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# Liquidity risk management and credit supply in the financial crisis ☆

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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, which are 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 takedown demand displaced lending capacity. We conclude that efforts to manage the liquidity crisis by banks led to a decline in credit supply.



## 1. Introduction

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, as well as how these efforts to weather the storm affected credit availability. Because the Federal Reserve sets the aggregate supply of liquidity in the banking system, focusing on only time series variation in liquidity merely illustrates choices made by the Fed (that is, the aggregate supply of liquidity). Our strategy instead is to put a spotlight on within-bank variation in holdings of cash and other liquid assets, which allows for an understanding of why some banks chose to build up liquidity faster than others during the crisis. This approach helps explain 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 more from exposure to undrawn loan commitments, the withdrawal of funds from wholesale deposits, and the loss of other sources of short-term financing than from the loss of demand deposits (e.g., Diamond and Dybvig, 1983). With both explicit and implicit government backing, deposits are unlikely to leave the banking system during crises. For example, Gatev and Strahan (2006) find inflows of deposits during periods of low market liquidity, while

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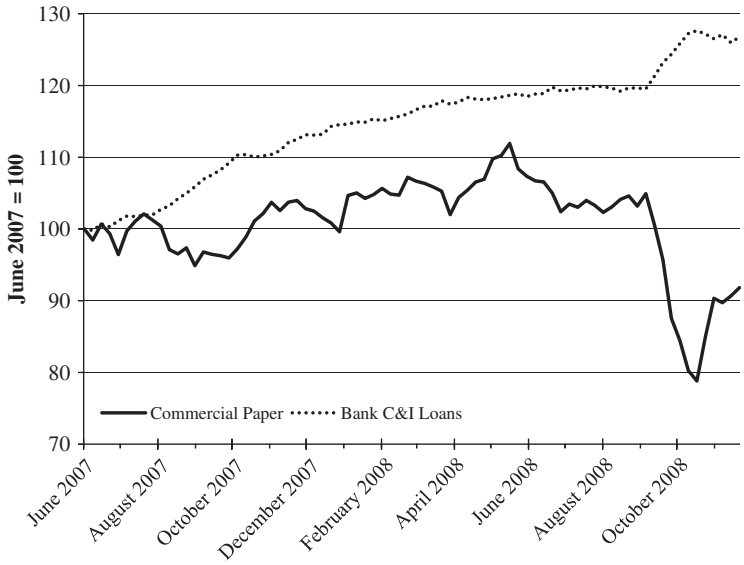


**Fig. 1.** Business lending rises as commercial paper moves back on the balance sheet. This figure shows the growth of commercial paper and bank business loans outstanding from June 2007 through November 2008. Data are obtained from the website of the Board of Governors of the Federal Reserve (www.chicagofed.org).

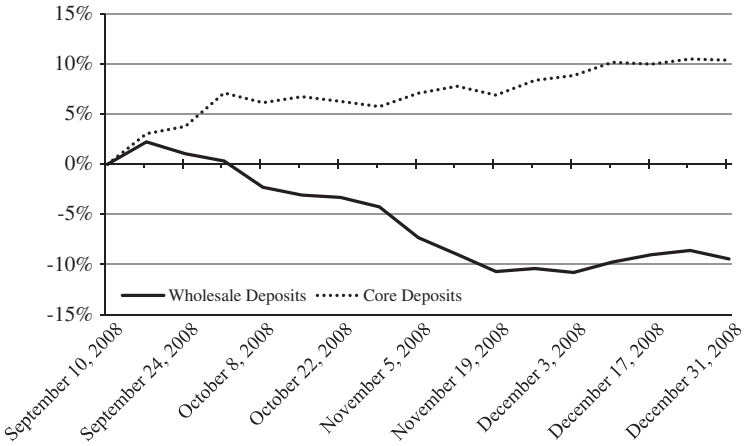


**Fig. 2.** Growth in deposits. This figure shows the weekly percentage change in core and wholesale deposits at commercial banks from September 10, 2008 through December 31, 2008. Core deposits include transactions deposits plus fully insured ( < $100,000) time deposits. Wholesale deposits include time deposits over $100,000. Data are obtained from the Federal Reserve's H8 weekly data on bank assets and liabilities.

Pennacchi (2009) does not find such flows during the pre-Federal Deposit Insurance Corporation (FDIC) period. Together this suggests that deposits insulate banks from liquidity risk due to the advent of government guarantees. 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, leading to a decline in commercial paper outstanding and an increase in bank lending (Fig. 1). At the same time, banks lost wholesale funds but gained retail deposits (Fig. 2).[1] We show that banks more exposed to this liquidity risk increased their holdings of liquid assets, which in turn reduced their capacity to make new loans.

On the asset side of balance sheets, banks holding assets with low market liquidity expanded their cash buffers during the crisis. Specifically, banks that held more loans, mortgage-backed securities (MBS), and asset-backed securities (ABS) tended to increase holdings of liquid assets and decrease investments in loans and new commitments to lend. Because of concerns 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

[1] Gorton (2009) and Gorton and Metrick (2009) draw parallels between the increase in haircuts in the repo markets and banking (*footnote continued*) panics and bank runs. These effects were greatest at large nonbank financial institutions.

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, and 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 bigger for the large bank sample.

We also test how banks managed shocks to loan demand stemming from preexisting unused loan commitments (held off the balance sheet). Unused commitments expose banks to liquidity risk, which became manifest when takedown 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 drawdowns thus displaced new credit origination during the crisis.

Our paper extends in three ways the 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. 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 data set [drawn from the quarterly Federal Financial Institutions Examination Council (FFIEC) *Reports of Income and Condition* (Call Reports)], which allows us to explore more dimensions of liquidity risk exposure and to quantify implications of our results for overall credit supply. 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, not total deposits, which provided stable funding to banks. Third, we work to rule out loan demand explanations for our results by exploiting geographical exposure from the FDIC Summary of Deposits and loan account data available from Call Reports.

Because we look at the whole banking system, our regressions can help draw out the macroeconomic implications of our results. We quantify how much credit would have contracted if banks had entered the fall of 2008 less exposed to liquidity risk. This analysis suggests that the pressure on bank balance sheets from takedowns on preexisting loan commitments and funding problems from wholesale markets account for most of the decline in new credit production. New credit production—that is, the sum of both on-balance sheet loans and undrawn commitments—fell by about $500 billion in the fourth quarter of 2008 (out of a total of slightly more than $14 trillion of total loans plus undrawn commitments to lend at the end of 2008). Had liquidity exposure been in the lower quartile across the whole banking system, our estimates suggest that new credit would have fallen by just $87 billion, or almost 90% less than the unadjusted figure.

In the remainder of the paper, we provide in Section 2 a brief chronology of the financial crisis to 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 3. We conclude in Section 4.

## 2. The TED spread during the financial crisis of 2007–2009

The financial crisis of 2007–2009 is the biggest shock to the US 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.[2] Fig. 3 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. 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 crisis began in the summer of 2007 when the asset-backed commercial paper market began to unravel in the face of uncertainty about the value and liquidity of some mortgage-backed securities (Acharya and Schnabl, 2010). The brewing crisis can be seen in the TED spread [the difference between the three-month London Interbank Offered Rate (LIBOR) and the three-month Treasury rate], which spiked above 200 basis points. From then until the spring of 2009, the TED spread (as well as other similar indicators) remained both elevated and volatile. 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 Fig. 4. [Fig. 4 also shows (in the shaded area) the period we designate as the crisis period in our robustness test below.]

Time variation in the TED spread tracks the severity of the crisis closely. For instance, the TED spread spiked in March 2008 as Bear Stearns failed. Conditions improved following the Bear Stearns bailout, and the TED spread subsided. In the summer of 2008, however, concerns about mortgage foreclosures rose, further downgrades of mortgage-backed securities by the credit rating agencies

[2] See Brunnermeier (2009) for a detailed discussion of these events.

