Large Excess Reserves in the United States: A View from the Cross-Section of Banks*

Huberto M. Ennis and Alexander L. Wolman
Research Department, Federal Reserve Bank of Richmond

Bank reserves in the United States increased dramatically at the end of 2008. Subsequent asset purchase programs in 2009 and 2011 more than doubled the quantity of reserves outstanding. We study the cross-sectional distribution of reserves in that period, and the relationship between holdings of reserves and other components of banks' balance sheets. We find that reserves were widely distributed, increasing the liquidity position of many banks which, at the same time, were far from facing tight capital constraints. Our findings have implications for assessing the importance of large quantities of excess reserves for monetary policy.

JEL Codes: G21, E44, E58.

1. Introduction

In the final months of 2008, the quantity of bank reserves in the United States increased by almost a factor of twenty, to more than $850 billion. During the second half of 2009 reserves increased again

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by approximately $300 billion, and in the first half of 2011 another significant increase in reserves took the level outstanding to approximately $1.6 trillion. These increases in reserves were the result of Federal Reserve policies aimed at mitigating the financial crisis and stabilizing the economy.

On October 1, 2008, the Federal Reserve began paying interest on reserves and, to maintain its interest rate target, no longer had to sterilize the creation of reserves associated with the various credit programs in place at the time. In late November 2008, the Federal Reserve also announced an asset purchase program that would increase its holdings of agency debt and mortgage-backed securities (MBS) by a total of $600 billion. As its lending programs started to wind down, the Federal Reserve increased the size of its planned asset purchases. The expanded program involved the purchase of $300 billion in Treasury securities beginning in March 2009 and a significant increase in the total purchases of agency debt and MBS. This program ended in March 2010. After a period of relative inactivity, the Federal Reserve undertook a new round of Treasury purchases between December 2010 and June 2011, for a total of $600 billion.[1]

These facts about the origin and evolution of aggregate bank reserves in the United States are well known. Much less attention has been devoted to the distribution of reserves across banks and to the interaction of reserves with other components of banks' balance sheets at the aggregate and individual levels. Studying these issues is the objective of this paper. We use cross-sectional data on banks' balance sheets from the regulatory filings commonly referred to as the Call Reports and other complementary data sources that provide aggregated information. For the period between mid-2008 and mid-2011, we document the relationship between reserve holdings and relevant bank-level measures of liquidity, capital, lending capacity, and lending opportunities.[2]

[1]Currently (as of April 2014), the Federal Reserve is engaged in an open-ended asset purchase program that entails acquiring $40 billion of agency mortgage-backed securities per month (starting in September 2012) and $45 billion of long-term Treasury securities per month (starting in January 2013). Since this current program is still under way and is open ended, it is not included in our study.

[2]In a recent related paper, Chang, Contessi, and Francis (2013) use regression analysis to study the cash holdings (net of required reserves) of all reporting

Why is studying the cross-sectional distribution of bank reserves interesting? We think that bank holdings of excess reserves can matter, under certain conditions, for the effect of monetary policy on the real economy (Ennis and Wolman 2010). In particular, large quantities of excess reserves make a strengthening economy potentially more sensitive to delays in (ex post) proper adjustments of monetary policy.

Our working hypothesis has points of contact with the bank lending view of monetary transmission (see Kashyap and Stein 1994). First, we proceed under the assumption that banks prefer to fund their lending activities with deposits instead of large (brokered) CDs or short-term interbank loans and that it takes time for banks to increase their deposit base. Second, we adhere to the view that some borrowers cannot find perfect substitutes for bank loans, especially in the short run.

Under these premises, a banking system that is holding a larger quantity of excess reserves is able to expand lending faster in response to changes in economic conditions (such as changes in real expected rate-of-return differentials). A way to understand this process is to think that holding reserves is a way for banks to "store" deposits that could eventually be used to finance lending. A banking system with a higher amount of "stored deposits" (i.e., excess reserves) can adjust lending more quickly than one that has already used most of its deposits to finance existing loans.

Of course, by paying interest on reserves (IOR), a policymaker could control how much banks want to move away from excess reserves and into loans (Dudley 2011). Higher IOR, everything else constant, will induce banks to refrain from making marginal loans with risk-adjusted rates of return comparable to the one being offered on reserves. However, determining when to adjust monetary policy is a difficult issue, and the possibility of policy being (on occasion) behind the curve is a real one (Plosser 2011 and Levin and Taylor 2013). When policy delays do occur, then the level of reserves and the distribution of reserves across banks can matter.

Aside from the availability of funding, the propensity of banks to expand lending quickly depends on other factors, such as the

institutions below the twenty largest, from the third quarter of 2008 to the second quarter of 2010.

state of their balance sheets.[3] In this paper, we study the cross-section of U.S. banks' balance sheets in an effort to better understand the general financial condition of the banks holding (most of) the reserves.

Five main findings arise from our analysis. First, reserves were widely distributed across the banking system, with both domestic and foreign institutions holding significant portions of the outstanding reserves. Second, reserves did not substitute for other liquid assets on banks' balance sheets: as total reserves increased, so did the banking system's total liquidity. Third, using data on leverage ratios, we conclude that the increase in reserves did not appear to constrain banks' ability to expand their balance sheets. Fourth, a significant proportion of reserves were held by banks apparently not restricted by capital requirements. Finally, there is little evidence that idiosyncratic changes in the return on lending induced banks to adjust their reserve holdings. We stated earlier that a large quantity of excess reserves gives a bank the potential to expand lending quickly. Of course, from 2008 through 2011, a rapid lending expansion did not materialize. These five findings seem to suggest that the lending behavior of banks during this period more likely reflected poor lending opportunities than limits induced by their financial conditions.

The paper is organized as follows. In the next section we discuss details of the data we use. After that, sections 3–7 each discuss one of the five main findings from our work. Section 8 concludes.

2. The Data

Our panel data covers commercial banks, savings banks, and trust companies, as well as uninsured branches and agencies of foreign banks. These institutions file quarterly supervisory reports, Call Reports, which are our primary data source. Our study does not cover credit unions and some other thrift institutions that were not required to report reserve holdings in their regulatory filings during the period of our study.

[3]The classic example of this interaction between different components of banks' balance sheets is the limitations that bank capital can impose on lending (Van den Heuvel 2002). But, as we discuss in later sections, there are others.

In the second quarter of 2011, there were 2,366 reporting institutions with reserve accounts, 237 of which were classified as uninsured.[4] Most of the uninsured institutions are affiliates of foreign banks, and in the second quarter of 2011 they held 98 percent of the reserves held by uninsured institutions.[5] For this reason, we refer to the uninsured group as FBOs (foreign banking organizations) for short, and we call the rest of the (insured) institutions domestic banks.

FBOs can hold accounts with Federal Reserve Banks, and thus reserves. However, since they do not hold insured deposits, they file a Call Report form, FFIEC 002, that is somewhat less detailed than the form FFIEC 031 or 041 filed by insured domestic institutions. For domestic institutions, we will aggregate banks up to the bank holding company level; decisions about reserve holdings presumably are made in the interest of the owners of the holding company.[6]

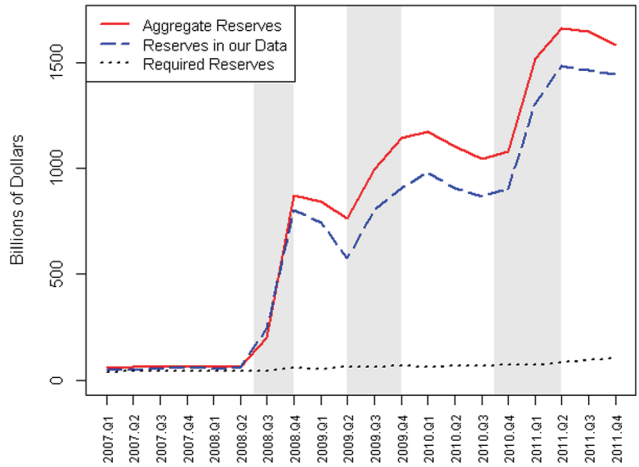
To complement the Call Reports when we discuss aggregate data for the banking system, we use the Federal Reserve's H.3 and H.4.1 statistical releases, which report aggregate reserves and other aspects of the Federal Reserve's balance sheet. This aggregate data released by the Federal Reserve is not derived from the Call Reports. Therefore, judgment is required when relating such data to

[4]In the second quarter of 2011, there were 7,147 reporting institutions in our data, 6,814 of which were insured. The 4,781 institutions that do not have reserve accounts are small banks that hold their reserves with correspondent banks. The correspondents report their respondents' reserves together with their own reserves. Thus, we have a measurement issue. With the Call Report data alone it is not possible to resolve this issue, but the non-account-holding banks hold a very small amount of assets—approximately 5 percent—so we are not too concerned about this source of mismeasurement.

