governors of the Federal Reserve.

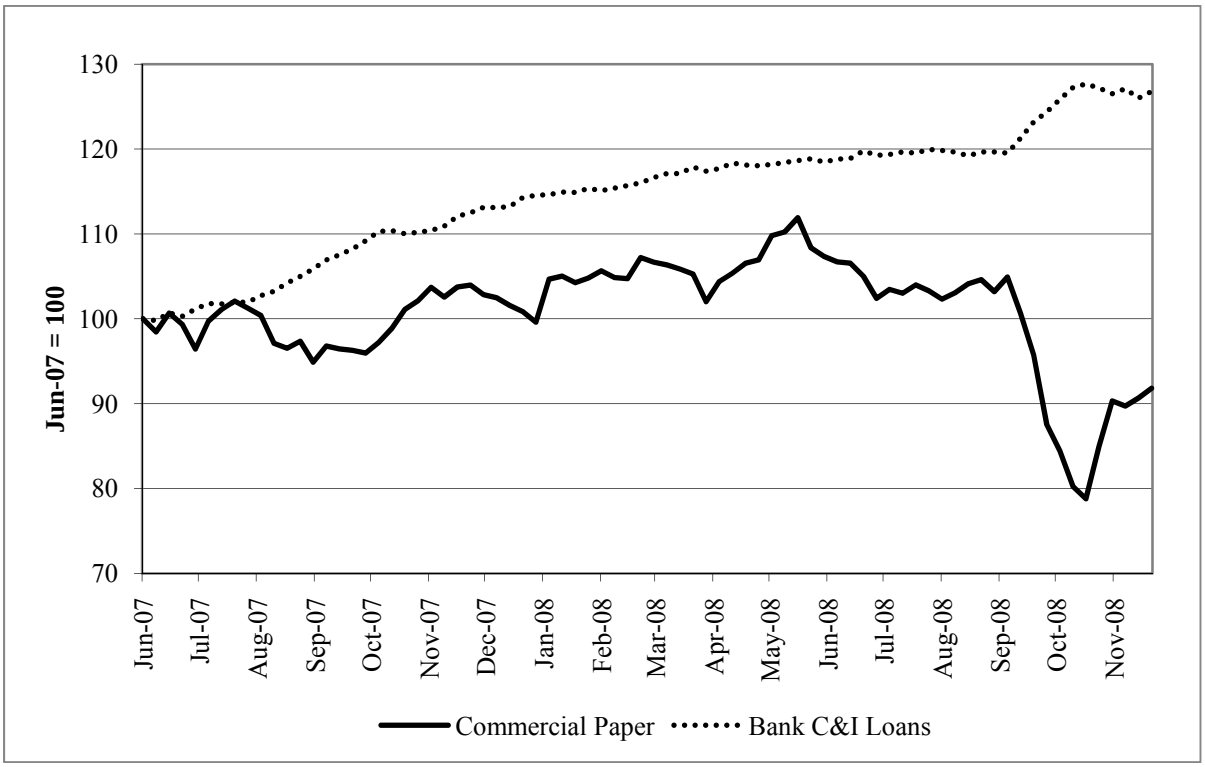
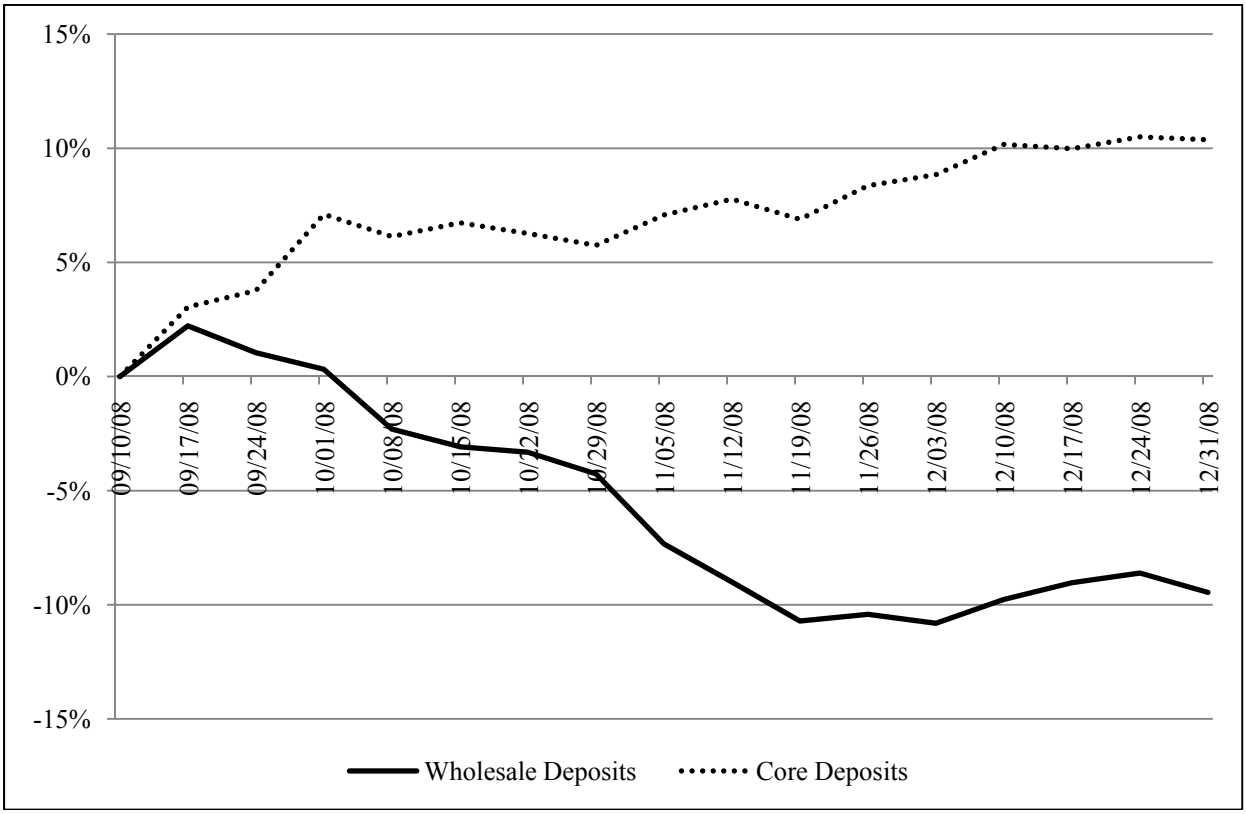


FIGURE 4
GROWTH IN DEPOSITS

This figure shows the weekly percentage change in core and wholesale deposits at commercial banks from September 10, 2008 through January 10, 2009. Core deposits include transactions deposits plus fully insured (<$100,000) time deposits. Wholesale deposits include time deposits over $100,000. Data are obtained from the Federal Reserve's H8 weekly data on bank assets and liabilities.