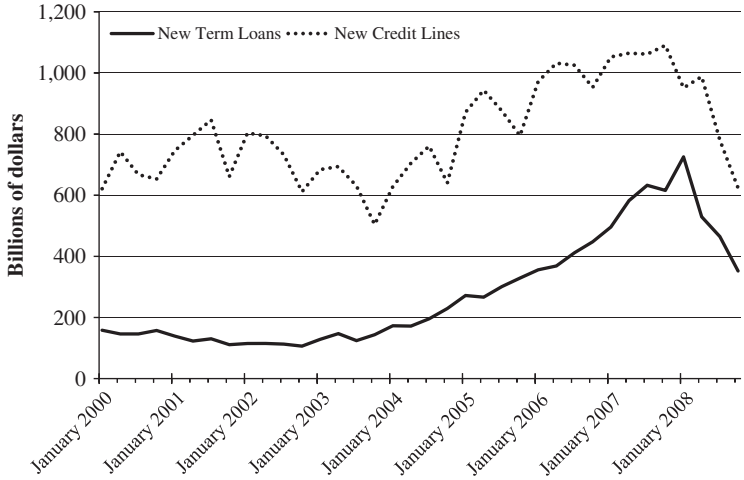


**Fig. 3.** Business loan originations collapse. This figure shows the dollar value of new term loans and credit lines issued to large businesses from 2000 (before the financial crisis) through 2008 (at the height of the financial crisis). Data used to construct the figure are obtained from the Loan Pricing Corporation's Dealscan database.

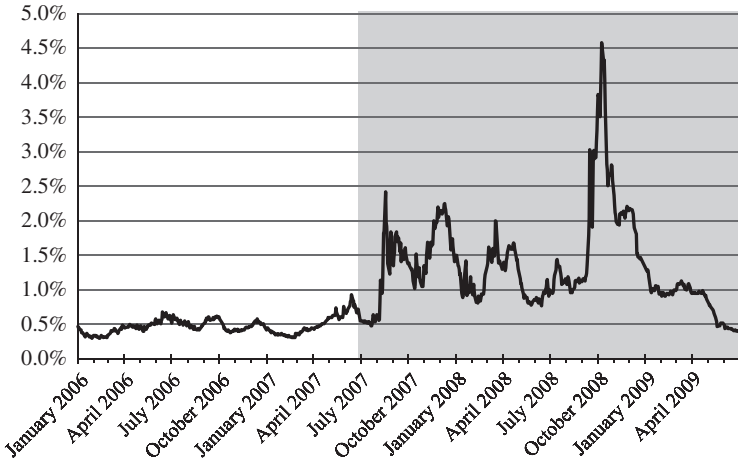


**Fig. 4.** The TED spread. This figure shows movements in the TED spread from 2006 through the second quarter of 2009. The TED spread is calculated as the difference between the three-month London Interbank Offered Rate (LIBOR) rate [obtained from the website of the Bulgarian National Bank (www.bnb.bg/#)] and the three-month Treasury rate [from the Federal Reserve Economic Data (FRED) website of the Federal Reserve Bank of St. Louis (http://research.stlouisfed.org/fred2/)]. The shaded area includes the period we designate the crisis period in our empirical analysis.

occurred, and losses to holders of these securities mounted. Losses on mortgages and mortgage-backed securities eventually led to the failure of several financial institutions, notably, Fannie Mae (Federal National Mortgage Association) and Freddie Mac (Federal Home Loan Mortgage Corporation) and then American International Group, Inc. (AIG) and Lehman Brothers. The depth of the crisis dramatically expanded when financial markets were shocked by the collapse of these institutions, along with the distressed sale of Merrill Lynch to Bank of America. The panic soon spread, leading to the expansion of insurance on deposits and interbank funds, first in Europe and then very quickly in the United States. The crisis truly abated only in the spring of 2009 when the stress tests of the large US banks brought private capital back into the system.

## 3. 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.

### 3.1. 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 could 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) (see Bhattacharya and Thakor (1993); Diamond and Rajan (2001b)). 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. In addition, Kashyap, Rajan, and Stein (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 (2009) 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 support to this notion. Gatev, Schuermann, and Strahan (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. Gorton and Winton (2000) conclude that regulators should be especially aware of these effects during recessionary environments, i.e., periods when regulators could 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 (2010) find that 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.[3] For example, Hannan and Hanweck (1988) find uninsured depositors require higher interest rates at riskier banks, and Maechler and McDill (2006) suggest uninsured depositors might not supply liquidity to weak banks at any price. Avery, Belton, and Goldberg (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. The Comptroller of the Currency's statement before Congress on September 19, 1984 that some financial institutions are too-big-to-fail (TBTF) was a positive wealth event for banks deemed TBTF (see O'Hara and Shaw, 1990). Further evidence is provided by Black, Collins, Robinson, and Schweitzer (1997), who observe a flight to quality as evidenced by changes in institutional ownership of TBTF bank equity shares.

### 3.2. Empirical specification

The discussion above suggests four key drivers of liquidity risk management for banks: (1) the composition of the asset portfolio (i.e., the market liquidity of assets), (2) core deposits as a fraction of total financial structure, (3) equity capital as a fraction of financial structure, and (4) funding liquidity exposure stemming from loan commitments (i.e., new loan originations via drawdowns). Asset size also likely relates to liquidity management, but it proxies for many other sources of heterogeneity. Hence, we include this variable in all of our regressions but refrain from interpreting its effect.

Our identification strategy is based on the premise that tight liquidity conditions during the financial crisis, measured by the TED spread, surprised banks and thus changed their management of liquidity risk exposure. That is, banks with high liquidity risk exposure would be expected to build up cash and other liquid assets and also to reduce new lending (particularly new commitments to lend) more than banks with low liquidity risk exposure when the TED spread spikes. We test this idea by interacting the TED spread with our four measures of liquidity exposure.

We build a quarterly panel data set 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

[3] 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.

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 can control for the normal impact (or correlation) of the liquidity exposure measures in our model and focus on the interaction of the TED spread with those variables. To be specific, we estimate the following three regressions:

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

$$\begin{aligned}\Delta Loans_{i,t}/Assets_{i,t-1} &= T_t^2 + B_i^2 + \gamma^1 Illiquid\ Assets/Assets_{i,t-1} \\ &+ \gamma^2 Illiquid\ Assets/Assets_{i,t-1} * TED_t \\ &+ \gamma^3 Core\ Deposits/Assets_{i,t-1} \\ &+ \gamma^4 Core\ Deposits/Assets_{i,t-1} * TED_t \\ &+ \gamma^5 Capital/Assets_{i,t-1} \\ &+ \gamma^6 Capital/Assets_{i,t-1} * TED_t \\ &+ \gamma^7 Commit/(Commit + Assets)_{i,t-1} \\ &+ \gamma^8 Commit/(Commit + Assets)_{i,t-1} * TED_t \\ &+ \gamma^9 Log\ Assets_{i,t-1} \\ &+ \gamma^{10} Log\ Assets_{i,t-1} * TED_t + \eta_{i,t}, \end{aligned} \tag{2}$$

and

$$\begin{aligned}\Delta Credit_{i,t}/(Commit + Assets)_{i,t-1} &= T_t^3 + B_i^3 + \lambda^1 Illiquid\ Assets/Assets_{i,t-1} \\ &+ \lambda^2 Illiquid\ Assets/Assets_{i,t-1} * TED_t \\ &+ \lambda^3 Core\ Deposits/Assets_{i,t-1} \\ &+ \lambda^4 Core\ Deposits/Assets_{i,t-1} * TED_t \\ &+ \lambda^5 Capital/Assets_{i,t-1} \\ &+ \lambda^6 Capital/Assets_{i,t-1} * TED_t \\ &+ \lambda^7 Commit/(Commit + Assets)_{i,t-1} \\ &+ \lambda^8 Commit/(Commit + Assets)_{i,t-1} * TED_t \\ &+ \lambda^9 Log\ Assets_{i,t-1} \\ &+ \lambda^{10} Log\ Assets_{i,t-1} * TED_t + \mu_{i,t}, \end{aligned} \tag{3}$$

where $T^1$, $T^2$, and $T^3$ are time 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. Because our panel covers 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 be interpreted only relative to the omitted category. We estimate each of these relations 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 Section 3.3. Variables are winsorized at the 1st and 99th percentiles.