[5]As of the second quarter of 2011, uninsured institutions held $678 billion of reserves. Among the uninsured institutions, there were 228 U.S. branches and agencies of foreign banks, 34 Edge and Agreement corporations, and 71 non-deposit trust companies.

[6]Note that some banking corporations have both U.S. insured affiliates and uninsured affiliates. An example of this is Deutsche Bank, which had both insured U.S. banks and an uninsured U.S. affiliate. We do not incorporate uninsured foreign affiliates when we aggregate U.S. insured banks at the holding company level. In principle, however, reserves in foreign affiliates could be transferred to a related U.S. bank relatively quickly if the parent company decided to do so. In the second quarter of 2011, Deutsche's domestic insured institutions reported reserves of about $21 billion, and its uninsured affiliate reported reserves of about $67 billion.

Figure 1. Total Reserves and Our Data



the aggregates constructed using the Call Reports. For example, the thrift institutions mentioned above do not report reserve holdings at the individual level, but those holdings are included in the measure of aggregate reserves in the H.3 tables. Thus, there will inevitably be a gap between the total reserves accounted for by our cross-sectional data and the total reserves reported on the H.3 statistical release. In the appendix, we explain in detail other issues with reconciling these two sources of data and how we deal with them in our analysis.

Figure 1 displays the time series for end-of-quarter total reserves as reported on the Federal Reserve's H.3 statistical release. Required reserves over the period in question and total reserves in our sample are also shown in the figure (dotted and dashed lines, respectively).[7] The gap between total reserves in our data and total reserves from the H.3 release amounted to $176.6 billion in the second quarter of 2011. Reserve holdings by credit unions and some other thrifts account for this gap.

[7]The Federal Reserve's H.3 statistical release typically does not cover the last day of the quarter, and for this reason the H.3 aggregates can show some inconsistencies with those produced using the Call Reports—our main data source. This is especially a factor during the periods when reserve balances change significantly from one day to the next, as was the case at the end of the third quarter of 2008.

Figure 1 also depicts three shaded areas that demarcate three distinct periods of noticeable increases in total reserves. Prior to the autumn of 2008, total reserves had been fluctuating between approximately $40 billion and $60 billion, and for the previous five years required reserves had never accounted for less than 80 percent of total reserves. Starting in mid-September 2008—the time of the Lehman Brothers bankruptcy—this situation changed dramatically and the level of reserves increased rapidly, to reach a level of approximately $850 billion by the end of the year. We call this surge in reserves the *first wave* of increases in reserves. As the Federal Reserve's credit programs were winding down, the level of reserves actually decreased during the first two quarters of 2009. A *second wave* of reserve increases came in the last two quarters of 2009, as the run-off of the credit programs no longer compensated for increases associated with the Federal Reserve's first asset purchase program. Total reserves increased by approximately $300 billion in this second wave, to reach a level of about $1.1 trillion. During most of 2010 the level of reserves fluctuated around that level. In November 2010, the Federal Reserve embarked on a new program of asset purchases for $600 billion, which resulted in a *third wave* of increases in total reserves lasting until the end of the second quarter of 2011. Reserves reached a level of $1.6 trillion at that time.[8]

The initial increase in reserves in September 2008 occurred in an environment of falling market interest rates on low-risk debt, and amid crisis conditions in financial markets. This combination of factors meant that there was both a lower opportunity cost and a higher perceived benefit of holding excess reserves. As a result, the demand for reserves likely increased.

In mid-October 2008, the Federal Reserve began paying interest on all reserve balances held by depository institutions. By mid-November 2008 the interest rate paid on reserves became essentially equal to the target for the federal funds rate, allowing the Federal Reserve to continue to increase the quantity of reserves independently of its interest rate target. With IOR close to the federal funds

[8]Ennis and Wolman (2012) discuss in more detail the Federal Reserve's policy actions and the resulting evolution of reserves. For a good taxonomy of the programs, see the Federal Reserve Board website, http://www.federalreserve.gov/monetarypolicy/bst_openmarketops.htm

rate, the costs of holding reserves were significantly reduced, and this remained the case for the rest of the period under study.[9] Keister and McAndrews (2009) explain that the increases in reserves can be viewed as an artifact of the credit and asset purchase programs that the Federal Reserve undertook. It should be stressed that while the asset purchase programs resulted in reserves increasing, the stated intention of those programs was to reduce long-term interest rates. Many papers have assessed their effectiveness in this dimension. See, for example, Gagnon et al. (2011).

3. The Distribution of Reserves

A natural first step toward understanding the potential implications of a large quantity of reserves is to determine who were the main holders of those reserves and to what extent the distribution of reserves changed over time. For this purpose, we provide an overview of the main features of the distribution of reserves across banks in our sample period.[10]

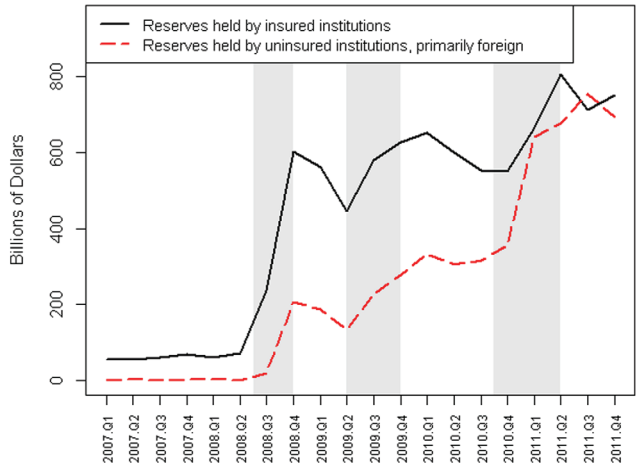
A first broad decomposition of aggregate reserves is between domestic banks and FBOs. Figure 2 shows that FBOs held a significant amount of reserves beginning in the third quarter of 2008. In fact, by 2011 the quantity of reserves was roughly the same in the two groups of institutions, even though total assets in FBOs are between 10 and 20 percent of total assets in domestic institutions. While both domestic banks and FBOs absorbed reserves during the first and second wave of increases in reserves, during the third wave FBOs increased their participation in reserve holdings significantly more than domestic banks. In fact, FBOs absorbed the lion's share of the reserves in the third wave.

Because FBOs are somewhat atypical banking organizations, we will discuss them in more detail below. We then turn our attention to domestic institutions and, in particular, to the distribution of

[9]The effective federal funds rate has generally been below IOR. It is widely believed that this reflects the fact that the government-sponsored enterprises cannot earn interest on reserves and only deal with a small set of counterparties, which are not willing to expand their balance sheets enough to compete away the spread. See, for example, Bech and Klee (2011).

[10]For brevity, we will often use the term "banks" when we mean "banks aggregated to the holding company level."

Figure 2. Insured and Uninsured Institutions



reserves across individual banks within this group. To the extent that there is a non-negligible idiosyncratic component to the arrival of lending opportunities, it is important to know whether reserves tend to be concentrated in a few banks or spread out across institutions.[11]

3.1 Foreign Banking Organizations

Uninsured FBOs increased their reserve holdings by a factor of more than 1,000 from the middle of 2008 to the middle of 2011, going from $563 million on June 30, 2008 to $666 billion on June 30, 2011.[12] As a proportion of total reserves, FBOs' reserves increased from 6 percent to close to 50 percent. Relative to FBOs' assets, reserves rose from 0.03 percent to more than 30 percent. Meanwhile, their

[11] While at any point in time the total amount of reserves in the system is set by the monetary authority, *an individual bank* can choose to hold whatever level of reserves it wishes. And, during the period under study here there was, in fact, substantial reallocation of reserve across banks from quarter to quarter (see Ennis and Wolman 2012 for calculations of gross flows of reserves across institutions).

[12] Reserve holdings at these institutions increased in the last two quarters of 2008, to reach a level of around $200 billion, and increased another $150 billion in the second half of 2009. But the biggest increase in reserve balances held by foreign institutions came during the Federal Reserve's second asset purchase program in the first half of 2011, when they increased their reserve balances by more than half ($363 billion) of the total size ($600 billion) of the program.

total assets rose by less than 2.5 percent, so the increase in reserves was accompanied by a significant reduction in the *levels* of some other asset categories.

There are several factors that can help explain why FBOs increased their reserves so much. In late 2008, many foreign institutions with large-dollar assets experienced difficulty in rolling over short-term dollar funding (Fleming and Klagge 2010, and Goldberg, Kennedy, and Miu 2011). One way these institutions responded was by drawing down their U.S. affiliates' deposits with the parent company to build up reserve accounts with the Federal Reserve, creating a pool of precautionary dollar balances.

Another element in explaining the increase in reserves is the decline in market interest rates that occurred over the period: with the Federal Reserve holding fixed the interest rate on reserves, it made sense for foreign (and domestic) institutions to hold a larger share of their assets in reserves than in securities bearing lower market interest rates.