Regression Eq. (1) tests how banks adjust their holdings of liquid assets, regression Eq. (2) tests how bank lending on the balance sheet adjusts, and regression Eq. (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 preexisting commitments (off-balance sheet items while undrawn). Hence, takedowns of previous commitments, which increased during the financial crisis after the commercial paper market dried up, could 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 Eq. (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. That is, loan commitment drawdowns do not affect this measure of overall credit supply because unused commitments decrease by the same level that loans increase. 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 instead of just total assets.

During the crisis, banks were no longer able to securitize loans (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 nonexistent. 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, $\lambda^8 < 0$).

In addition to the models in regression Eqs. (1)–(3), we report models using an indicator variable for the crisis period instead of the TED spread. We set the crisis

indicator equal to one from 2007Q3 through 2009Q2 (see Fig. 4).

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 regression Eqs. (1)–(3). Said differently, we are sidestepping the problem that policy makers, 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 Eq. (1) allows us to understand how that liquidity was distributed across the banking system, which is endogenously determined by variations in banks' liquidity demands.

### 3.3. Data

We build our panel data set from the quarterly FFIEC Call Reports, which all regulated commercial banks file with their primary regulator.[4] Because some banks are owned by a common holding company, we aggregate the bank-level data for banks with common ownership because these ownership ties could foster liquidity sharing across subsidiaries (see Houston, James, and Marcus, 1997). Specifically, we sum Call Reports data at the highest holding company level for multibank 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 and Federal Reserve guidelines, we segregate banks into two size groups based on beginning of quarter book value of assets: large banks have assets of greater than $1 billion and small banks have assets less than or equal to $1 billion. Banks with asset growth greater than 10% 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 Reports 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 ($\Delta Liquid\ Assets_{i,t}/Assets_{i,t-1}$), 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 ($\Delta Credit_{i,t}/(Commit+Assets)_{i,t-1}$). While Loutskina (in press) finds that securitizable assets offer banks a liquidity buffer during normal markets, these markets dried up starting in the summer of 2007. We thus drop mortgage-backed securities and asset-backed securities from our definition of liquid assets and instead include them in our measure of illiquid assets.[5] In addition, we report an alternative measure of the change in liquid assets that includes just cash plus US government securities plus Fed funds sold and securities purchased under agreements to resell, but it leaves out other securities. US government securities clearly maintained their liquidity in the crisis, whereas Fed funds and reverse repos remained highly liquid due to their very short maturity.[6]

**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 *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 |

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 ($Illiquid\ Assets/Assets_{i,t-1}$), the fraction of the firm's balance sheet financed with core deposits at the beginning of the period ($Core\ Deposits/Assets_{i,t-1}$), 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 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 ($Log\ Assets_{i,t-1}$).[7] Each of these variables is included in the regressions independently and

[4] Call Reports data are publicly available at the website of the Federal Reserve Bank of Chicago (www.chicagofed.org).

[5] 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.

[6] Repurchases agreements (that is, the sale of assets with agreement to repurchase them) were a source of funding problems for firms such as Bear Stearns and Lehman Brothers. However, we are looking at banks as lenders, not as borrowers, in this market. That is, our measure of liquid assets includes only so-called reverse repos, in which the position acts as an asset to the bank instead of as a liability.

[7] Specifically, *Illiquid Assets* = loans and leases net of unearned income and allowances + MBS and ABS HTM securities + MBS and ABS AFS securities. Core deposits are defined as the sum of deposits under $100,000 plus all transactions deposits.

**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 are 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 US commercial banks over the period 2006Q1 through 2009Q2. Crisis quarters cover 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). Tests for significant differences in means are based on unpaired *t*-tests. Tests for significant differences between large bank and small bank medians are based on the Wilcoxon–Mann–Whitney test statistic. ***, **, and * denote that the large bank sample differs significantly from the small bank sample at the 1%, 5%, and 10% level, respectively.

| | Average | 25th percentile | Median | 75th percentile | Standard deviation |
|---|---|---|---|---|---|
| *Panel A: Large banks during noncrisis quarters* | | | | | |
| Δ*Liquid Assets*/*Assets* (percent) | −0.18*** | −1.17 | −0.09*** | 0.99 | 2.92 |
| Δ(*Cash*+*US Treas*+*Fed Funds*+*Repos*)/*Assets* (percent) | −0.10*** | −0.86 | −0.01*** | 0.76 | 2.51 |
| Δ*Loans*/*Assets* (percent) | 1.39 | 0.29 | 1.33*** | 2.57 | 3.03 |
| Δ*Credit Supply*/(*Commit*+*Assets*) (percent) | 1.60*** | 0.22 | 1.46*** | 2.91 | 3.63 |
| *Panel B: Small banks during noncrisis quarters* | | | | | |
| Δ*Liquid Assets*/*Assets* (percent) | −0.40 | −2.17 | −0.21 | 1.64 | 4.11 |
| Δ(*Cash*+*US Treas*+*Fed Funds*+*Repos*)/*Assets* (percent) | −0.36 | −1.95 | −0.15 | 1.49 | 4.12 |
| Δ*Loans*/*Assets* (percent) | 1.32 | −0.31 | 1.06 | 2.72 | 3.33 |
| Δ*Credit Supply*/(*Commit*+*Assets*) (percent) | 1.41 | −0.38 | 1.06 | 2.89 | 3.97 |
| *Panel C: Large banks during crisis quarters* | | | | | |
| Δ*Liquid Assets*/*Assets* (percent) | −0.22* | −1.41 | −0.20 | 1.05 | 3.39 |
| Δ(*Cash*+*US Treas*+*Fed Funds*+*Repos*)/*Assets* (percent) | 0.02 | −0.88 | −0.02 | 0.92 | 3.10 |
| Δ*Loans*/*Assets* (percent) | 0.85*** | −0.40 | 0.83 | 2.13 | 3.39 |
| Δ*Credit Supply*/(*Commit*+*Assets*) (percent) | 0.50*** | −0.90 | 0.54*** | 1.98 | 4.08 |
| *Panel D: Small banks during crisis quarters* | | | | | |
| Δ*Liquid Assets*/*Assets* (percent) | −0.34 | −2.30 | −0.21 | 1.91 | 4.43 |
| Δ(*Cash*+*US Treas*+*Fed Funds*+*Repos*)/*Assets* (percent) | −0.07 | −1.84 | 0.01 | 1.96 | 4.41 |
| Δ*Loans*/*Assets* (percent) | 1.04 | −0.60 | 0.76 | 2.44 | 3.39 |
| Δ*Credit Supply*/(*Commit*+*Assets*) (percent) | 0.96 | −0.80 | 0.65 | 2.40 | 4.98 |
| *Panel E: Large banks during 2008Q4* | | | | | |
| Δ*Liquid Assets*/*Assets* (percent) | 0.54** | −0.81 | 0.15 | 1.79 | 3.09 |
| Δ(*Cash*+*US Treas*+*Fed Funds*+*Repos*) /*Assets* (percent) | 0.47* | −0.52 | 0.12 | 1.33 | 2.72 |
| Δ*Loans*/*Assets* (percent) | 0.54*** | −0.32 | 0.75 | 1.94 | 4.40 |
| Δ*Credit Supply*/(*Commit*+*Assets*) (percent) | 0.07*** | −1.16 | 0.20*** | 1.46 | 5.01 |
| *Panel F: Small banks during 2008Q4* | | | | | |
| Δ*Liquid Assets*/*Assets* (percent) | 0.16 | −1.65 | 0.16 | 2.22 | 4.41 |
| Δ(*Cash*+*US Treas*+*Fed Funds*+*Repos*) /*Assets* (percent) | 0.14 | −1.50 | 0.18 | 2.12 | 4.39 |
| Δ*Loans*/*Assets* (percent) | 0.97 | −0.53 | 0.81 | 2.40 | 3.22 |
| Δ*Credit Supply*/(*Commit*+*Assets*) (percent) | 0.73 | −0.83 | 0.56 | 2.20 | 3.57 |
| *Panel G: Large bank characteristics* | | | | | |
| *Illiquid Assets*/*Assets* (percent) | 77.88*** | 74.36 | 79.95*** | 84.82 | 11.41 |
| *Core Deposits*/*Assets* (percent) | 58.57*** | 52.97 | 61.08*** | 67.80 | 14.41 |
| *Capital*/*Assets* (percent) | 11.69*** | 9.56 | 10.39*** | 11.96 | 5.54 |
| *Commit*/(*Commit*+*Assets*) (percent) | 16.79*** | 10.89 | 15.22*** | 19.84 | 11.10 |
| *Book Value of Total Assets* ($MM) | 19,739.53*** | 1,378.79 | 2,135.22*** | 5,361.55 | 116,421.91 |
| *Panel H: Small bank characteristics* | | | | | |
| *Illiquid Assets*/*Assets* (percent) | 70.27 | 63.09 | 73.34 | 80.86 | 15.10 |
| *Core Deposits*/*Assets* (percent) | 66.44 | 60.86 | 67.88 | 74.08 | 11.63 |
| *Capital*/*Assets* (percent) | 18.56 | 11.12 | 13.71 | 18.43 | 104.65 |
| *Commit*/(*Commit*+*Assets*) (percent) | 9.18 | 4.87 | 8.34 | 12.24 | 7.02 |
| *Book Value of Total Assets* ($MM) | 195.39 | 59.08 | 123.22 | 254.98 | 197.35 |