In mid-2011, amid the European sovereign debt crisis, dollar funding concerns at foreign banks again became a major issue. In addition, in April 2011 a change in the FDIC premium for deposit insurance lowered the effective return on reserves for insured institutions.[13] With the Federal Reserve's asset purchases driving up aggregate reserves, it was predictable for them to flow disproportionately to uninsured FBOs that were not exposed to the increased premium (Kreicher, McCauley, and McGuire 2013).

Table 1 summarizes the changes in FBOs' balance sheets during the three waves of increases in reserves. For a more comprehensive description of these changes, see Ennis and Wolman (2012). The asset categories in the table, in addition to reserves, are some of the categories that experienced significant changes as reserves changed. During the first wave, reserves increased by more than 10 percent of assets, and this change was more than offset by a change in

[13]Insured institutions contribute a quarterly assessment to fund the Federal Deposit Insurance Fund. An institution's assessment is calculated by multiplying its assessment rate by its assessment base. From the beginning of the FDIC until 2010, a bank's assessment base was about equal to its total domestic deposits. The 2010 financial reform legislation (the Dodd-Frank Act) required that the FDIC amend its regulations effective April 2011 to define a bank's assessment base as its average consolidated total assets minus its average tangible equity.

Table 1. Balance Sheets of Uninsured FBOs

Time Period	Reserves	Net Due from Related DIs	Loans and Leases
	(measured as % of assets)		
First Wave	10.06	−10.91	3.37
Second Wave	7.71	−1.57	−3.08
Third Wave	15.59	−9.38	−1.11

FBOs' deposits at other related institutions ("net due from related depository institutions").[14] During the second wave, reserves rose by almost 8 percent of assets, with offsetting reductions in deposits at related institutions (1.57 percent), loans (3.08 percent), and various other asset categories (not included in the table). Finally, in the third wave (the Federal Reserve's second asset purchase program), reserves increased by more than 15 percent of assets, and deposits at related institutions and loans again offset a significant portion of that change.

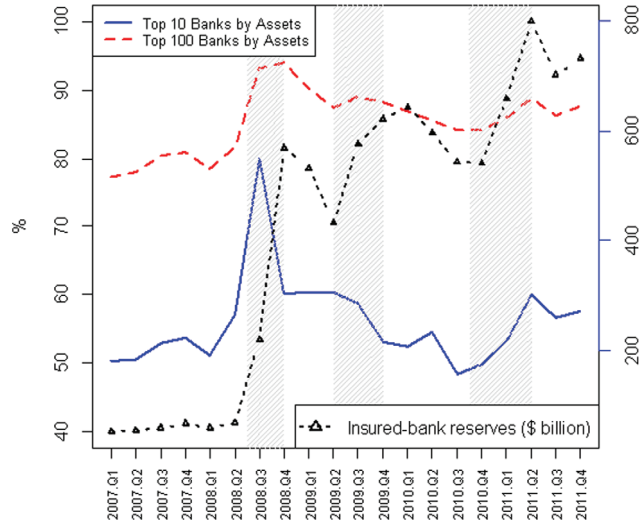
It should be stressed here that reserves at foreign institutions are by no means "stuck" there. Just as the foreign institutions rapidly increased their reserve holdings from 2008 to 2011, they could rapidly decrease those balances. These institutions hold significant quantities of both loans and securities, and they could be sensitive to economic conditions and market interest rates in choosing their reserve positions.

3.2 Domestic Banks

The high concentration of assets in the domestic banking sector is a well-documented fact (Janicki and Prescott 2006). For this reason, reserve holdings are also likely to be highly concentrated. Figure 3 plots the time series for the percentage of total reserves of U.S. insured banks held by the top 10 and top 100 banks by assets on the left axis, and the level of insured-bank reserves on the right axis.

[14]These foreign institutions were major participants in the Federal Reserve Term Auction Facility, which lent significant amounts to banks between 2008 and 2010 (see Benmelech 2012 for details).

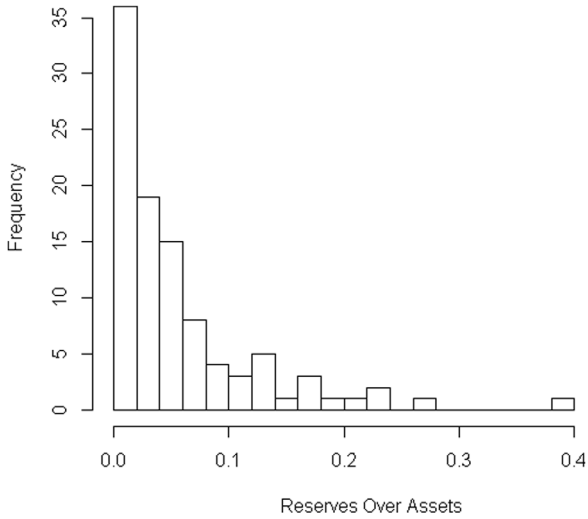
Figure 3. Reserves Held by Top 10, Top 100 Insured Banks



The 10 largest banks tend to hold roughly half of the reserves (and 55 percent of the assets—not shown in figure 3) and the top 100 banks hold roughly 80 percent of the reserves (and also 80 percent of the assets). It seems that the proportion of reserves held by the top 100 banks moved to a permanently higher level (approximately 85 percent) after the level of reserves increased at the end of 2008. This change in the proportion of reserves held by the top 100 banks did not correspond to a similar change in the proportion of assets. In fact, the proportion of assets held by the largest banks was fairly stable during the entire period under consideration.

We can also see in figure 3 that the percentage of reserves held by the ten largest banks increased significantly in the third quarter of 2008 when the level of reserves was increasing rapidly for the first time. This is also true for the top 100 banks. Initially the top 10 banks were the main drivers of the increase in the proportion of reserves held by the top 100 banks. From the fourth quarter of 2008 onward, however, the banks in the top 100 group which were not in the top 10 group increased their reserve holdings more markedly (as shown by the increasing distance between the solid and the dashed lines in figure 3). Starting in the third quarter of 2010, the top 10

Figure 4. Reserves Over Assets, 2010:Q2 (top 100 institutions by assets)

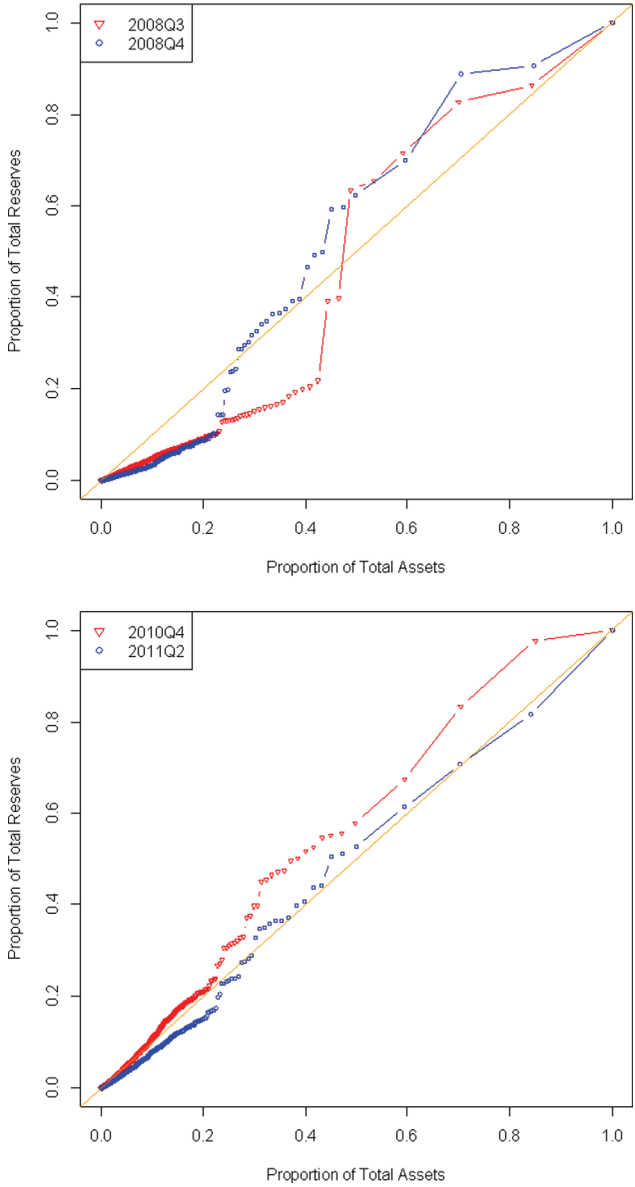


banks again increased their reserve holdings faster than the rest of the large banks in the system. Note that the periods when aggregate reserves grew rapidly tended to coincide with the periods when the top 10 banks increased their holdings of reserves faster than the rest.