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 (www.bnb.bg/#)] and the three-month US Treasury rate [from the Federal Reserve Economic Data (FRED) website of the Federal Reserve Bank of St. Louis (http://research.stlouisfed.org/fred2/)]. 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., $\beta^2$, $\beta^4$, $\beta^6$, $\beta^8$, and $\beta^{10}$ in regression Eq. (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 noncrisis 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 noncrisis quarters. For large banks, the mean (median) percentage change in loans to assets is 1.39 (1.33) during the noncrisis 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 noncrisis 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 noncrisis 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 noncrisis 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 noncrisis period. While mean and median liquid assets fall on average during both noncrisis 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 noncrisis period and −0.22 (−0.20) during the crisis period, yet it 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. We see the same pattern with the alternative measure of liquidity (change in cash plus US government securities plus Fed funds sold and securities purchased under agreements to resell to assets). We also test equality of the means and medians across the two samples. We find that while credit grew faster at large banks during normal quarters, it grew significantly slower during the crisis quarters. This likely reflects the greater effect of the liquidity crisis on the larger banks.

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% and 18.56%, respectively, and at large banks they are 58.75% and 11.69%, respectively. Further, large banks have more illiquid assets per dollar of total assets than small banks (77.80% versus 70.27%) and also hold a greater fraction of unused commitments compared with small banks (16.79% versus 9.18%). All of these differences are statistically significant at the 1% level. These simple comparisons suggest that large banks are more exposed to liquidity risk than small banks across all four dimensions: more undrawn commitments, less capital, less reliance on core deposits, and lower liquidity of balance sheet assets.

### 3.4. Regression results

Table 3 reports our models for regression Eqs. (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 greater decreases in credit origination. The interaction between the TED spread and each exposure measure enters the regressions in every case with opposite signs (compare Columns 1 and 4 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 4). 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 of Table 3). Taken together, this is strong evidence that banks built up liquidity buffers to offset the increased risk during 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 3) are consistent with those for total credit production (Column 4) 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 takedown 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 that were more exposed to preexisting commitments.

In Table 4, we replace the TED spread with an indicator variable equal to one during the quarters in which TED was elevated, i.e., 2007Q3 through 2009Q2. 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 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 zero and one.

One of our most consistent findings is that core deposits (transactions deposits plus other insured funds) helped banks sustain lending. In fact, in unreported tests we add wholesale deposits (uninsured, nontransactions deposits) as an 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.

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.[8] Further,

[8] Billett, Garfinkel, and O'Neal (1998) also find at the micro level that distressed banks tend to substitute insured deposits for uninsured deposits.

**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 US 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 (www.chicagofed.org). Banks with asset growth greater than 10% 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 US Treasury bill secondary market rate. LIBOR data are from the Bulgarian National Bank website (www.bnb.bg/#) and Treasury bill data are from the Federal Reserve Economic Data (FRED) website of the Federal Reserve Bank of St. Louis (http://research.stlouisfed.org/fred2/). Standard errors, clustered at the firm level, are reported in parentheses. ***, **, and * denote that the coefficients are statistically significantly different from zero at the 1%, 5%, and 10% level, respectively.