According to figure 3, large institutions held a large portion of total reserves. But, were reserve holdings across these large institutions proportional to assets? Figure 4 displays the histogram of the ratio of reserves to assets in the second quarter of 2010 for the 100 largest insured institutions by assets. We choose this quarter because it is representative of a time when total reserves were not increasing rapidly and financial conditions were relatively calm. The figure shows that there was in fact wide dispersion in the ratio of reserves to assets across institutions.

So far we have discussed the distribution of reserve holdings among the largest banks. To get a broader view of the distribution of reserves across the entire domestic banking system, we construct a plot *similar* to a Lorenz curve for reserves. Figure 5 presents those plots. Instead of ranking banks by reserves on the horizontal axis, they are ranked by assets, and the horizontal axis measures fraction

Figure 5. Lorenz-Type Curve of Concentration of Reserves



of assets, not fraction of banks.[15] As is clear from the top chart in figure 5, the largest banks held a disproportionately high amount of reserves at the peak of the crisis in late 2008.

In the curve that corresponds to the end of the third quarter of 2008 (triangles), we see two institutions that held a disproportionate amount of reserves relative to assets. These institutions are State Street Bank (with $52 billion, amounting to 19 percent of its assets) and BONY Mellon (with $38 billion, amounting to 16 percent of its assets), both banks that primarily provide services to other financial institutions. During the peak of the financial crisis, State Street and BONY likely faced significant uncertainty about their needs for payment-related liquidity, which would justify holding a disproportionately large amount of reserves.

At the end of 2008, banks holding the bottom 20 percent of assets held less than 10 percent of reserves. During the second wave, reserves slowly became more evenly distributed across banks. If anything, large banks held a lower proportion of the reserves than they held of the assets in the system. By mid-2010, this same group of banks held almost exactly 20 percent of the reserves, and in fact, the Lorenz-type curve for the second quarter of 2010 (not included in the figures) roughly overlaps with the 45-degree line for the first 25 percent of assets (and reserves) in the system. Perhaps the normalization of financial conditions contributed to a more even distribution of reserves and a higher participation of smaller banks in the holding of those reserves. Also, the fact that the Federal Reserve conducts open-market operations with only a very small set of counterparties may tend to create some concentration of reserves in large institutions when those open-market operations are large. Since by mid-2010 the quantity of reserves had not been growing for some time, this force towards concentration of reserves in large banks was not operative at the time, allowing the reserves to become more evenly distributed.[16]

[15]Note that because the horizontal axis measures fraction of assets, the curves can lie above the 45-degree line.

[16]It is interesting to note that prior to September 2008, small banks held a disproportionately large share of reserves because reserve holdings were driven by required reserves, and small banks, on average, hold relatively large reservable deposits. In this sense, although the level of reserves was much higher, the distribution of reserves among small banks in 2010 had moved back close to its pre-crisis state.

The bottom chart in figure 5 shows the Lorenz-type curves for the fourth quarter of 2010 and the second quarter of 2011. The figure indicates that the third wave of increases in reserves, which happened mostly during the first half of 2011, resulted in a shift in the distribution of reserves towards large banks. In other words, by the end of the second quarter of 2011 the largest banks in the system held a higher proportion of total reserves than they held at the end of 2010, when the 2010–11 Federal Reserve asset purchase program started.

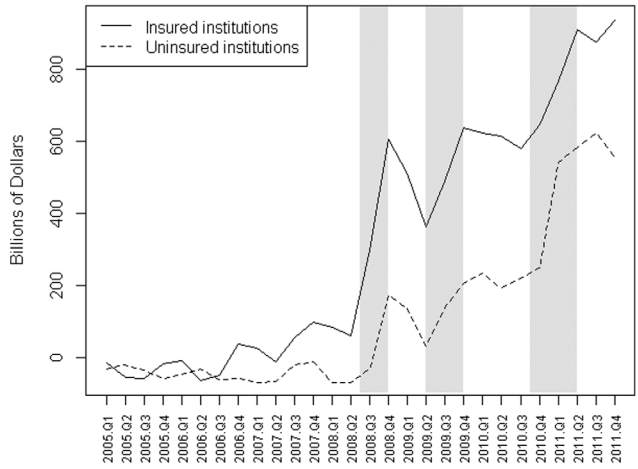
The degree to which reserves were concentrated among banks is informative for the banking system's ability to adjust to changing conditions. Bank lending opportunities likely arise in an idiosyncratic and partly unexpected manner. Even in situations when general economic conditions are improving, some banks may experience more active demand for loans than others. Anticipating which banks will be the ones making more loans seems challenging. At the same time, according to our working hypothesis, the ability of banks to quickly take advantage of new lending opportunities depends in part on the quantity of reserves they are holding. The fact that the reserves were fairly widespread across banks in the data, as we have shown in this section, suggests that many of those banks could have been in a favorable position to tap their reserve holdings had lending opportunities arrived.

4. Bank Liquidity

Interest-bearing reserves are a close substitute for short-term low-risk securities. An increase in aggregate bank reserves brought about by Federal Reserve policies can, in principle, be offset by a reduction in banks' holdings of short-term low-risk securities. If the offset is complete and total effective liquidity in the banking system does not change, then changes in total reserves are unlikely to make a difference for lending and monetary policy more generally. In this section, we look at the data on bank liquid assets and reserves to assess the extent of the substitution between reserves and other liquid assets during our sample period.

In figure 6, we display time series for measures of aggregate liquidity held by banks. For insured domestic institutions, the solid line comprises reserve balances, vault cash, short-term securities (one

Figure 6. Aggregate Bank Liquidity



year or less to maturity), and net repo and federal funds sold to non-banks. We view this measure as a reasonable proxy for low-risk assets on the banking system's balance sheet. Given the large changes in levels that we are concerned with, alternative measures of liquidity are unlikely to modify the main conclusions. Note, however, that we have excluded from aggregate bank liquidity in figure 6 federal funds sold to banks, reverse repo with banks, and balances due from other depository institutions. These items represent liquidity to individual institutions but not to the banking system as a whole. For this reason, our measure of aggregate liquidity seems most relevant when considering aggregate shocks to the banking system, instead of idiosyncratic shocks to certain banks that could be accommodated by changes in interbank lending.

FBOs do not report short-term securities. For those institutions the dashed line in figure 6 plots a measure of liquidity that instead uses U.S. Treasury securities and U.S. government agency obligations as the measure of liquid securities.

According to figure 6, prior to the crisis aggregate liquidity in the banking system was actually negative in some periods: banks were borrowing short-term funds from the non-bank sector in excess of the liquid assets they held. The initial increase in liquidity in the fall of 2008 corresponds to a period when banks' demand for liquid assets is likely to have increased significantly (Ashcraft, McAndrews,

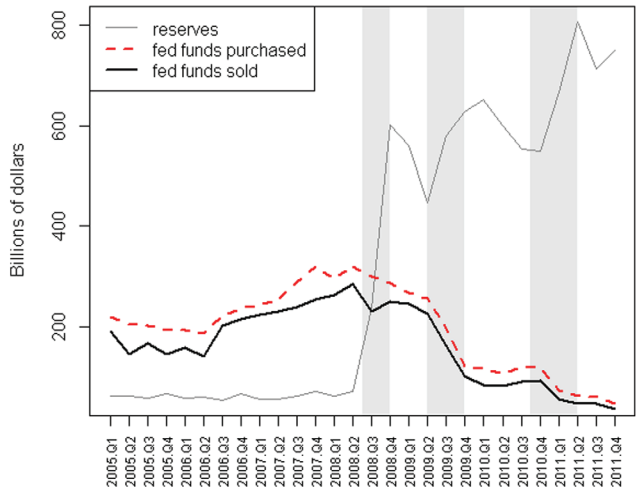
and Skeie 2011). However, in subsequent quarters financial market conditions tended to normalize, and still the quantity of liquid assets remained high—increasing with both of the Federal Reserve asset purchase programs. We interpret these patterns as saying that contrary to what one might have expected, once financial conditions normalized, the banking system did not primarily substitute reserves for other forms of liquid assets. In fact, from 2009 to 2011 aggregate liquidity in insured institutions increased by more than the increase in reserves (reserves increased by $350 billion and liquidity increased by $560 billion) and the increase in liquidity occurred at both insured and uninsured institutions.[17]

Having looked at aggregate bank liquidity, we now turn our attention to the cross-section of domestic banks. Aside from reserves and securities, individual banks hold liquidity in the form of deposits with other banks or short-term loans to other banks. For this reason, we modify our measure of liquidity to include all the components in the aggregate measure used in figure 6 plus balances due from other depository institutions. While this modification in the definition of liquidity is conceptually important, it is empirically less consequential given the policy environment under consideration. By paying interest on reserves at a near-market rate and dramatically increasing the quantity of reserves, the Federal Reserve changed the calculus of individual banks' liquidity management. Banks that previously economized on holding reserves and then borrowed when needed in the federal funds market no longer faced a significant cost of, instead, holding a high level of precautionary reserves. For this reason, the volume of activity in the federal funds market declined considerably. Figure 7 shows that among the insured institutions in our sample, trading in the federal funds market fell from around $300 billion in the second quarter of 2008 to around $50 billion in the second quarter of 2011.