| | $\Delta Liquid\ assets_t / Assets_{t-1}$ | $\Delta(Cash+US\ Treas+Fed\ Funds+Repos_t)/Assets_{t-1}$ | $\Delta Loans_t / Assets_{t-1}$ | $\Delta Credit_t / (Commit+Assets)_{t-1}$ |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| *Panel A: Large banks (total assets > $1 billion)* | | | | |
| *Illiquid Assets/Assets*$_{t-1}$ | 0.209*** | 0.187*** | −0.015 | 0.030* |
| | (0.023) | (0.020) | (0.014) | (0.017) |
| *Illiquid Assets/Assets*$_{t-1}$**TED* | 2.423*** | 0.773 | −1.145* | −1.340* |
| | (0.863) | (0.710) | (0.678) | (0.762) |
| *Core Deposits/Assets*$_{t-1}$ | 0.004 | 0.004 | −0.025*** | −0.044*** |
| | (0.014) | (0.010) | (0.009) | (0.011) |
| *Core Deposits/Assets*$_{t-1}$**TED* | −0.837 | −0.440 | 1.231*** | 1.356** |
| | (0.663) | (0.601) | (0.453) | (0.555) |
| *Capital/Assets*$_{t-1}$ | −0.042 | −0.096** | 0.042 | 0.088* |
| | (0.050) | (0.039) | (0.037) | (0.054) |
| *Capital/Assets*$_{t-1}$**TED* | −0.499 | −2.314 | 5.732** | 5.984** |
| | (2.233) | (2.068) | (2.637) | (2.699) |
| *Commit/(Commit+Assets)*$_{t-1}$ | 0.070*** | −0.065*** | 0.176*** | −0.012 |
| | (0.023) | (0.018) | (0.027) | (0.032) |
| *Commit/(Commit+Assets)*$_{t-1}$**TED* | 0.933 | 0.602 | 2.303** | −2.753*** |
| | (0.961) | (0.736) | (0.937) | (0.855) |
| *Log Assets*$_{t-1}$ | −0.016*** | −0.017*** | −0.017*** | −0.027*** |
| | (0.005) | (0.004) | (0.005) | (0.007) |
| *Log Assets*$_{t-1}$**TED* | 0.186*** | 0.132** | 0.064 | 0.131* |
| | (0.072) | (0.061) | (0.052) | (0.067) |
| Firm dummies | Yes | Yes | Yes | Yes |
| Quarterly time dummies | Yes | Yes | Yes | Yes |
| *N* | 6,462 | 6,462 | 6,462 | 6,462 |
| Adjusted *R*-squared | 0.244 | 0.205 | 0.404 | 0.342 |
| *Panel B: Small banks (total assets ≤ $1 billion)* | | | | |
| *Illiquid Assets/Assets*$_{t-1}$ | 0.291*** | 0.278*** | −0.067*** | −0.051*** |
| | (0.011) | (0.007) | (0.004) | (0.006) |
| *Illiquid Assets/Assets*$_{t-1}$**TED* | 0.240 | −0.702*** | −0.546*** | −0.516*** |
| | (0.296) | (0.265) | (0.163) | (0.183) |
| *Core Deposits/Assets*$_{t-1}$ | −0.028*** | −0.039*** | 0.002 | −0.002 |
| | (0.006) | (0.005) | (0.005) | (0.006) |
| *Core Deposits/Assets*$_{t-1}$**TED* | −0.229 | −0.871*** | 0.673*** | 1.553*** |
| | (0.295) | (0.268) | (0.204) | (0.238) |
| *Capital/Assets*$_{t-1}$ | −0.008 | −0.006 | 0.070*** | 0.067*** |
| | (0.012) | (0.013) | (0.009) | (0.012) |
| *Capital/Assets*$_{t-1}$**TED* | −1.456*** | −2.744*** | 1.135*** | 1.058*** |
| | (0.500) | (0.471) | (0.273) | (0.325) |
| *Commit/(Commit+Assets)*$_{t-1}$ | −0.167*** | −0.152*** | 0.295*** | −0.137*** |
| | (0.010) | (0.010) | (0.009) | (0.012) |
| *Commit/(Commit+Assets)*$_{t-1}$**TED* | 3.090*** | 1.933*** | 1.071** | −3.034*** |
| | (0.611) | (0.568) | (0.459) | (0.557) |
| *Log Assets*$_{t-1}$ | −0.040*** | −0.039*** | −0.015*** | −0.028*** |
| | (0.003) | (0.003) | (0.004) | (0.006) |
| *Log Assets*$_{t-1}$**TED* | −0.311*** | −0.269*** | 0.079*** | 0.021 |
| | (0.033) | (0.029) | (0.022) | (0.024) |
| Firm dummies | Yes | Yes | Yes | Yes |
| Quarterly time dummies | Yes | Yes | Yes | Yes |
| *N* | 78,581 | 78,581 | 78,581 | 78,581 |
| Adjusted *R*-squared | 0.270 | 0.253 | 0.380 | 0.299 |

**Table 4**
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 US 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 (www.chicagofed.org). Banks with asset growth greater than 10% 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 that the coefficients are statistically significantly different from zero at the 1%, 5%, and 10% level, respectively.

| | $\Delta Liquid\ Assets_t/Assets_{t-1}$ | $\Delta(Cash+US\ Treas+Fed\ Funds+Repos_t)/Assets_{t-1}$ | $\Delta Loans_t/Assets_{t-1}$ | $\Delta Credit_t/(Commit+Assets)_{t-1}$ |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| *Panel A: Large banks (total assets > $1 billion)* | | | | |
| *Illiquid Assets/Assets*$_{t-1}$ | 0.205*** | 0.180*** | −0.012 | 0.029* |
| | (0.022) | (0.019) | (0.013) | (0.017) |
| *Illiquid/Assets*$_{t-1}$**CRISIS* | 0.048*** | 0.023** | −0.021** | −0.020** |
| | (0.012) | (0.009) | (0.008) | (0.009) |
| *Core Deposits/Assets*$_{t-1}$ | −0.002 | 0.000 | −0.022*** | −0.041*** |
| | (0.012) | (0.008) | (0.008) | (0.011) |
| *Core Deposits/Assets*$_{t-1}$**CRISIS* | −0.002 | 0.001 | 0.020*** | 0.021*** |
| | (0.008) | (0.007) | (0.006) | (0.007) |
| *Capital/Assets*$_{t-1}$ | −0.065 | −0.123*** | 0.064* | 0.109** |
| | (0.048) | (0.038) | (0.035) | (0.050) |
| *Capital/Assets*$_{t-1}$**CRISIS* | 0.033 | −0.010 | 0.063* | 0.072** |
| | (0.030) | (0.026) | (0.032) | (0.033) |
| *Commit/(Commit+Assets)*$_{t-1}$ | −0.069*** | −0.064*** | 0.189*** | −0.020 |
| | (0.022) | (0.018) | (0.025) | (0.031) |
| *Commit/(Commit+Assets)*$_{t-1}$**CRISIS* | 0.020* | 0.013 | 0.014 | −0.039*** |
| | (0.011) | (0.010) | (0.012) | (0.011) |
| *Log Assets*$_{t-1}$ | −0.016*** | −0.017*** | −0.017*** | −0.025*** |
| | (0.005) | (0.004) | (0.005) | (0.007) |
| *Log Assets*$_{t-1}$**CRISIS* | 0.002** | 0.001 | 0.002*** | 0.002*** |
| | (0.001) | (0.001) | (0.001) | (0.001) |
| Firm dummies | Yes | Yes | Yes | Yes |
| Quarterly time dummies | Yes | Yes | Yes | Yes |
| *N* | 6,462 | 6,462 | 6,462 | 6,462 |
| Adjusted *R*-squared | 0.246 | 0.205 | 0.407 | 0.346 |
| *Panel B: Small banks (total assets < $1 billion)* | | | | |
| *Illiquid Assets/Assets*$_{t-1}$ | 0.286*** | 0.274*** | −0.068*** | −0.049*** |
| | (0.007) | (0.007) | (0.004) | (0.005) |
| *Illiquid/Assets*$_{t-1}$**CRISIS* | 0.014*** | −0.003 | −0.009*** | −0.012*** |
| | (0.003) | (0.003) | (0.002) | (0.002) |
| *Core Deposits/Assets*$_{t-1}$ | −0.032*** | −0.044*** | 0.005 | 0.001 |
| | (0.005) | (0.005) | (0.005) | (0.006) |
| *Core Deposits/Assets*$_{t-1}$**CRISIS* | 0.003 | −0.008** | 0.007** | 0.022*** |
| | (0.004) | (0.003) | (0.003) | (0.003) |
| *Capital/Assets*$_{t-1}$ | −0.016 | −0.015 | 0.073*** | 0.071*** |
| | (0.011) | (0.012) | (0.009) | (0.011) |
| *Capital/Assets*$_{t-1}$**CRISIS* | −0.006 | −0.029*** | 0.017*** | 0.021*** |
| | (0.006) | (0.006) | (0.004) | (0.004) |
| *Commit/(Commit+Assets)*$_{t-1}$ | −0.159*** | −0.150*** | 0.300*** | −0.150*** |
| | (0.010) | (0.009) | (0.009) | (0.011) |
| *Commit/(Commit+Assets)*$_{t-1}$**CRISIS* | 0.038*** | 0.029*** | 0.004 | −0.046*** |
| | (0.007) | (0.007) | (0.005) | (0.007) |
| *Log Assets*$_{t-1}$ | −0.041*** | −0.040*** | −0.014*** | −0.025*** |
| | (0.003) | (0.003) | (0.004) | (0.005) |
| *Log Assets*$_{t-1}$**CRISIS* | −0.004*** | −0.003*** | 0.001*** | 0.000 |
| | (0.000) | (0.000) | (0.000) | (0.000) |
| Firm dummies | Yes | Yes | Yes | Yes |
| Quarterly time dummies | Yes | Yes | Yes | Yes |
| *N* | 78,581 | 78,581 | 78,581 | 78,581 |
| Adjusted *R*-squared | 0.270 | 0.253 | 0.381 | 0.302 |

the Federal Deposit Insurance Corporation extended its insurance coverage to virtually 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 Fig. 2

**Table 5**
Fixed effects regressions of credit growth on TED spread, firm characteristics, and interactions: standardized regression coefficients.