We denote by OLq_i the liquidity, other than reserves, held by bank i. Thus total liquidity of bank i is the sum of OLq_i and reserves R_i. To understand the relationship between increases in reserves and increases in liquidity at the level of individual banks, we run the following regression *separately* for each of the three waves:

[17]It is of course true that because reserves were introduced by purchasing Treasury and mortgage-related securities, the consolidated private sector did substitute reserves for other forms of liquid assets. The extent to which the increase in reserves matters depends in large part on the extent to which banks matter.

Figure 7. Interbank Activity at Insured Institutions



$$\frac{\Delta OLq_{it}}{A_{it}} = \alpha_t + \beta_t \frac{\Delta R_{it}}{A_{it}} + \varepsilon_{it},$$

where ΔOLq_{it} is the change in OLq_i between the beginning and the end date of a given wave t and A_{it} is the level of total assets of institution i at the beginning of wave t, with $t = 1, 2, 3$. We normalize the change in liquidity by assets to avoid an automatic positive correlation driven by bank size. Similarly, we exclude reserves from the dependent variable to avoid generating any spurious correlation.

Table 2 reports the dollar change in (total) liquidity per dollar increase in reserves implied by the estimated coefficients (i.e., the value of $1 + \widehat{\beta}_t$, where $\widehat{\beta}_t$ is the estimated value of β_t). We also report in the table the standard error of $\widehat{\beta}_t$ and the R-squared from the regression.[18]

[18] As a robustness check, we run the regression excluding the two clearing banks, JP Morgan Chase and BONY, and State Street, since these are banks with potentially very different exposure to the financial crisis. As we saw in section 3, BONY and State Street were indeed evident outliers for the change in reserves during the first wave of increases in reserves. Excluding these three banks, however, does not change the results in any significant way.

Table 2. Reserves and Liquidity

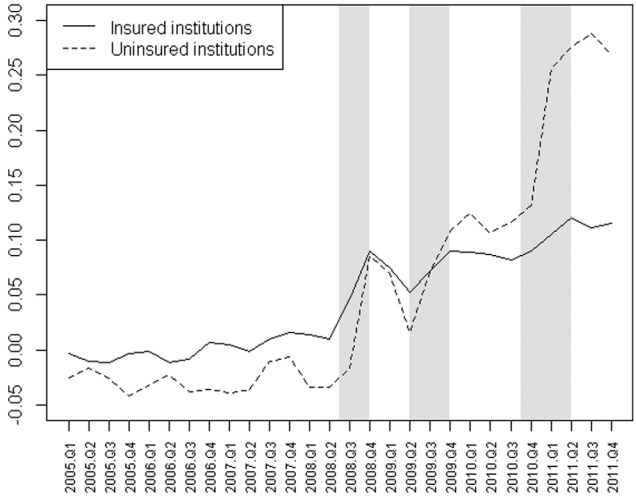
Time Period	$1 + \widehat{\beta}_t$	Standard Error of $\widehat{\beta}_t$	R-squared
First Wave	0.662	0.040	0.42
Second Wave	0.777	0.060	0.11
Third Wave	0.945	0.076	0.00

We see in table 2 that changes in reserves are not offset by changes in other liquid assets at the level of individual banks (that is, $\widehat{\beta}_t$ is significantly different from -1). Rather, (total) liquidity changes almost one for one with reserves, especially during the second and third waves. During the first wave, a crisis period, the correlation between reserves and other sources of bank liquidity is stronger, as is evident from the table ($\widehat{\beta}_t$ is close to -0.4). This stronger correlation may in part be the result of banks stocking up reserves for precautionary reasons as they were losing access to other sources of liquidity during the crisis (Ashcraft, McAndrews, and Skeie 2011, and Berrospide 2013).

So far, we have considered only absolute measures of bank liquidity. Often, macroeconomic models with money and banking posit an aggregate technology whereby reserves, in their role as the ultimate liquid asset, are an input into the production of deposits.[19] In these models, the focus of attention is generally the ratio of aggregate liquid assets to aggregate deposits. Figure 8 plots the ratios of the measures of aggregate liquidity in figure 6 to total deposits at domestic banks and FBOs. The figure could be considered an empirical counterpart of the assumptions in the aforementioned models. There are two points worth noting from the figure. First, the ratio of FBOs' liquid assets to deposits went from being negative to almost 30 percent. A significant portion of the increase came in 2011, not surprising since these institutions do not offer insured deposits and the terms for holding reserves shifted in their favor after the change in FDIC insurance premiums in April of 2011. Second, for insured domestic institutions, the increase in liquidity relative to deposits

[19] An early example of a macro model with deposits and reserves is Chari, Christiano, and Eichenbaum (1995). More recently, versions of this approach have been taken by Canzoneri et al. (2008), Hornstein (2010), and Ireland (2014).

Figure 8. Ratio of Aggregate Bank Liquidity to Total Deposits



was dramatic in late 2008 but relatively modest since then. In other words, while figure 6 already showed that domestic banks were not simply substituting reserves for other liquid assets, figure 8 shows that the increases in liquidity after 2008 were accompanied by nearly proportional increases in deposits.

In their recent contributions, Hornstein (2010) and Ireland (2014) are explicitly concerned with monetary policy when interest is paid on reserves, and thus deserve some special attention here. In Hornstein (2010), reserves are a perfect substitute for bonds in serving as liquidity, which must be held as a constant proportion of deposits (a technological assumption). In contrast, Ireland assumes that reserves serve a unique function in supporting deposits, so that even when there is interest on reserves at the market interest rate, banks have a determinate demand for reserves. Hornstein's model would require a large shift in the deposit-taking technology to accommodate the increase in liquidity relative to deposits since mid-2008. However, from 2009 through 2011 the behavior of domestic banks does not seem grossly at odds with Hornstein's model: with the interest rate on reserves essentially equal to the short-term market rate, banks' ratio of liquid assets to deposits fluctuated in a relatively narrow range.

With reserves having a unique character in Ireland's model, it is appropriate instead to look at the ratio of *reserves* to deposits. Although the interest rate on reserves has been constant since late 2008, short-term market rates have exhibited some fluctuations. Ireland's model predicts that the ratio of reserves to deposits would co-move negatively with the difference between market rates and IOR. Using weekly data from the Federal Reserve's H.15 and H.8 statistical releases, covering January 2009 through June 2011, the correlation between the three-month Treasury-bill rate and the ratio of aggregate reserves to deposits was −0.74. Unfortunately, it is not possible to compute this correlation only for insured institutions using weekly data.[20]

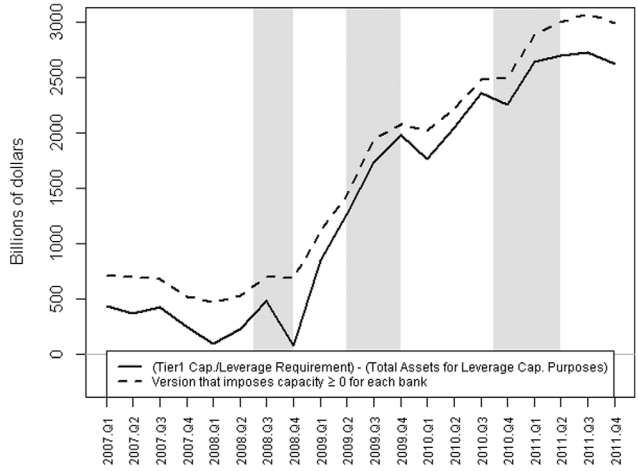
5. Bank Balance Sheet Capacity

Since reserves must be held by banks, a significant increase in the stock of reserves could, potentially, put pressure on banks' balance sheet capacity (Martin, McAndrews, and Skeie 2011). *For a given level of bank capital*, increases in the outstanding stock of reserves must be met with a decrease in other asset categories or in banks' leverage ratios. Regulatory requirements may restrict the latter as a margin of adjustment. To the extent that banks' leverage ratios are close to their regulatory minimum, increasing the stock of reserves implies that some other category of assets (for example, loans) must fall, and in that sense increases in reserves may become contractionary.

To assess the impact of the increases in reserves on banks' balance sheet capacity during our sample period, we start by computing an aggregate measure of balance sheet capacity for the largest 100 domestic banks. Denote by ρ the required leverage ratio—that is, the required ratio of tier 1 capital to assets, following the definition used in the Call Reports. Given capital holdings K, a bank could

[20]Kashyap, Rajan, and Stein (2002) emphasize the role of liquid assets in supporting not only deposit taking but also lending that is done through loan commitments. In the fall of 2008 there was a large increase in lending as commitments were drawn upon (see, for example, Ivashina and Scharfstein 2010). Surely that phenomenon must have played some role in the observed willingness of banks to hold higher liquidity in late 2008 and early 2009. However, for much of our sample period lending growth was practically non-existent and therefore cannot explain the increase in bank liquidity.

Figure 9. Balance Sheet Capacity of Top 100 Banks (based on leverage requirement = 0.07)



increase its assets up to K/ρ and still satisfy the maximum leverage restriction. We define as the bank's balance sheet capacity the difference between K/ρ and its actual level of assets for leverage capital purposes (as reported in the Call Reports).

Using a value of ρ equal to 7 percent, we aggregate in figure 9 the balance sheet capacity of the top 100 banks in two alternative ways: one in which we allow capacity to be negative (solid line) and one where we only consider positive values for the purpose of aggregation (dashed line).[21] We see in the figure that balance sheet capacity in fact increased significantly during this period. Of course, there are several factors that could explain this increase. For example, as a result of the crisis, many banks might have decided to strengthen their capital position at the same time that good lending opportunities were hard to come by. Also, as we saw in figure 2, a significant portion of the increase in reserves associated with the third wave did not flow onto the balance sheets of domestic banks.

To get a better sense of whether the increases in reserves put pressure on banks' balance sheets, we exploit the cross-sectional

[21] Taking $\rho = 0.07$ is a conservative choice. According to banking regulations at the time, to be considered well capitalized a bank had to have a ratio of capital to assets not lower than 5 percent.

dimension of our data set.[22] Figure 10 presents two charts, one corresponding to the first wave of increases in reserves and the other to the third wave; the chart for the second wave is similar and is not included for brevity.

The structure of the figures deserves some explanation. For each wave, we plot the leverage ratios for the largest 100 domestic banks against their changes in total assets net of reserves.[23] Furthermore, we split the sample into two sub-samples—banks that experience a large change in reserves (greater than 0.5 percent of the total change in reserves for these banks—represented with a dark circle in the figure) and the rest (represented with a light cross). If the increase in reserves put pressure on banks' balance sheets, then those banks that increased their reserve holdings significantly would have shown a positive correlation between their leverage ratio and the change in their assets net of reserves; banks that increased their reserves and had a low leverage ratio would have had to adjust their balance sheet by decreasing some other asset, and hence would have shown a decrease in their assets net of reserves.

Figure 10 shows little evidence of a positive relationship between the leverage ratio and the change in assets net of reserves during the first and third wave of increases in reserves. If anything, figure 10 seems to indicate that those banks that increased their reserves significantly and had a relatively low leverage ratio (between 5 percent and 10 percent) actually increased their holdings of other assets. We conclude from these charts that reserves, as they were created, did not crowd out other kinds of banking assets (such as securities, loans, and leases).[24]

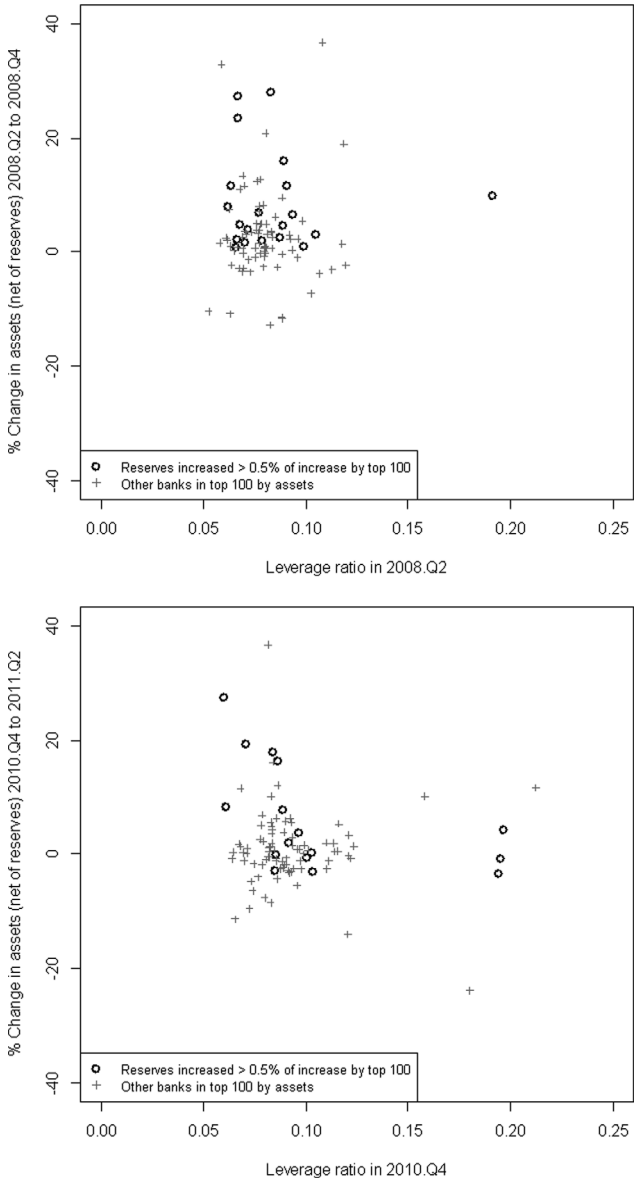
There is thus no clear evidence that the observed increases in reserves during the 2008–11 period systematically reduced the balance sheet capacity of banks. If anything, the balance sheet

[22]Aside from increases in the stock of aggregate reserves, the balance sheet capacity of domestic banks could play a role in a situation where the incentives for FBOs to hold reserves change abruptly and large quantities of reserves start to move into the balance sheet of insured domestic institutions.

[23]The two charts in figure 10 omit outliers with asset growth of more than 45 percent. This eliminates five observations from the top chart and two observations from the bottom chart.

[24]This finding is robust to different thresholds for what is considered a large increase in reserves and also to the sub-sample of large banks that is chosen.

Figure 10. Leverage Ratio and Net-of-Reserves Asset Growth (top 100 banks by assets)



capacity of (large) banks appears to have increased during that period. In principle, excess balance sheet capacity would allow banks to increase lending even without decreasing their holdings of reserves. More germane to the subject of this paper is the case in which banks fund new lending with their holdings of excess reserves. Such activity, however, has no implications for the balance sheet capacity of banks: it constitutes just a swap of one asset (reserves) for another asset (loans). Obviously, swapping reserves for loans has implications for the riskiness of the bank's balance sheet and impacts the bank's position regarding existing risk-sensitive capital regulations. We turn to this issue next.

6. Bank Capital

As a readily available source of funding, high levels of reserves provide flexibility to a bank that is looking to expand its loan portfolio. However, loans (and risky securities) are associated with higher capital requirements than reserves. A bank that is holding reserves but is facing a binding capital constraint is thus unlikely to engage in a sudden expansion of lending. As with deposits, raising capital quickly can be costly. For this reason, even a bank that holds a high level of excess reserves may not be able to take advantage of new lending (or investment) opportunities (see, for example, Van den Heuvel 2002 and Carlson, Shan, and Warusawitharana 2011).

During the first wave of reserve increases around the peak of the crisis, the possibility of banks increasing their lending activity seemed quite remote. However, by the end of 2009 and the beginning of 2010, U.S. economic conditions had become more stable and an increase in bank lending was not beyond the realm of possibility. In such a situation, it seems useful to assess the extent to which banks held capital that would have allowed them to "convert" excess reserves into loans or other risky assets.[25]

For the 100 largest (insured) banks, the charts in figure 11 plot the ratio of reserves to assets on the vertical axis and the risk-based capital ratio for each bank on the horizontal axis. The top chart in

[25]Relatedly, Bliss and Kaufman (2003) argue that the effects of reserve injections by the Federal Reserve depend on whether or not capital requirements are binding.