This table reports fixed effects regressions of quarterly 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 US commercial banks over the period 2006Q1 through 2009Q2. 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 (www.chicagofed.org). Banks with asset growth greater than 10% 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 US Treasury bill secondary market rate. LIBOR data are from the Bulgarian National Bank website (www.bnb.bg/#) and Treasury bill data are from the Federal Reserve Economic Data (FRED) website of the Federal Reserve Bank of St. Louis (http://research.stlouisfed.org/fred2/). Standard errors, clustered at the firm level, are reported in parentheses. ***, **, and * denote that the coefficients are statistically significantly different from zero at the 1%, 5%, and 10% level, respectively.

| | Large banks (total assets $>$ \$1 billion) | Medium banks (total assets \$500 million to \$1 billion) | Small banks (total assets \$100 million to \$500 million) | Smallest banks (total assets $\leq$ \$100 million) |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| *Illiquid Assets*/*Assets*$_{t-1}$ | 0.116* | −0.111** | −0.180*** | −0.383*** |
| | (0.068) | (0.055) | (0.028) | (0.033) |
| *Illiquid Assets*/*Assets*$_{t-1}$**TED* | −5.253* | −5.581*** | −2.235** | −1.493 |
| | (2.989) | (2.146) | (1.140) | (1.187) |
| *Core Deposits*/*Assets*$_{t-1}$ | −0.230*** | −0.117** | −0.043* | 0.037 |
| | (0.058) | (0.048) | (0.026) | (0.034) |
| *Core Deposits*/*Assets*$_{t-1}$**TED* | 7.050** | 6.608*** | 4.565*** | 3.929*** |
| | (2.886) | (2.523) | (1.045) | (1.259) |
| *Capital*/*Assets*$_{t-1}$ | 0.134* | 0.056 | 0.237*** | 0.017 |
| | (0.082) | (0.104) | (0.040) | (0.044) |
| *Capital*/*Assets*$_{t-1}$**TED* | 9.120** | -0.612 | 2.349** | 3.024* |
| | (4.113) | (2.315) | (1.081) | (1.605) |
| *Commit*/(*Commit*+*Assets*)$_{t-1}$ | −0.048 | −0.148** | −0.171*** | −0.421*** |
| | (0.123) | (0.070) | (0.028) | (0.028) |
| *Commit*/(*Commit*+*Assets*)$_{t-1}$**TED* | −10.702*** | −4.714* | −5.057*** | −2.295* |
| | (3.322) | (2.726) | (1.287) | (1.254) |
| *Log Assets*$_{t-1}$ | −1.246*** | −0.325*** | −0.641*** | −0.708*** |
| | (0.318) | (0.060) | (0.048) | (0.073) |
| *Log Assets*$_{t-1}$**TED* | 6.091* | −1.751 | 0.078 | 1.573 |
| | (3.118) | (2.091) | (0.985) | (1.121) |
| Firm dummies | Yes | Yes | Yes | Yes |
| Quarterly time dummies | Yes | Yes | Yes | Yes |
| *N* | 6,462 | 7,097 | 38,166 | 33,318 |
| Adjusted *R*-squared | 0.342 | 0.347 | 0.300 | 0.367 |

(which shows weekly changes in core and wholesale deposits at commercial banks from September 10, 2008 through January 10, 2009).[9] 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 that were more reliant on core deposit financing faced fewer liquidity problems during the crisis than banks that relied more heavily on wholesale sources of debt financing.

### 3.5. Magnitudes and macro-implications for credit production

We offer two distinct ways to assess the economic magnitude of liquidity exposure on credit production. First, we reestimate our regressions for banks in different size bins and report standardized coefficients, in which both the dependent variable and each of the bank-level characteristics are divided by the standard deviation of that variable across the sample. (We do not normalize the TED spread because this shock is common across the sample.) We estimate our model separately for banks in different size bins: those with assets below \$100 million, those with assets between \$100 million and \$500 million, those with assets between \$500 million and \$1 billion, and those with assets above \$1 billion.

The results (presented in Table 5) show that liquidity exposure mattered more in explaining how large banks adjust credit growth to liquidity shocks, the TED spread shock, than small banks. The standardized effects of the TED interactions are largest for banks in the highest asset-size bin in almost all cases. Thus, liquidity risk exposure affects the adjustments of credit, relative to observed variations across the sample, more for larger banks than smaller banks. This seems, at first blush, counterintuitive but could be understood by the fact that larger banks entered the crisis much more exposed than smaller banks across all four dimensions. They had lower capital, more unused commitments, greater reliance on wholesale funds, and higher holdings of illiquid assets (recall Table 2).

Second, Table 6 summarizes the economic magnitude, in dollar terms, implicit in our model. We answer the

[9] Source is the Federal Reserve's H8 weekly data on bank assets and liabilities.

**Table 6**
Economic impact of liquidity shocks during 2008Q4.

This table reports the estimated effect of the liquidity shock in the financial crisis on changes in liquid assets, loans, and credit supply in 2008Q4. We adjust the actual changes in 2008Q4 as if each right-hand side variable observed below the 75th percentile (measured 2007Q4) had been equal to the 75th percentile level to simulate the response of the banking system if all banks had had low liquidity exposure. Panel A subjects banks to the 250 basis points TED spread shock observed in 2008Q4 and uses coefficients from Table 3; Panel B subjects banks to the overall shock of moving into the financial crisis regime and uses the coefficients from Table 4. ***, **, and * denote that the coefficient estimates are statistically significantly different from zero at the 1%, 5%, and 10% levels, respectively. The data are observed quarterly for a panel of US commercial banks over the period 2006Q1 through 2009Q2.

| | $\Delta Liquid\ Assets_{2008Q4}$ | $\Delta(Cash+US\ Treas+Fed\ Funds+Repos)_{2008Q4}$ | $\Delta Loans_{2008Q4}$ | $\Delta Credit_{2008Q4}$ |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| *Panel A: Large banks (total assets > $1 billion) (N=427), based on coefficients from Table 3* | | | | |
| Actual change ($BN) | 168 | 121 | −52 | −503 |
| *Illiquid Assets* adjustment ($BN) | −10*** | −3 | 5* | 6* |
| *Core Deposits* adjustment ($BN) | −53 | −28 | 79*** | 86** |
| *Capital* adjustment ($BN) | −2 | −10 | 25** | 26** |
| *Commit* adjustment ($BN) | −101 | −65 | −249** | 297*** |
| Adjusted change ($BN) | 2 | 15 | −192 | −87 |
| *Panel B: Large banks (total assets > $1 billion) (N=427), based on coefficients from Table 4* | | | | |
| Actual change ($BN) | 168 | 121 | −52 | −503 |
| *Illiquid Assets* adjustment ($BN) | −8*** | −4** | 3** | 3** |
| *Core Deposits* adjustment ($BN) | −5 | 3 | 51*** | 53*** |
| *Capital* adjustment ($BN) | 6 | −2 | 11* | 13** |
| *Commit* adjustment ($BN) | −86* | −56 | −60 | 168*** |
| Adjusted change ($BN) | 75 | 62 | −47 | −265 |

following hypothetical questions: How much less cash and other liquid assets would banks have accumulated if exposure to liquidity risk had been low throughout the banking system? How much more credit would banks have supplied had exposure to liquidity risk been low throughout the system? (We assume in this exercise that the coefficients would remain constant in an environment of lower overall exposure to liquidity risk.)

To answer these questions, in Panel A of Table 6 we move each bank's liquidity exposure to the lowest quartile of the distribution and then reestimate the change in credit (or liquid assets) implicit in our regression models stemming from the TED spread shock observed in the fourth quarter of 2008. For example, consider a bank with $100 billion in assets, $60 billion in loans on balance sheet and $20 billion in unused loan commitments as of the end of 2007. Suppose that this hypothetical bank reduced its stock of credit ($60 billion in loans+$20 billion in unused commitment) by 1% during the fall of 2008; that is, suppose loans plus total unused commitments fell by $800 million. These figures represent a large bank operating at the 75th percentile of the distribution for the commitment ratios (20%, recall Table 2). For such a bank, we adjust its change in credit production as if it had commitment exposure at the 25th percentile (11%) in the face of the 250 basis points TED spread observed on average during the fall of 2008. That is, for this bank we estimate the following:

$$\textit{Actual change in credit} = -\$800 \text{ million},$$

$$\textit{Adjustment} = (0.11-0.20)*0.025*(-2.753)*\$120 \text{ billion} = +\$744 \text{ million},$$

and

$$\textit{Adjusted change in credit} = -\$56 \text{ million}.$$

The *adjusted change in credit* equals the actual change in credit plus the product of the hypothetical movement of liquidity exposure (0.11–0.20) times the TED spread (250 basis points) times the estimated interaction term (recall Table 3, Column 4) times the bank's precrisis sum of assets plus commitments ($120 billion). We then sum up the *adjusted change in credit* across all large banks to arrive at an aggregate estimate of how much credit would have changed in the fall of 2008 had all large banks entered the quarter with low liquidity exposure. (We make no adjustment for banks below the 25th percentile of commitment exposure.) We estimate similar adjustments across the other three dimensions of liquidity exposure. That is, we move banks below the 75th percentile of the core deposits distribution up to the 75th percentile; we move banks below the 75th percentile of the capital-asset distribution to the 75th percentile; and we move banks above the 25th percentile of the illiquid assets distribution down to the 25th percentile. For each of these changes, we aggregate up how liquid assets, loans, and total credit would have changed in the fall of 2008.

Panel B of Table 6 reproduces a similar experiment but uses the coefficients from the interaction of liquidity exposure with the crisis indicator. These adjustments are smaller and are perhaps a more conservative estimate because the TED spread reached its maximum in October 2008.

The total adjustments to liquidity accumulation and credit production are very large.[10] For example, large

[10] We estimate similar aggregates for small banks. These effects are much smaller because most of the assets in the banking system are held by large banks.

**Table 7**
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 US 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 commercial and industrial loans, 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 that the coefficients are statistically significantly different from zero at the 1%, 5%, and 10% level, respectively.

| | Base model (Table 3, Column 4) | With loan shares*TED | With state*TED effects |
|---|---|---|---|
| | (1) | (2) | (3) |
| *Panel A: Large banks (total assets $>$ $1 billion)* | | | |
| *Illiquid Assets/Assets$_{t-1}$* | 0.030* | 0.027 | 0.038** |
| | (0.017) | (0.017) | (0.017) |
| *Illiquid Assets/Assets$_{t-1}$*TED* | −1.340* | −0.897 | −1.787** |
| | (0.762) | (0.781) | (0.791) |
| *Core Deposits/Assets$_{t-1}$* | −0.044*** | −0.049*** | −0.045*** |
| | (0.011) | (0.012) | (0.012) |
| *Core Deposits/Assets$_{t-1}$*TED* | 1.356** | 1.594*** | 0.940 |
| | (0.555) | (0.567) | (0.594) |
| *Capital/Assets$_{t-1}$* | 0.088* | 0.091* | 0.095* |
| | (0.054) | (0.055) | (0.055) |
| *Capital/Assets$_{t-1}$*TED* | 5.984** | 5.581** | 5.093* |
| | (2.699) | (2.626) | (2.847) |
| *Commit/(Commit+Assets)$_{t-1}$* | −0.012 | −0.009 | −0.019 |
| | (0.032) | (0.031) | (0.032) |
| *Commit/(Commit+Assets)$_{t-1}$*TED* | −2.753*** | −3.676*** | −2.613*** |
| | (0.855) | (0.869) | (1.006) |
| *Log Assets$_{t-1}$* | −0.027*** | −0.028*** | −0.027*** |
| | (0.007) | (0.007) | (0.007) |
| *Log Assets$_{t-1}$*TED* | 0.131* | 0.112* | 0.234*** |
| | (0.067) | (0.067) | (0.081) |
| Firm dummies | Yes | Yes | Yes |
| Quarterly time dummies | Yes | Yes | Yes |
| Loan share and 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 | 0.347 |
| *Panel B: Small banks (total assets $\leq$ $1 billion)* | | | |
| *Illiquid Assets/Assets$_{t-1}$* | −0.051*** | −0.058*** | −0.049*** |
| | (0.006) | (0.005) | (0.006) |
| *Illiquid Assets/Assets$_{t-1}$*TED* | −0.516*** | −0.335* | −0.504*** |
| | (0.183) | (0.201) | (0.187) |
| *Core Deposits/Assets$_{t-1}$* | −0.002 | −0.008 | 0.001 |
| | (0.006) | (0.006) | (0.006) |
| *Core Deposits/Assets$_{t-1}$*TED* | 1.553*** | 1.394*** | 1.155*** |
| | (0.238) | (0.241) | (0.242) |
| *Capital/Assets$_{t-1}$* | 0.067*** | 0.056*** | 0.069*** |
| | (0.012) | (0.010) | (0.012) |
| *Capital/Assets$_{t-1}$*TED* | 1.058*** | 1.075*** | 0.915*** |
| | (0.325) | (0.343) | (0.328) |
| *Commit/(Commit+Assets)$_{t-1}$* | −0.137*** | −0.144*** | −0.138*** |
| | (0.012) | (0.012) | (0.012) |
| *Commit/(Commit+Assets)$_{t-1}$*TED* | −3.034*** | −2.881*** | −3.631*** |
| | (0.557) | (0.553) | (0.581) |
| *Log Assets$_{t-1}$* | −0.028*** | −0.038*** | −0.027*** |
| | (0.006) | (0.002) | (0.006) |
| *Log Assets$_{t-1}$*TED* | 0.021 | 0.030 | 0.063** |
| | (0.024) | (0.030) | (0.026) |
| Firm dummies | Yes | Yes | Yes |
| Quarterly time dummies | Yes | Yes | Yes |
| Loan share and loan 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 |

banks' accumulation of $168 billion in liquid assets during 2008Q4 falls to almost zero ($2 billion) after our adjustment (Panel A). In other words, the model suggests that there would have been no liquidity buildup in the face of the 250 basis points TED spread had banks operated with low levels of liquidity risk exposure going into the fall of 2008. Similarly, the drop in credit production would have been nearly 90% lower had banks been less exposed. The raw data indicate a drop in loans plus commitments of $503 billion for the large banks. This decline drops to just $87 billion after adjusting for liquidity risk. At the same time, our adjustment shows that liquidity exposure increased loans held on bank balance sheets. Total unadjusted lending falls by $52 billion for large banks, whereas the adjusted figure falls by $192 billion. This occurs because firms drew on preexisting lines en masse during the crisis.

The results are smaller but still substantial if we use the coefficients from the crisis-indicator model (Panel B). This model acts as if the shocks to liquidity were the same in all quarters from the middle of 2007 on and thus understates the impact during 2008Q4, when TED reached its apogee and credit declined most dramatically. Nevertheless, the adjustments to the predicted decline in credit would have reduced the decline nearly 50% (from $503 billion down to $265 billion).