Figure 11. Reserves vs. Total Risk-Based Capital Ratio in 2009:Q4 (top 100 banks by assets)

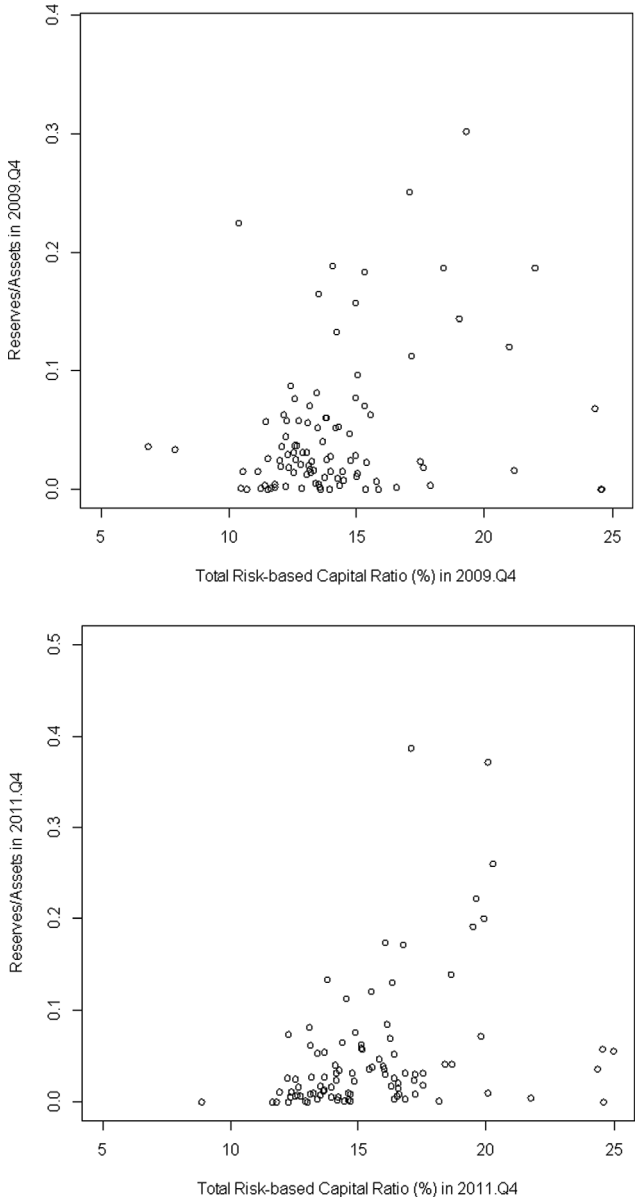


Table 3. Loanable Reserves at Large Insured Institutions (billions of dollars)

		Loanable Reserves	
	Reserves	Standard	Conservative
2009:Q4	510	485 (95%)	317 (62%)
2011:Q4	594	543 (91%)	452 (76%)

figure 11 corresponds to the last quarter of 2009 and the bottom chart is for the end of 2011 (the last data point in our sample). The figures show that in both periods there were a number of banks with fairly high capital ratios (above, say, 12 percent) that were also holding significant levels of reserves.[26]

Based on the figure alone, it is difficult to quantify banks' immediate ability to expand lending. To get a better sense of the quantitative importance of this factor, we compute an aggregate measure of *loanable reserves* that adjusts for the fact that each bank's new lending has to be consistent with satisfying its capital requirement and other regulatory requirements (the calculations are explained in the appendix). In the fourth quarter of 2009, the top 100 banks held $510 billion of reserves, and we calculate that $485 billion were loanable reserves (see table 3). We also calculate a more conservative measure of loanable reserves that takes into account that, during the later part of our sample period, U.S. regulators were in the process of raising capital requirements, and banks may have changed their behavior in anticipation thereof.[27] Even with our more conservative measure, $317 billion of reserves could be considered loanable. In summary, while binding capital requirements are likely to limit the

[26]At the time, to be considered well capitalized, a bank had to have a total capital ratio of at least 10 percent.

[27]The new rules on bank capital were approved by U.S. regulators in July 2013. The rules increased capital requirements and introduced a new minimum requirement on common equity capital. Our conservative measure is broadly consistent with the new rules. We assume that banks were targeting a 10.5 percent tier 1 capital ratio and a 12.5 percent total capital ratio. While we do not make adjustments to account for banks' common equity positions (which were not part of the regulation during our sample period), our measure is conservative enough that such an adjustment is unlikely to have any significant effect on the results.

ability of certain banks to transform reserves into loans, it is clear from the top chart in figure 11 and our measure of loanable reserves that in late 2009 several banks would have been able to use reserves to accommodate a significant increase in loan demand without facing binding capital constraints.

The bottom chart in figure 11 shows that again in the last quarter of 2011 large banks with significant holding of reserves were generally well capitalized, and that in fact there were many large banks with both high levels of reserves and high capital ratios. According to our measure of loanable reserves, $543 billion of the $594 billion of reserves held by these banks were loanable given existing capital requirements, and $452 billion were loanable using the more conservative calculation. In other words, a significant proportion of the reserves held by large banks in the last quarter of 2011 could have been quickly used to fund loans without pushing these banks against their minimum regulatory capital levels. In line with the findings in Berrospide and Edge (2010), these numbers suggest that, rather than bank capital, loan demand was likely the main driving force behind banks' lending behavior.

The two charts in figure 11 also show that large banks in general had higher capital ratios in 2011 than at the end of 2009. Additionally, from figure 3 we know that they held more reserves. For these two reasons, as table 3 clearly indicates, the potential for large banks to create loans funded with reserves increased considerably between 2009 and 2011.

So far, we have demonstrated that the large outstanding level of bank reserves in 2011, in combination with the liquidity and capital position of large banks, could have supported a sudden increase in bank credit if conditions would have warranted. Evidently, aggregate loan demand did not materialize during the period under consideration. However, it is possible that some individual banks might have experienced an outbreak of lending opportunities. By looking at their responses, then, we could gain some insight into the possible interaction of reserves and bank credit in the aggregate. In principle, good lending opportunities should get reflected in the bank's return on lending. For this reason, we turn now our attention to the cross-section of interest income for insured banks in our sample.

7. Bank Interest Income

In the months prior to the autumn of 2008, market interest rates were over 2 percent and bank reserves yielded effectively zero interest. At the time, most banks held minimal excess reserves, with the potential benefits from holding reserves unable to compensate for the unfavorable rate-of-return differential. By the end of 2008, once the Federal Reserve had started to pay interest on reserves and to let the federal funds rate fluctuate in a 0- to 25-basis-points range, the decision of any given bank to hold reserves had changed dramatically.

For example, for the majority of the time between late 2008 and the end of our sample period, the interest rate on Treasury bills was below the 25-basis-points interest rate on reserves. For a bank choosing how to allocate its liquid assets, this became an obvious reason to favor reserve holdings over Treasury bills. Because the Treasury bill return is widely available, this shift in the rate-of-return differential affected all banks equally. However, the rates of return on lending opportunities vary across banks and, presumably, affect the opportunity cost of holding reserves for each bank. The question then arises whether those banks experiencing an unusually high return on their lending activities tended to accumulate fewer reserves.

To address this question, we concentrate our attention on the later part of the sample period: the years 2010 and 2011. Of course, one could also study this issue using data from 2008 and 2009. However, unusual economic circumstances during that period directly undermine the possibility of identifying any meaningful relationship between reserve holdings and rates of return on lending opportunities.

We construct a balanced panel with the largest 100 insured banks by assets. We approximate each bank's return on loans in the third quarter of 2010 (2011) by the forward-looking ratio of average loan interest income in the third and fourth quarter of 2010 (2011) to the level of loans in the third quarter of 2010 (2011). The first row of table 4 summarizes the distribution of rates of return on lending. We observe substantial heterogeneity in the level of rates, which is not surprising given the wide array of lending strategies pursued by different banks in the United States. When interpreting this table, it is important to keep in mind that the returns shown in the first row do not make any correction for risk.

Table 4. Distribution of Quarterly Rates of Return on Loans Across Top 100 Banks (annualized, in percentage terms)

	Min.	1st Quart.	Median	Mean	3rd Quart.	Max.	St. Dev.
Level 2011	−0.00	4.58	5.17	5.56	5.70	18.59	2.26
Change 2010 to 2011	−5.23	−0.39	−0.17	−0.15	−0.00	5.73	0.10

The second row of table 4 shows the change in returns from the third quarter of 2010 to the third quarter of 2011. These numbers give us an approximate measure of the change in each bank's rate of return on lending. Furthermore, differencing is a crude way to control for fixed variation in strategies across banks (with respect to riskiness, for example). The main feature to highlight from these calculations is that in general during this period changes in rates of return on lending were small relative to the level of those rates.

If banks with better lending prospects perceive a higher opportunity cost of holding reserves and hence hold less of them, then we should find a negative correlation between the changes in reserves and the changes in rates of return on lending across banks. We run a set of cross-section regressions to investigate this issue, using as the dependent variable the change in reserves (divided by assets) for each of the top 100 banks between the second half of 2010 and the second half of 2011. To focus on banks with significant lending activities, we only include in the regression those banks with a loan-to-asset ratio greater than 0.25. Our main results are reported in table 5. The coefficient on the change in the rate of return on lending is actually positive and not significant even when we add several controls, such us the change in deposits (over assets), the relative size of the institution, and the percentage change in assets (and even when we control for possible outliers). We conclude from this evidence that without much idiosyncratic variation in returns, it is difficult to determine whether an individual bank would choose to reduce their reserve holdings when experiencing especially good lending opportunities: during the period under study, meaningful changes in lending opportunities simply do not appear to have occurred.

Table 5. Regression of Change in Reserves (Divided by Assets) for Large Banks, from Second Half of 2010 to Second Half of 2011

	All Banks with Loan-to-Asset Ratio > 0.25			Without Top 4 Banks	Without Outliers	
	(1)	(2)	(3)		All	Only Banks with Positive Loan Growth
ΔReturn on Loans	0.838	0.837	0.875	0.826	1.298	1.916
ΔDeposits over Assets	0.333***	0.333***	0.330**	0.332***	0.233***	0.209**
ΔAssets over Assets	−0.127	−0.127	−0.125	−0.126	−0.092	−0.084
Assets as % of Total			0.379			
Dummy Top 4 Banks		0.035	−5.723			
Intercept	−1.220**	−1.222**	−1.362**	−1.222*	−0.868**	−0.750
Adjusted R^2	0.29	0.28	0.27	0.29	0.25	0.27
Number of Observations	96	96	96	92	85	43

Notes: *** indicates a p-value of less than 1 percent, ** a p-value less than 5 percent, and * a p-value less than 10 percent. Outliers are defined as those observations where the absolute value of the change in reserves was greater than 10 percent of bank assets and the absolute value of the change in return on loans was greater than 4 percent.

8. Conclusion

We see the research described in this paper as shedding light on the cross-sectional consequences of the dramatic increase and sustained high level of bank reserves in the United States between the last months of 2008 and the end of 2011. Our empirical investigation provides several elements that are relevant for assessing the policy implications of a banking system with large levels of excess reserves.

We uncovered five main patterns in the data. First, we found that reserves were widely distributed across banks and appeared to get relatively more concentrated in large banks only during periods of high growth in the total amount of reserves outstanding. When the total level of reserves stabilized for some time, reserves became more evenly distributed among institutions. Uninsured institutions (mainly U.S. branches and agencies of foreign banks) played a significant role in absorbing the changes in aggregate reserves during the sample period. In fact, in the second quarter of 2011 these institutions, numbering around 200, held more than 40 percent of total reserves.

Second, we observed an increase in the level of total liquidity in the banking system concurrent with the increase in aggregate reserves. In other words, reserves did not substitute for liquid securities at banks but rather complemented them, resulting in a material increase in total bank liquidity. With the Federal Reserve paying interest on reserves, banks had less of an incentive to economize on reserve holdings. They appear to have shifted from a policy of holding a low level of liquidity and regularly borrowing in the interbank market, to holding a permanently high level of outside liquidity with a significant share of excess reserves.

Third, we do not find evidence that the increase in reserves put pressure on insured banks' balance sheet capacity. If anything, between 2008 and 2011 large domestic banks increased their potential for balance sheet growth. While this fact does not have direct implications for banks' ability to fund lending with reserves, it does suggest that the banking system could expand significantly without confronting tight regulatory constraints.

Fourth, after the height of the financial crisis had passed and as the Federal Reserve increased aggregate reserves by undertaking

large asset purchase programs, reserves flowed to the balance sheets of banks with relatively abundant capital. As a result, once crisis conditions abated, the lion's share of reserves in most of the large banks in our sample could have been converted into loans without creating any substantial pressure on their capital ratios.

Finally, we consider the possibility that changes in the rate of return on lending could drive the decision of individual banks to hold reserves. We find that during our sample period changes in rates of return on lending were small and not tightly linked to changes in the reserve allocation across large banks. The evidence, though, is far from conclusive. It may just be that the effect on reserves becomes evident only when more significant changes in rates of return occur.

This paper has concentrated on the period 2008 to 2011, when the Federal Reserve's second asset purchase program was completed. Since then, total reserves have increased by more than $1 trillion, making it increasingly important to understand whether and to what extent reserves matter for monetary policy and economic outcomes. The objective of our work was to contribute to that process.

Appendix

Integrating Aggregate and Cross-Sectional Data

Aggregate reserve balances with Federal Reserve Banks are reported in the Federal Reserve's H.3 release. Because banks can also use vault cash to satisfy reserve requirements, to arrive at a number for "Total Reserves" we sum depository institutions' reserve balances with Federal Reserve Banks and vault cash, both from the H.3 release.[28] To construct the analogous number for an individual bank in our sample, we sum the Call Report entries "balances due from federal reserve banks" and "currency and coin." Required reserves for an

[28]Note that there is a significant quantity of deposits at Federal Reserve Banks that is not included in our definition (or the Federal Reserve's definition) of reserves. On June 29, 2011 the U.S. Treasury held $106 billion on deposit at the Federal Reserve. Other institutions such as the International Monetary Fund, the United Nations, the World Bank, Fannie Mae, and Freddie Mac also have accounts with the Federal Reserve. Neither the Treasury's balances nor these other institutions' balances are included in reserves.

individual bank can be estimated using Call Report deposits and the Federal Reserve's formula for required reserves, though these calculations are less reliable because of the complications in the accounting rules used for reserves requirements. Excess reserves are the amount by which balances due from the Federal Reserve and vault cash used to satisfy reserve requirements exceeds required reserves. Unfortunately, while "vault cash used to satisfy reserve requirements" is reported in the H.3 release, it is not a Call Report entry. We assume that all vault cash is used to satisfy reserve requirements. To compare aggregated Call Report reserves plus currency and coin to the H.3 release's reserves plus vault cash, we need to make an adjustment for required clearing balances. For aggregated Call Report reserves held by insured institutions, we subtract required clearing balances, as reported in the Federal Reserve's H.4.1 release; these balances are included in balances due from Federal Reserve banks in the Call Report, but they are excluded from reserve balances in the H.3 release. This adjustment is minor. Required clearing balances had been trending down for several years and by the end of 2010 amounted to only $2 billion in total. It is important to note that this adjustment is not possible at the level of individual banks and hence we simply use the Call Report items "balances due" and "currency and coin" to proxy for the reserve position of individual banks at each point in time.

Calculating Total Loanable Reserves

Capital requirements in the United States mandate that banks satisfy several minimum ratios of capital to assets, based on different measures of capital and of assets. The leverage ratio, for example, is a simple ratio of capital to assets (without any significant adjustments). Transforming reserves into loans on the asset side of the balance sheet does not change this ratio in any material way. For this reason, the leverage ratio does not play a role in our calculation of loanable reserves.

The tier 1 capital ratio is the ratio of tier 1 capital to risk-adjusted assets.[29] The risk charge for reserves is lower than the risk charge for loans. Hence, transforming reserves into loans results in an

[29]Tier 1 capital consists of common equity and some types of preferred stock.

increase in risk-adjusted assets and, given tier 1 capital, a decrease in the tier 1 capital ratio. A bank with a low tier 1 capital ratio will then be less able to increase lending (or investment), even if it is holding sufficient excess reserves to fund the loans.

The total capital ratio is the ratio of the sum of tier 1 and tier 2 capital to risk-adjusted assets.[30] As with tier 1 capital, a bank with a relatively low total capital ratio (such that approaching the regulatory minimum becomes a concern) will tend to limit its expansion of credit, even when funding could be readily provided with the holdings of excess reserves.

In summary, some of the potential lending capacity associated with holding excess reserves should be "discounted" to the extent that those reserves are being held by banks with (effectively) binding capital constraints. It is impossible to determine precise levels of capital ratios at which the requirements become effectively binding. Some banks may be willing to make certain loans even if their capital requirement is relatively low. Others may take a more conservative approach to capital management and lending.

To obtain a simple estimate, we take the view that each bank's loanable reserves are given by the amount of new loans that could be funded by excess reserves while keeping the bank "well capitalized" for regulatory purposes. Reserves have zero weight in the computation of risk-weighted assets, and we take a conservative approach and assume all loans have 100 percent risk weight. During our sample period, a "well-capitalized" bank needed a tier 1 capital ratio higher than 6 percent and a total capital ratio higher than 10 percent. Using this criterion, we compute for each quarter in our data set the following measure of loanable reserves for the largest 100 insured banks in the sample:

$$LR(t) = \sum_i \min\left\{ \frac{\left[K_i^{T1}(t) - K_{iR}^{T1}(t)\right]^+}{0.06}, \frac{\left[K_i^{T}(t) - K_{iR}^{T}(t)\right]^+}{0.1}, \right.$$
$$\left. \left[R_i(t) - R_{iR}(t)\right]^+ \right\},$$

[30]Tier 2 capital consists of allowance for loan losses, subordinated debt, and other convertible debt securities.

where K_i^{T1} is the dollar amount of tier 1 capital held by bank i and K_{iR}^{T1} is the amount of tier 1 capital that would allow the bank to have a ratio equal to 6 percent. Similarly, K_i^T is the dollar amount of total capital held by bank i and K_{iR}^T is the amount of total capital that would allow the bank to have a ratio equal to 10 percent. Finally, R_i is the level of reserves held by bank i and R_{iR} is the required reserves (net of vault cash) given its average level of transaction accounts liabilities in the quarter. The superscript + sign means that we are only considering non-negative values of these terms.

In 2011, capital ratios were regarded as likely to increase in the near future, especially for large banks. For this reason, we also compute a more conservative measure of loanable reserves based on the Basel III proposal. In particular, we fix the required tier 1 capital ratio to 10.5 percent and the total capital ratio to 12.5 percent. We use these ratios as a way to obtain a relatively conservative measure of loanable reserves, given the uncertainty with respect to capital requirements at the time.[31]

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