The aggregation also highlights the economic importance of both core deposits as a stabilizing source of funds and undrawn commitments as a major source of destabilizing asset-side liquidity exposure. If large banks had held core deposits at the 75th percentile or higher, our calculation suggests that credit production would have been higher by $86 billion, and if all banks had exposure to undrawn commitments at the 25th percentile credit or lower, credit would have grown by $297 billion more. These two effects dominate the aggregates both because the estimated coefficients are large and because large banks were much more exposed to liquidity risk going into the crisis. The relative importance of core deposits in the funding structure of banks tends to decrease with size, while the relative importance of undrawn commitments increases with size. Thus, the adjustments to credit tend to be larger for large banks than for small banks.

### 3.6. Robustness tests

Loan demand probably began to decline during the crisis quarters and, thus, could play some role in explaining the drop in credit production. Because our model includes bank fixed effects and time indicators, and because we focus only on the interaction between TED and liquidity exposure, demand explanations could drive our interaction effects only if two conditions hold: (1) loan demand must be correlated with within-bank variation in our measures of liquidity risk and (2) loan demand must fall more at banks with high liquidity risk when the economy moves from boom (low TED spread) to bust (high TED spread) than at banks with low liquidity risk. Table 7 shows that adding variables plausibly related to changes in demand conditions had little impact on 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 two robustness tests to sweep out possibly omitted demand factors. First, we introduce the share of real estate loans to total loans and the share of business loans to total loans as right-hand-side regressors, along with interactions between each of these with the TED spread. Second, we sweep out potential demand variation related to geographical location of borrowers by adding a set of state-level indicator variables and their interaction with the TED spread. For a given bank, we define a state indicator to equal one if the bank has branches located in that state, based on the branch-level data at the FDIC's "Summary of Deposits." Because most business lending, particularly lending to small business, relies on monitoring facilitated by close geographic proximity, branch location correlates closely with borrower location. For example, Berger, Miller, Petersen, Rajan, and Stein (2005) 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. Thus, this second robustness check probably works very well for small banks but could be less effective for large banks.

The results of these robustness tests are reported in Table 7. Because the emphasis here is on loan demand variation, we report only the models of total credit production. The first column of Table 7 reproduces the baseline models from Table 3, Column 4. These data 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. No evidence exists that coefficients are systematically moving toward or away from zero (e.g., no evidence of attenuation bias or 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.

## 4. 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 Brothers and the AIG bailout. The Fed first attempted to stabilize the financial system with traditional tools of monetary policy, then expanded their balance sheet by more than $1 trillion over a few weeks, and later implemented new techniques 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 that relied more heavily on stable sources of financing, i.e., core deposits and capital, continued to lend relative to other banks. Off-balance sheet liquidity risk, in the form of undrawn loan commitments, materialized as borrowers drew on preexisting commitments in large quantities. These takedowns displaced lending capacity and constrained new credit origination. When we aggregate our results up, we find that most of the decline in bank credit production during the height of the crisis can be explained by liquidity risk exposure.

## References


Acharya, V.V., Schnabl, P., 2010. Do global banks spread global imbalances? The case of asset-backed commercial paper during the financial crisis of 2007–09. IMF Economic Review 58, 37–73.

Ashcraft, A.B., 2008. Does the market discipline banks? New evidence from the regulatory capital mix. Journal of Financial Intermediation 17, 543–561.

Avery, R.B., Belton, T.M., Goldberg, M.A., 1988. Market discipline in regulating bank risk: new evidence from the capital markets. Journal of Money, Credit, and Banking 20, 597–610.

Berger, A.N., Bouwman, C.H.S., 2009. Bank liquidity creation. Review of Financial Studies 22, 3779–3837.

Berger, A. N., Bouwman, C. H. S., 2010. How does capital affect bank performance during financial crises? SSRN: 〈http://ssrn.com/abstract=1739089〉.

Berger, A., Miller, N., Petersen, M., Rajan, R., Stein, J., 2005. Does function follow form? Evidence from the lending practices of large and small banks. Journal of Financial Economics 76, 237–269.

Bhattacharya, S., Thakor, A.V., 1993. Contemporary banking theory. Journal of Financial Intermediation 3, 2–50.

Billett, M., Garfinkel, J., O'Neal, E., 1998. The cost of market vs. regulatory discipline. Journal of Financial Economics 48, 333–358.

Black, H.A., Collins, M.C., Robinson, B.L., Schweitzer, R.L., 1997. Changes in market perception of riskiness: the case of too-big-to-fail. Journal of Financial Services Research 20, 389–406.

Brunnermeier, M.K., 2009. Deciphering the liquidity and credit crunch 2007–2008. Journal of Economic Perspectives 23, 77–100.

Diamond, D.W., Dybvig, P.H., 1983. Bank runs, deposit insurance, and liquidity. Journal of Political Economy 91, 401–419.

Diamond, D.W., Rajan, R.G., 2000. A theory of bank capital. Journal of Finance 55, 2431–2465.

Diamond, D.W., Rajan, R.G., 2001a. Banks and liquidity. American Economic Review 91, 422–425.

Diamond, D.W., Rajan, R.G., 2001b. Liquidity risk, liquidity creation, and financial fragility: a theory of banking. Journal of Political Economy 109, 287–327.

Flannery, M.J., 1998. Using market information in prudential bank supervision: a review of the US empirical evidence. Journal of Money, Credit, and Banking 30, 273–305.

Flannery, M.J., 2001. The faces of "market discipline". Journal of Financial Services Research 20, 107–119.

Gatev, E., Schuermann, T., Strahan, P.E., 2009. Managing bank liquidity risk: how deposit–loan synergies vary with market conditions. Review of Financial Studies 22, 995–1020.

Gatev, E., Strahan, P.E., 2006. Banks' advantage in hedging liquidity risk: theory and evidence from the commercial paper market. Journal of Finance 61, 867–892.

Gorton, G., 2009. Slapped in the face by the invisible hand: banking and the panic of 2007. SSRN: 〈http://ssrn.com/abstract=1401882〉.

Gorton, G. Metrick, A., 2009. Securitized banking and the run on the repo. Unpublished Working Paper 15223. National Bureau of Economic Research, Cambridge, MA.

Gorton, G., Pennacchi, G., 1990. Financial intermediaries and liquidity creation. Journal of Finance 45, 49–71.

Gorton, G. B., Winton, A., 2000. Liquidity provision, bank capital, and the macroeconomy. SSRN: 〈http://ssrn.com/abstract=253849〉.

Goyal, V.K., 2005. Market discipline of bank risk: evidence from subordinated debt contracts. Journal of Financial Intermediation 14, 318–350.

Hannan, T.H., Hanweck, G.A., 1988. Bank insolvency risk and the market for large certificates of deposit. Journal of Money, Credit, and Banking 20, 203–211.

Houston, J., James, C., Marcus, D., 1997. Capital market frictions and the role of internal capital markets in banking. Journal of Financial Economics 46, 135–164.

Ivashina, V., Scharfstein, D., 2010. Loan syndication and credit cycles. American Economic Review 100, 57–61.

Kashyap, A.K., Rajan, R., Stein, J.C., 2002. Banks as liquidity providers: an explanation for the coexistence of lending and deposit taking. Journal of Finance 57, 33–73.

Loutskina, E., The role of securitization in bank liquidity and funding management. Journal of Financial Economics, in press, doi:10.1016/j.jfineco.2011.02.005.

Maechler, A.M., McDill, K.M., 2006. Dynamic depositor discipline in U.S. banks. Journal of Banking and Finance 30, 1871–1898.

O'Hara, M., Shaw, W., 1990. Deposit insurance and wealth effects: the value of being "too big to fail". Journal of Finance 45, 1587–1600.

Pennacchi, G.G., 2009. Deposit insurance. Unpublished Working Paper, University of Illinois, Urbana–Champaign.